The Penn State McNair Journal

Summer 2006, Volume 13

The Penn State McNair Journal is published annually and is the official publication of the Ronald E. McNair Scholars Program at Penn State. No responsibility for the views expressed by the authors in this journal is assumed by the editors or the Ronald E. McNair Scholars Program.

The program is funded by a $285,503 Ronald E. McNair Post-Baccalaureate Achievement Program grant from the U.S. Department of Education.

THE PENN STATE MCNAIR JOURNAL

Summer 2006 Volume Thirteen

Table of Contents

McNair Scholar Articles

WELCOME

Since 1991, the Penn State McNair Scholars Program has enriched the lives of students at both Penn State and Virginia State University, our partner in the McNair collaboration. The McNair Program holds a very special place in our lives, as well as in the lives of the faculty and staff who work with our students. This publication celebrates their achievements and we offer it to our readers with pride and pleasure.

This is the thirteenth issue of the Penn State McNair Journal. We congratulate the 2006 Penn State McNair Scholars and their faculty research advisors! This journal presents the research conducted in the summer of 2006 by undergraduate students from Penn State and Virginia State University who are enrolled in the Penn State McNair Scholars Program.

The articles within this journal represent many long hours of mutual satisfying work by the Scholars and their professors. The results of their research are published here and have also been presented at various research conferences around the country. We are especially proud to see how these students have grown as researchers and scholars. The hard work, dedication, and persistence required in producing new knowledge through research is most evident in these articles.

We very much appreciate the guidance, expertise, caring and patience of our fine group of Penn State faculty research advisors. For their ongoing support and assistance, we thank Graham Spanier, President of Penn State University; Rodney Erikson, Provost of Penn State University; Eva Pell, Senior Vice President of Research and Dean of the Graduate School; Evelynn Ellis, Senior Director of the Office of Graduate Educational Equity, the administrative home of the McNair Scholars Program. Also, special thanks to Eddie Moore, President of Virginia State University, and Gladys Nunnally, Honors Program Director at Virginia State University.

We are also fortunate to have the support and encouragement of many faculty and staff members who have worked with our students as social mentors or who have presented workshops and seminars on the many aspects of graduate and faculty life. You give the most precious of gifts to our students – your time in volunteering to support, encourage and nurture our Scholars' hopes and dreams.

Teresa Tassotti
Project Director

Curtis Price
Academic Coordinator

TRIO PROGRAMS ON THE NATIONAL LEVEL

Since their establishment in the mid-sixties as part of Lyndon Johnson's War on Poverty Program, TRIO Programs have attempted to provide educational opportunity and make dreams come true for those who have traditionally not been a part of the educational mainstream of American society. The TRIO programs are funded under Title IV of the Higher Education Act of 1965. While student financial aid programs help students overcome financial barriers to higher education, TRIO programs help students overcome class, social and cultural barriers to higher education. There are eight TRIO programs, which include the original three – Upward Bound, Talent Search and Student Support Services. The additional programs are Educational Opportunity Centers, Upward Bound Math & Science Centers, the Ronald E. McNair Post-Baccalaureate Achievement Program, a dissemination program, and a training program for TRIO staff. McNair programs are located at 180 institutions across the United States and Puerto Rico. The McNair Program is designed to prepare participants for doctoral studies through involvement in research and other scholarly activities.

TRIO PROGRAMS AT PENN STATE

The TRIO Programs at Penn State comprise six of the nine TRIO programs. There are two Educational Opportunity Centers, one in Philadelphia and the other in Pittsburgh; Ronald E. McNair Scholars Program; Student Support Services Program; two Talent Search Programs serving western Pennsylvania and York, Upward Bound; and Upward Bound Math & Science. These programs annually serve more than 5,000 students, from 6th graders through adults, with clear potential for academic success. The programs operate both at University Park and in communities across the state, often linking with middle schools, high schools, and community agencies. The programs focus on helping students overcome economic, social, and class barriers so that they can pursue education beyond high school.

MCNAIR SCHOLARS PROGRAM AT PENN STATE

Designed for low-income and first-generation college students, and students from groups underrepresented in graduate education, the McNair Scholars Program at Penn State encourages talented undergraduates to pursue the doctoral degree. The program works closely with these participants through their undergraduate career, encourages their entrance into graduate programs, and tracks their progress to successful completion of advanced degrees.

The goal of the McNair Program is to increase graduate degree attainment of students from the above-mentioned underrepresented segments of society. McNair Scholars are presented with opportunities to study and do research in the University's state-of-the-art facilities in order to hone those skills required for success in doctoral education. Through both academic year and summer program components, McNair Scholars are required to complete a series of steps that lead to their application and enrollment in a graduate program of their choice.

Since 1991, the McNair Scholars Program at Penn State has helped 147 students earn their baccalaureate degrees. Of these graduates, 114 or 78 percent have gone on to graduate school at institutions across the country. And within this group, 20 or 18 percent have earned their doctoral or professional degrees and another 32 or 28 percent have earned their master's degrees only. Currently, there are 52 or 46 percent of alumni who are enrolled in their graduate programs, 13 of whom have earned their master's and are now pursuing their doctorates. Among the institutions McNair alumni have attended or now attend are: Penn State, Harvard, University of California-Berkeley, University of California-Davis, Stanford, Howard, Cornell, UCLA, Boston University, Indiana University-Bloomington, University of North Carolina-Chapel Hill, University of Maryland-College Park, John Hopkins University, University of Pennsylvania, Purdue, DePaul, and Ohio State, to name just a few.

Summer 2006 McNair Scholars and Program Staff

Standing (left to right): Curtis Price (Academic Coordinator), Robert Ksiazkiewicz, Andrae Laws, Robert Allen Young, Michael Mollenhauer, Mohammed Faacy Farook, Saalim Carter, Joshua Walker, Dipnil Chowdhury

Sitting (left to right): Teresa Tassotti (Program Director), Shartaya Mollett, Tamara Fleming, Courtnee-Evan Spino, Renee Killins, Judy Banker (Staff Assistant), Alana Curry

ABOUT RONALD E. MCNAIR

Dr. Ronald Erwin McNair, the second African American to fly in space, was born on October 21, 1950, in Lake City, South Carolina. In 1971, he received a Bachelor of Science degree, magna cum laude, in physics from North Carolina A&T State University. He continued his education at the Massachusetts Institute of Technology (MIT) where, in 1976, he earned his Ph.D. in physics.

While at MIT, McNair performed some of the earliest development of chemical and high-pressure CO lasers. He went on to study laser physics at E'cole D'ete Theorique de Physique in Les Houches, France. He was well published and nationally known for his work in the field of laser physics through the Hughes Laboratory.

In 1978, McNair realized his dream of becoming an astronaut when he was selected from a pool of several thousand applicants to be included in the first class of thirty-five applicants for the space shuttle program. Ronald McNair and six other astronauts died on January 28, 1986 when the space shuttle *Challenger* exploded after launching from the Kennedy Space Center in Florida.

McNair was an accomplished saxophonist; held a sixth-degree, black belt in karate; and was the recipient of three honorary doctorates and a score of fellowships and commendations. He was married to the former Cheryl Moore and is the father of two children, Reginald Ervin and Joy Cheray. After his death, Congress approved funding to honor the memory of McNair by establishing the Ronald E. McNair Post-Baccalaureate Achievement Program, which became the sixth program funded under the TRIO Programs umbrella.

"Historians, who will write about McNair, the man, will discover that there was much more to him than his scholastics achievements. Friends who knew him, say he walked humbly and never boasted about his achievements. They say his commitments were to God, his family and to the youths he encouraged to succeed."
(Ebony, May 1986)

SPECIAL ACKNOWLEDGEMENTS

PROGRAM AND EDITORIAL STAFF

Teresa Tassotti, Program Director
Curtis Price, Academic Coordinator
Judy Banker, Staff Assistant

RESEARCH METHODS COURSE INSTRUCTOR

Rama B. Radhakrishna

FACULTY RESEARCH ADVISORS AND EDITORS

Peter Arnett
Avery August
David Conroy
Lori Francis
Philip Atiba Goff
Michael Milligan
Susan Mohammed
Patrick McDaniel
Stephen Piazza
Jeffrey Peters
Stephen Schaeffer
Anne Thompson

SOCIAL MENTORS

Peter Arnett
Deborah Atwater
Guy Barbato
Larry Brown
David Conroy
Wayne Gersie
Joyce Hopson-King
Kimberly Menard
Rama Radhakrishna
Maggie Thomas
Pamela Thomas-Buchanan
Anne Thompson
Katherine Warren

McNair Alumni on the Move

We congratulate our recent graduates and are very proud of their accomplishments. We also extend congratulations to those Penn State McNair alumni who have earned their graduate degrees as well as those alumni currently enrolled in graduate studies.

At the graduate level…

Taimarie Adams (PSU 2003)	J.D., Harvard University
Karla (James) Anderson (VSU 1999)	M.S., Central Michigan University
Michael Benitez (PSU 2001)	M.Ed., Penn State University
Jose Buitrago (PSU 1995)	M.L.A., Harvard University
Sherese Burnham (PSU 1999)	M.S., University of Central Florida
Aaron Brundage (PSU 1995)	M.S., Penn State University
	Ph.D., Purdue University
Sofia Cerda-Gonzalez (PSU 1999)	D.V.M., Cornell University
Debbie Charles (PSU 2001)	M.S., University of Maryland-College Park
Catherine Crawford (PSU 1996)	M.Ed., Central Michigan University
Natasha Deer (PSU 1995)	M.A., Florida State University
Alicia DeFrancesco (PSU 1997)	M.B.A., Babson College
Lurie Daniel (PSU 2000)	J.D., New York University
Jorge Delgado (PSU 2004)	M.S., Purdue University
Eve Dunbar (PSU 1998)	Ph.D., University of Texas-Austin
Latia Eaton (VSU 2003)	M.S.W., University of Baltimore
Carol Elias (VSU 1997)	M.Ed., Virginia State University
Michael Godeny (PSU 2002)	Ph.D., University of Florida
Antoinette Gomez (PSU 1994)	M.S., Clark-Atlanta University
Cristina Gonzalez (PSU 1999)	M.D., Albert Einstein Medical School
Sherie Graham (PSU 2002)	M.S., University of Michigan
Janet Harris (PSU 1996)	M.Ed, Duquesne University
Angela Hess (PSU 1998)	Ph.D., University of Iowa
Priscilla Hockin-Brown (PSU 1996)	M.S., Michigan State University
	Ph.D., Rutgers University
Marissa (Graby) Hoover (PSU 2000)	M.S., Temple University
Meng He (PSU 2002)	M.A., American University
Jeffrey Himes (PSU 1997)	M.S., West Virginia University
Alisa Howze (PSU 1994)	Ph.D., Texas A&M University
Andrea Jones (VSU 1998)	M.P.A., Virginia State University
Michelle Jones (PSU 1996)	Ph.D., Penn State University
Leshawn Kee (VSU 1998)	M.A., Regents University
Haroon Kharem (PSU 1996)	Ph.D., Penn State University
Carrie (Hippchen) Kuhn (PSU 2001)	M.A., Stanford University
LaShawne (Long) Miles (PSU 2001)	M.Ed., Xavier University
Charmayne Maddox (PSU 2004)	M.Ed., Penn State University
Debra Marks (VSU 1996)	M.S., University of Virginia
Robert Miller (PSU 1999)	Ph.D., University of Kentucky
Bethany Molnar (PSU 1998)	M.S., Northeastern University
Nicole Morbillo (PSU 1998)	Ph.D., New York University
Ndidi Moses (PSU 2000)	M.A., Penn State University,
	J.D., University of Connecticut
Robert Osmanski (PSU 1995)	M.S., Penn State University

Hui Ou (PSU 2005)	M.S., Cornell University
Caryn Rodgers (PSU 2000)	Ph.D., St. John's University
Lilliam Santiago-Quinones (PSU 1998)	M.Ed., Bowling Green State University
Thomas Shields (PSU 1998)	M.A., Penn State University
Christie Sidora (PSU 2000)	M.A., Duquesne University
Melik Spain (VSU 1996)	M.S., Virginia Tech University
Anthony Spencer (PSU 1999)	Ph.D., Northwestern University
Shawyntee Vertilus (PSU 1998)	M.P.H./M.D., New York Medical College
Patrice White (VSU 2001)	M.S., University of Maryland-College Park
Romon Williams (VSU 1995)	M.S., Wake Forest University
Wendy Williamson (PSU 1995)	M.B.A., Penn State University
Kenya Wright (VSU 1997)	M.S., North Carolina State University
Heneryatta Ballah (PSU 2004)	M.A., Ohio State University, now pursuing Ph.D. at Ohio State
Laurian Bowles (PSU 1999)	M.A., University of London, now pursuing Ph.D. at Temple University
Felecia Evans (PSU 2002)	M.S., Texas Tech University, now pursuing Ph.D. at Texas Tech
Natasha Faison (PSU 1999)	M.S., Penn State University, now pursuing Ph.D. at Eastern Michigan University
Derek Gray (VSU 1998)	M.A., SUNY-Albany, now pursuing J.D. at North Carolina Central University
Rashid Njai (PSU 2000)	M.P.H., University of Michigan, now pursuing Ph.D. at University of Michigan
Mark Palumbo (PSU 2000)	M.S., Wright State University, now pursuing Ph.D. at Wright State
Zakia Posey (PSU 1999)	M.A., Michigan State University, now pursuing Ph.D. at Michigan State
Steven Thompson (PSU 1997)	M.S., Indiana University-Purdue, now pursuing Ph.D. at Clemson University

At the undergraduate level…

Johnese Bailey (VSU) May 2006
Syleena Guilford (VSU) December 2005
Juliet Iwelumor (PSU) May 2006
Marie Krouse (PSU) May 2006
Kenya Ramey (VSU) May 2006

On to graduate school in Fall 2006…

Johnese Bailey (VSU 2006) now pursuing graduate studies at University of South Carolina
Juliet Iwelumor (PSU 2006) now pursuing graduate studies at Penn State University
Kenya Ramey (VSU 2006) now pursuing graduate studies at Temple University

In graduate school as of Fall 2006…

Juan Abreu (PSU 2002)	Rutgers University (Law/Criminal Justice)
Luis Agosto (PSU 2005)	University of Pennsylvania (Immunology)
Omotayo Banjo (PSU 2004)	Penn State University (Media Studies)
Angelo Berrios (PSU 2000)	St. Joseph's University (Education)

Jennifer Carman (PSU 2000)	Strayer University (Health Administration)
Michael Collins (VSU 2005)	Howard University (Medicine)
Catherine Crawford (PSU 1996)	Central Michigan University (Education)
Trinaty Crosby (PSU 2005)	Howard University (Social Work)
Max Fontus (PSU 1999)	Indiana University-Bloomington (Chemistry)
Tiana Garrett (VSU 2001)	University of North Carolina-Chapel Hill (Chemistry
Kathy Goodson (VSU 2005)	University of Maryland-College Park (Biochemistry)
Maria Gutierrez (PSU 2005)	University of California-Berkeley (Middle East Studies)
Mark Harewood)VSU 2000)	Webster University
Dustin Holloway (PSU 2002)	Boston University (Molecular Biology)
Mimi (Abel) Hughes (PSU 2002)	University of California at Los Angeles (Atmospheric Sciences)
Lanik Lowry (PSU 2002)	University of Maryland-College Park (Human Resources)
Lourdes Marcano (PSU 1995)	University of Tennessee (Business Administration)
Leanna Mellott (PSU 2000)	Ohio State University (Sociology)
Angel Miles (PSU 2003)	University of Maryland-College Park (Women's Studies)
Edward Mills (VSU 2003)	University of Illinois at Urbana-Champaign (History)
LaShauna Myers (PSU 2003)	University of Pennsylvania (Higher Education)
Kizzy (Frey) Nicholas (PSU 2000)	Penn State University (Education)
Nikkia Ogburn (VSU 1997)	Longwood University
Tracie Parker (VSU 2003)	Ohio State University (Music Education)
Franche Pierre-Robinson (VSU 2002)	University of Illinois-Chicago (Education)
Tiffany Polanco (PSU 2004)	Rutgers University (Animal Science)
Kristin Rauch (PSU 2004)	University of California-Davis (Anthropology)
Cavin Robinson (PSU 2002)	DePaul University (Philosophy)
Sassy Ross (PSU 2001)	New York University
Adriana Segura (PSU 2006)	Northwestern University (Medicine)
Kedesha Sibliss (VSU 2003)	Georgetown University (Medicine)
Luisa Soaterna (VSU 2004)	John Hopkins University (Biophysics)
Kashra Taliaferro (PSU 2003)	University of Maryland-College Park (Education)
Selima Taylor (PSU 2004)	New York University (Health Science Administration)
Anthony Paul Trace (PSU 2004)	University of Virginia (Medicine/Biochemistry & Molecular Genetics
Kahlil Williams (PSU 2001)	University of Pennsylvania (Political Science)

Labor Unions and Antitrust Legislation: Judicial Activism vs. Judicial Restraint from 1890-1941

Saalim A. Carter, McNair Scholar, Penn State University

Faculty Research Adviser
Dr. Michael Milligan, Senior Lecturer
Department of History
The College of Liberal Arts

INTRODUCTION

In the March 1941 issue of the *American Federationist*, the American Federation of Labor's (AFL) primary publication, there was an article entitled "Mr. Arnold Gets Stopped."[1] The article was referring to Thurman Arnold, Assistant Attorney General in charge of the Antitrust Division in Franklin Delano Roosevelt's Department of Justice. Arnold was well known for his trust-busting campaign and acute insight concerning the legal mechanisms for controlling corporate monopolies. His later tenure in this position, however, was marked by attempts to use the 1890 Sherman statute to curtail the practices of labor combinations. In the February 1941 *U.S. v. Hutcheson* decision, the U.S. Supreme Court put a halt to his efforts to prosecute an AFL affiliated union for violating the Sherman statue. The article's text stated the following:

> With remarkable analytical insight, and in language noteworthy for its crystal clearness, Justice [Felix] Frankfurter traced the struggle between Congress and the judiciary over the relationship of the Sherman Act to labor. It described the Clayton and Norris-LaGuardia Acts as 'a series of enactments touching one of the most sensitive national problems.'
>
> 'The underlying aim of the Norris-LaGuardia Act was to restore the broad purpose which Congress thought it had formulated in the Clayton Act but which was frustrated, so Congress believed, by 'unduly restrictive judicial construction.'[2]

This restrictive construction was established over time by conservative *Lochner* era courts that interpreted the Sherman Act broadly to include labor unions and interpreted the labor exemptions of the Clayton Act narrowly to prevent any legislative relief.[3] This, as it was called, was indicative of *Lochner* era activism. But with the decision in *Hutcheson*, the article stated that "It took a struggle of a quarter of a century to do it, but it has been done at last—and done well."[4] The significance of this legal victory was also echoed by national newspapers, including the *New York Times*. In one *New York Times* article, entitled "High Courts Holds Unions Exempt From Sherman Act in Own Disputes," the author stated that the *Hutcheson* decision marked a

---

[1] Joseph A. Padway, "Mr. Arnold Gets Stopped," *American Federationist.* Vol. 48. No. 13 (1941): 12-13.
[2] Padway, 12-13; *U.S. v. Hutcheson*, 312 U.S. 219 (1941).
[3] Ibid.
[4] Ibid.

crossroads in labor's battle against the inappropriate application of the Sherman statute to its organizations and the use of injunctions, which had become a potent weapon for employers in labor disputes.[5]

The 1941 *Hutcheson* decision was a decisive victory for labor, but what is vital was how the court arrived at this decision. Was this outcome the result of judicial restraint, which repudiated *Lochner* era activism? Or, was it the result of a responsive legislature, which answered the calls of discontented labor organizations? Responding to labor's agitation, Congress passed the surprisingly ambiguous Clayton Act in 1914. The Norris-LaGuardia Act years later clarified its pro-labor use. In *Hutcheson,* labor was granted immunity from the operation of the Sherman statute and a new standard was developed. The doctrinal framework provided in Frankfurter's majority opinion in *Hutcheson* represented a sudden victory for pro-labor judicial restraint over long prevailing conservative, judicial activism. During this time, "judicial restraint" was best defined as deference towards the legislature and thus restraint in applying judicial construction or judge-made law. *Lochner* era "judicial activism," on the other hand, was best defined as what Frankfurter described as excessive, "unduly restrictive judicial construction."[6]

Frankfurter's position was founded in his sympathy toward labor and his belief in the clear legislative intent of the Clayton Act, which he exaggerated. Frankfurter was correct in concluding that the intent of the Norris-LaGuardia Act was to clarify the language of the Clayton Act and further extend the range of labor practices exempt from the antitrust statutes. The legislative history of the Norris-LaGuardia Act is clear in this matter.

A BRIEF HISTORIOGRAPHY

A vast majority of the historical analysis on this topic ends in 1930, two years prior to the passage of the Norris-LaGuardia Act and at the height of the Anti-Injunction Movement. In 1930, two major books were written on this topic: *Labor and the Sherman Act* by Edward Berman[7] and *The Labor Injunction* by Felix Frankfurter and Nathan Greene.[8] Berman's book provided an unparalleled analysis of the history the Sherman and Clayton statutes and how they applied to labor organizations. Reviewing the evolution of labor and antitrust cases in the courts, he showed how over time *Lochner* era courts were able to interpret the Sherman Act broadly to include labor unions. In addition, Berman demonstrated how the courts applied an unduly restrictive judicial construction when interpreting the labor exemption of the Clayton Act. Unfortunately, his study was published just prior to the passage of the Norris-LaGuardia Act of 1932 and before the 1941 *Hutcheson* decision, which ultimately made his comprehensive analysis inept.

In *The Labor Injunction*, Frankfurter and Greene condemned the over-reaching application of injunctions in labor disputes.[9] The central thesis of their book was that the use of

---

[5] Louis Stark, "High Court Holds Unions Exempt From Sherman Act in Own Disputes," *New York Times*, 4 February 1941, 1.
[6] Padway, 13.
[7] Edward Berman, *Labor and the Sherman Act*, New York: Russell & Russell, 1930.
[8] Felix Frankfurter and Nathan Greene, *The Labor Injunction*, New York: The Macmillan Company, 1930.
[9] Ibid.

injunction was legally flawed and constituted an inappropriate use of judicial authority. They asserted that in equity theory the use of an injunction was an extraordinary legal measure that should be invoked only in emergencies characterized by "immediate danger of irreparable damage to physical property."[10] Labor disputes, however, usually permitted time for recourse in a court of law. Frankfurter and Greene further stated that by the 1920s, with the ordering of so many injunctions against labor, this practice "made a shambles of legal theory." The "extraordinary remedy of injunction," they argued, had the "ordinary legal remedy, almost the sole remedy."[11]

Charles Gregory's 1941 article "The New Sherman-Clayton-Norris LaGuardia Act"[12] refutes the legal reasoning of Justice Felix Frankfurter. Gregory argued Frankfurter was essentially legislating from the bench.[13] He also states that Frankfurter's over-exuberance to help out labor obscured his interpretation of the Norris-LaGuardia Act and caused him to define the intent of the legislature where no definitive intent was presented in the law. Gregory entitled his article "The New Sherman-Clayton-Norris LaGuardia Act" as a criticism of Frankfurter's judicial interpretation in *Hutcheson*. Gregory was the classic conservative case; numerous conservatives after *Hutcheson* attempted to paint Frankfurter as a radical jurist who cavalierly pieced together distinctly different pieces of legislation.

Dallas L. Jones' 1957 article "The Enigma of the Clayton Act"[14] sheds light on the legislative history of the Clayton Act and the rise of "Industrial Democracy"[15] in which labor made a deal with the Woodrow Wilson Administration and the Democratic Party for favorable labor legislation in return for political support. Jones highlighted the vast ambiguities of the legislative intent to exclude labor from the Sherman statute. But he does not blame Congress for the "qualifiers" and the equivocating language of the Clayton Act that enabled *Lochner* era courts to interpret the labor exemptions as narrowly as it had in the 1921 *Duplex* decision.[16] In *Duplex*, Jones stated that "The Supreme Court interpretation of these sections [Section 6 and Section 20 of the Clayton Act—the labor exemption provisions] was so narrow as to render them ineffective." [17] Jones blamed Woodrow Wilson for the failure of these sections because of his interference with the legislative processes in an attempt to garner favor with both business and labor supporters. The political interference of the executive led to two interpretations of the purpose of the Clayton Act and resulted in the bill's ambiguous language and inclusion of qualifiers such as "lawfully" and "peacefully."[18]

---

[10]Edwin E. Witte, "The Labor Injunction." *The American Economic Review*, Vol. 20, No. 3 (1930):522-524; "Irreparable-injury rule" is "the principle that equitable relief [such as an injunction] is available only when no adequate legal remedy [such as monetary damages] exists." Bryan A. Garner, *Black's Law Dictionary*. St. Paul: West Publication Co, 2001: 372.

[11] Frankfurter., 13

[12] Charles O. Gregory, "The New Sherman-Clayton-Norris LaGuardia Act," *The University of Chicago Law Review*, Vol. 8, No. 3. (1941): 503-516.

[13] Ibid., 515.

[14] Dallas L. Jones, "The Enigma of the Clayton Act," *Industrial and Labor Relations Review*, (1957): 201-221.

[15] Ibid., 201; Joseph A. McCartin, *Labor's Great War: The Struggle for Industrial Democracy and the Origins of Modern American Labor, 1912-1921*, Chapel Hill: The University of North Carolina Press, 1997.

[16] Jones, 218.

[17] Ibid., 221.

[18] Ibid., 218.

Irving Bernstein's 1966 work, *The Lean Years: A History of the American Worker 1920-1933* provides a brief, yet compelling history of the "Anti-Injunction Movement" [19] and the motivation behind it. This movement clearly depicts labor's agitation against the ineffectiveness of the Clayton Act and the use of injunctions to halt collective bargaining. Labor sought substantial legislative relief from the courts' use of injunction against their organization, and Bernstein is effective at explaining why Congress responded with the passage of the Norris-LaGuardia Act in 1932. The Norris LaGuardia Act clarified the language of Section 20 of the Clayton Act and decreased the scope of labor activities that could be stopped by injunctions.

Supporting the argument made by Dallas L. Jones in 1957, Joseph McCartin's 1997 monograph, *Labor's Great War: The Struggle for Industrial Democracy and the Origins of Modern American Labor, 1912-1921,*[20] elucidates labor's alliance with the Wilson Administration and his vacillating support for favorable labor legislation. Wilson, as presented in the Jones' article, is portrayed as a man more concerned with his political career than with actually helping labor. McCartin adds that Wilson's uncertain support for labor stemmed from his discontent with industrial strife that adversely affect America's preparedness for World War I.[21]

So, unlike the Jones study, McCartin's depicts Wilson as not only concerned with his political position with business, but also with limiting industrial strife for America's entry into the war. Consequently, McCartin asserts that Wilson forced both business and labor leaders to compromise. While catering to both labor and business, Wilson interfered with the legislative response to labor's agitation with the application of the Sherman Act to labor. Wilson did not support full immunity of labor from the operation of the Sherman statute, and it was this belief, along with his interference, that ultimately resulted in two different Congressional interpretations of the aim of the Clayton Act. It also explains why the language of the Clayton Act was both ambiguous and weighted down with qualifiers.

The most recent scholarship on this topic is presented by George I. Lovell's 2003 book, *Legislative Deferrals; Statutory Ambiguity, Judicial Power, and American Democracy.*[22] Using the vehicle of labor legislation in the nineteenth and twentieth centuries, Lovell argues that "legislators, by enacting purposefully vague laws, consciously and cleverly transfer policy-making power to the courts."[23] Focusing primarily on his argument concerning the Clayton and Norris LaGuardia Acts, Lovell shifts the blame for the Clayton Act's ineffectiveness away from the judicial and executive branches and places it clearly on Congress. Lovell argues that legislators were often caught between "powerful constituencies with incompatible demands," and deliberately "empowered" *Lochner* era courts by enacting vague laws and thereby shifted policy-making responsibilities to the judiciary.[24] During the passage of the Clayton and Norris LaGuardia Acts, Lovell details how legislators cleverly positioned themselves for political

---

[19] Irving Bernstein, *The Lean Years: A History of the American Worker 1920-1933*, Boston: Houghton Mifflin Company, 1966: 339

[20] See McCartin.

[21] Ibid., 39.

[22] George I. Lovell, Legislative *Deferrals; Statutory Ambiguity, Judicial Power, and American Democracy,* Cambridge: Cambridge University Press, 2003.

[23] Beau Breslin, "Review of Legislative Deferrals; Statutory Ambiguity, Judicial Power, and American Democracy," *Department of Government, Skidmore College.* Vol. 13 No. 11 (2003).

[24] Lovell, xix.

capital by working on two fronts. The first front was to enact laws to satisfy constituents and the second was to avoid the political consequences of such legislation by writing the statutes in ambiguous language. This is evident in the passage of the Clayton Act which resulted in vague language which the courts easily misconstrued.

My historiographical contribution centered on what was at stake for labor during the late 19th and early 20th century. Did labor have a right to exist as what John Kenneth Galbraith called a "countervailing power," that is, an equal power to bargain with rapacious industrial giants? And, the most pertinent question was, if labor would have failed its battle for industrial equality, then what was at stake for American society as a whole?

In writing my thesis, I used the vehicle of labor unions and antitrust legislation to critically examine the legal dimensions of this question. Between 1890 and 1941, a major battle raged in the courts—the battle between *Lochner* era, judicial activists, who sided with industrial giants against labor, and judicially restrained jurists, who fought to protect labor's legal authority to bargain collectively with employers.

Frankfurter was an ardent admirer of Justice Oliver Wendell Holmes Jr. and his philosophy on the proper place of the judiciary in relation to the legislature. Holmes stated: "The Legislature has the power to decide what the policy of the law shall be, and if it has intimated its will, however indirectly, that will should be recognized and obeyed."[25] This belief in the overall, yet sometimes implicit, will of the legislature and his sympathy towards labor led to Frankfurter's elimination of decades of judge-made law and the establishment of a new doctrinal standard in *Hutcheson.* Frankfurter was accused of exaggerating the uniformity of Congress's will to exclude labor from the antitrust laws. With the passage of the Norris-LaGuardia Act, however, Congress clearly responded to the judiciary's interpretation of the Clayton Act in *Duplex*. Frankfurter argued that the overall will of Congress was to exempt labor from the purview[26] of the Sherman statute, and his majority opinion in *Hutcheson* reflected this belief.

JUDICIAL ACTIVISM VS. JUDICIAL RESTRAINT

The *Lochner* era represented a period of consistent judicial hostility towards labor. Although the *Lochner* era judicial philosophy began to form in the 1890s, the symbolic case did not arrive until 1905 with the Supreme Court decision in *Lochner v. New York*. The case involved a New York statute that limited the number of hours a baker could work each week. In 1899, Joseph Lochner, owner of Lochner's Home Bakery, was fined for violating this law. He appealed the lower court's fine, and his case went before the Supreme Court in 1905. By a narrow margin of five to four, the Supreme Court rejected the argument that the law was needed to protect the health of bakers. Justice Rufus Peckham, writing for the majority, stated that the

[25] Keifer & Keifer v. Reconstruction Finance Corp., 306 U.S. 381 (1939)
[26] "*Law.* The body, scope, or limit of a statute." Garner, Bryan A, *Black's Law Dictionary*. St. Paul: West Publication Co, 2001: 574.

New York law was an "unreasonable, unnecessary and arbitrary interference with the right to free contract."[27]

Lochner argued that the "right to free contract" was one of the fundamental rights of "substantive due process." The Fourteenth Amendment of the Constitution states "... nor shall any State deprive any person of life, liberty, or property, without due process of law."[28] Starting with the *Dred Scott v. Sandford* (1857), the Supreme Court established that the "due process clause" was not just a procedural guarantee, but a "substantive" limitation on governmental regulations over individuals and their economic interests. By the end of the nineteenth century, it had become the judiciary's version of *laissez-faire* and was indicative of the Supreme Court's hostility to pro-labor legislation. Holmes, on the other hand, wrote the dissenting opinion in which he stated that the majority was engaging in judicial "activism." Further, Holmes asserted that the case was decided not on the law, but "upon the economic theory which a large part of the country does not entertain." [29] Conservative *Lochner* era jurists established a doctrine that protected the principles of *laissez-faire* by interpreting broadly the "due process" of Section 1.

Judicial restraint is a theory of judicial interpretation which promotes the limited exercise of the judiciary when deciding cases.[30] For example, in deciding constitutional questions, judicially-restrained jurists will first look at the U.S. Constitution. When this fails to produce results, the jurists "defer" to the Framers in order to discern their intent. It is this judicial restraint (deference) that Frankfurter and Holmes employed when deciding cases. Frankfurter noted: "Courts are not representative bodies. They are not designed to be a good reflex of a democratic society."[31]

Most of Frankfurter's views on judicial restraint were derived from his close relationship to Holmes who was a U.S. Supreme Court justice and learned legal philosopher. Holmes espoused a form of judicial self-restraint in which he deferred to the explicit or implicit intent of Congress when presented with difficult cases. The *Lochner* era, however, forced Holmes to dissent in numerous cases in which he represented the minority voice surrounded by overreaching jurists. In *Weaver v. Palmer Brother* (1926), Frankfurter praised Holmes in a letter for his vigorous dissent concerning the proper application of the Fourteenth Amendment's "due process clause."

In that case, Holmes echoed his 1905 *Lochner* opinion by arguing that the Court's overturning of a Pennsylvania law prohibiting the use of unsterilized "shoddy" as filling in beds was radical, judicial activism. Holmes, with Louis Brandeis and Harlan Stone concurring, dissented:

---

[27] Paul Kens, *Lochner v. New York: Economic Regulation on Trial* Lawrence: University Press of Kansas, 1998: 18; Rudolph J.R. Peritz, *Competition Policy in America: History, Rhetoric, Law*, Oxford: Oxford University Press, 1996: 45-48.
[28] Ibid.
[29] Ibid., 171.
[31] Mark Silverstein, "Felix Frankfurter: Judicial Restraint and Individual Liberties," *The American Historical Review*, Vol. 97, No. 5. (1997): 1621-1622.
[31] Harold J. Spaeth, "The Judicial Restraint of Mr. Justice Frankfurter—Myth or Reality," *Midwest Journal of Political Science,* Vol. 8, No. 1 (1964): 24.

> If the Legislature of Pennsylvania was of opinion that disease is likely to be spread by the use of shoddy in comfortables [beds], I do not suppose that the Court would pronounce the opinion so manifestly absurd that it could not be acted upon…I think that we are pressing the Fourteenth Amendment 'too far.[32]

In both *Lochner v. New York* and *Weaver v. Palmer Brother*, Holmes deferred to the judgment of the legislatures and their determination to bar business practices that were hazardous to public health and safety.

When conservative judges interpreted the Sherman Act, they engaged in *Lochner* era activism by broadly defining the scope of the act to include labor, even though the will of Congress was to halt the rise of corporate monopolies. Judicially-restrained jurists, like Frankfurter, on the other hand, looked to the legislative histories to discern Congress's intent. This judicial deference later played a significant role on Frankfurter's conclusion in the 1941 *Hutcheson* decision.[33]

EARLY JUDICIAL UNCERTAINTY WITH THE SHERMAN ACT: THE LEGISLATIVE HISTORY OF THE SHERMAN ACT

Embodying labor's agitation in 1910, twenty years after consistent judicial misapplications of the Sherman statute, Samuel Gompers' declared angrily: "We know the Sherman law was intended by Congress to punish illegal trusts and not the labor unions, for we had various conferences with members of Congress while the Sherman Act was pending, and remember clearly that such a determination was stated again and again."[34] Gompers was right insofar as Congress's intent was to strike at the "evils of massed capital"[35] and to free competition from the anticompetitive hold of monopolies. But Congress ultimately passed legislation that the courts used to strike at the workingman.

The first debates on the Sherman Antitrust bill began on February 4, 1889. Early on, Senators included price-raising prohibitions in the original drafts of the bill. These price-raising prohibitions were measures intended to make the Sherman Act more effective against business combinations. This is significant because all of these early prohibitions also were more effective against labor and farmer organizations, and this fear permeated the minds of pro-labor Senators.[36]

When Senator John Sherman presented his bill to the Finance Committee, it was entitled, "A bill to declare unlawful trusts and combinations in restraint of trade (competition) and production."[37] Section 1 of that original bill stated explicitly that business combinations that restrained trade were illegal. On March 21, 1890, extensive debates began in the U.S. Senate.

---

[32] Robert M. Mennel and Christine L. Compston, *Holmes and Frankfurter: Their Correspondence, 1912-1934*, Hanover: University Press of New England, 1996:199.
[33] Mark Silverstein, "Felix Frankfurter: Judicial Restraint and Individual Liberties," *The American Historical Review*, Vol. 97, No. 5. (1997): 1621-1622.
[34] Samuel Gompers, "The Sherman Law. Amend It or End It," *American Federationist*. Vol. 17. No. 3 (1910): 187, 202.
[35] Berman, 7.
[36] Ibid.
[37] Ibid.

Senator Sherman delivered a forceful speech on the merits of the anti-price raising measures and its effectiveness in preventing trusts. His entire speech never mentioned any intent that his bill should reach labor unions.[38]

Senator Frank Hiscock, on the other hand, firmly believed that the bill was unconstitutional and argued that it was applicable to labor organizations. He stated "Will it be said that [labor] combinations are not made with a view of advancing costs and regulating the sale of property? Will it be argued that they do not directly do it?"[39] Many pro-labor Senators, like Hiscock, believed that a price raising prohibition made the Sherman bill applicable to labor unions. Specifically, it was the Reagan amendment, presented by Senator John Reagan, which increased the penalties of the Sherman bill and added a measure prohibiting combinations that raised prices. Senator Henry Teller offered a caveat on the proposed Reagan amendment, stating that the Farmers' Alliance would be adversely affected by it.[40]

The Farmers' Alliance was a national organization of farmers that increased the price of farm products. Under the Reagan amendment, the Farmers' Alliance would be in violation of restraint of trade when in actuality this organization was, most likely, economically beneficial. The Farmers' Alliance was instituted in response to postbellum monetary deflation and falling commodity prices. Deflation led to widespread debt among farmers, and many lost their farms because they were not able to sell their goods at high enough prices. The Farmers' Alliance was a cooperation of individual farmers who formed an agricultural cartel to eliminate middlemen and sell their merchandise at higher prices to larger commodity brokers.[41]

Senator James George informed Senator Teller that not only the Reagan amendment, but the Sherman bill as well had this same effect. Besides the Farmers' Alliance, Teller concluded that the Knights of Labor would also be within the prosecutorial reach of the Sherman bill. The Knights of Labor, Senator George observed, increased the wages of its members and this increased the price of labor and eventually employers compensated by raising prices on products. Senator Reagan, as reflected by the Congressional debates, clearly had no intention of his amendment affecting the Farmers' Alliance or the Knights of Labor and offered a proviso to exempt these organizations. "Therefore, I suggest," Reagan stated, "…by a little modification it may be possible to relieve the bill of any doubt on this point."[42] In response to Reagan's labor exemption, Senator Sherman explained the nature of his bill. He said,

> It [the Sherman bill] does not interfere in the slightest degree with voluntary associations made to affect public opinion to advance the interests of a particular trade or occupation… [such organizations] are not business combinations…And so the combinations of workingmen to promote their interests, promote their welfare, and increase their pay…are not affected in the slightest in the words or intent of the bill as now reported.[43]

---

[38] Ibid., 12.
[39] Ibid., 14.
[40] Ibid., 14; Peritz, 15.
[41] J.E. Bryan, *The Farmers' Alliance: Its Origin, Progress and Purposes*, Fayetteville: Arkansas, 1991: 157.
[42] Berman, 17.
[43] Ibid., 17; Peritz, 14.

This assurance, however, did not quell the concerns of pro-labor Senators. Senator William Stewart responded to Senator Sherman and stated that without the exemption the bill reached labor. Senator Teller agreed and argued that there was a great probability that labor and farmers' organizations faced prosecution under the Sherman bill.[44] "Strong corporations," he warned," were more likely to evade prosecution.

On the next day, March 25, 1890, the Senate debate continued along with the debate on the price raising prohibition and its effect on labor also continued. After persistent pressure from pro-labor Senators, Senator Sherman offered a labor exemption, but qualified it by stating "I do not think it necessary, but at the same time to avoid any confusion, I submit it to come in at the end of the first section."[45] By placing the labor exemption in the first section, it stressed the significance of labor immunity. Sherman's confidence that his bill immunized labor, on first glance, raises the suspicion that he intended the opposite, but when looking at the language of his original bill, it is quite clear that it targeted business monopolies. The language "restraint of competition," Senator Sherman believed, was sufficient for the courts to interpret the law to embrace businesses and not labor. The labor exemption read as follows: "It is [Provided] that this act shall not be construed to apply to any arrangements, agreements, or combinations between laborers."[46] This amendment was immediately adopted without the need for a roll call or recorded vote, illuminating the general feeling of Congress.

After the inclusion of a labor exemption, the Sherman bill was then inundated by "encumbering amendments."[47] Congress adopted amendments which placed taxes on dealing in futures, and liquor products and prohibitions on certain types of gambling. The bill became so packed with amendments that confused the language that Senator Arthur Gorman declared the bill "worse than a sham and a delusion."[48] He insisted that the amendments made the bill ineffective, echoing the concerns of a growing number of Senators.

Senator Sherman also expressed this belief and was concerned that the amendments hindered passage of his legislation, prompting Senator Joseph Hawley to suggest that the bill be sent to the Judiciary Committee, which had the power to eliminate, modify, and smooth out the language of Sherman's bill. On a vote of 29 to 24, the Senate voted against Senator Hawley's proposal. On March 27th, the Senate held a vote to consider the amendments one-by-one. When Senator Sherman's labor exemption was considered, Senator George Edmunds argued against it, stating "this [is a] matter of capital…and labor is an equation."[49] Senator Edmunds did not see labor at a disadvantage as did the pro-labor Senators and argued vigorously that labor combinations and business combinations were equals. But it was very clear to other Senators that labor and capital were not equals. Some years later, Frankfurter agreed with this reasoning and

[44] Berman, 19.
[45] Ibid, 21.
[46] Ibid., 21.
[47] Ibid., 22; Peritz, 18-21.
[48] Berman, 24.
[49] Berman, 24; Peritz 23.

insisted that "There is no greater inequality than the equal treatment of unequals."[50] Senators Sherman and Eugene Hoar argued in defense of the labor exemption.[51]

Again hoping to resolve the conflict over the encumbering amendments, including the labor exemption, the Senate voted 31 to 28 to send the bill to the Judiciary Committee. It should be noted that during that Senator Edmunds voted against this measure. This is significant because he was the chair of the Judiciary Committee, and as someone who appeared hostile to labor organizations, he did not want to send it to the Judiciary Committee where he could have manipulated the language so that the bill could be applied to labor. Evidenced in the debate was that the labor exemption debate was one of many in which he participated.

The bill was sent to the Judiciary Committee and under Edmunds' direction, the committee crafted a new bill which was similar to the one that eventually passed. The Judiciary Committee changed the title of the bill from, "A bill to declare unlawful trusts and combinations in restraint of competition and production"[52] to the more inclusive title, "A bill to protect trade and commerce against restraint and monopolies." This title was the final alteration made by Senator Edmunds who initially sought to include labor under the purview of the Sherman statute.

On April 8, 1890, the Senate took up consideration of the Judiciary Committee's substitute bill without a labor exemption attached by Senator Sherman and without the price-raising prohibition attached by Senator Reagan. Agitated by legislative delays, Senator Sherman agreed to vote for the substitute bill to move along his legislation for final passage. He declared "I shall vote for it, not as being precisely what I want, but as best under the circumstances that the Senate is prepared to give in this direction."[53] The Senate passed the substitute bill 52 to 1. Prior to passage, no debate on the labor exemption's absence from the substitute bill took place, nor did any debate occur on the absent price raising prohibition. It is possible that pro-labor Senators thought they won a victory with the elimination of Reagan's amendment, which they deemed more harmful than the Sherman bill itself.

Debate on the Judiciary Committee's substitute bill focused on the effectiveness of the Sherman statute against business combinations. When the bill was referred to the House for passage, no extensive debates occurred on its broad language and possibility of reaching labor. A conference committee worked out minor changes and the bill passed the House on June 28th. On July 2, 1890, the Sherman Antitrust bill was sign into law by President Benjamin Harrison.

Regarding Congressional intent, did the omission of a labor exemption from the final bill mean that its organizations were within its scope? It seems unlikely. During Congressional debates, every mention of labor dealt with the "price raising prohibition." Since the bill that passed the Judiciary Committee was not debated, pro-labor Senators probably thought the labor exemption unnecessary. It was the "all-inclusive" potency of the price raising prohibition that concerned pro-labor Senators. With its removal, the debates ended. None of the pro-labor Senators, including labor's most resolute ally, Senator Hoar, opposed the final passage of the

[50] Michael E. Parrish, *Felix Frankfurter and His Times: The Reform Years*, New York: The Free Press, 1982: 65.
[51] Berman, 26; Peritz 20.
[52] Berman, 11.
[53] Ibid., 29.

substitute bill in debate. They were lulled into a false sense of security with the removal of the price raising prohibition.

Moreover, even though Senator Edmunds, Chairman of the Judiciary Committee, saw labor as an equal to business, his views did not reflect the Senate as a whole. The Judiciary Committee was assigned the task of eliminating superfluous amendments and streamlining Sherman's bill. Therefore, the theory that Senator Edmund cleverly outmaneuvered his pro-labor opponents through the Judiciary Committee can not be substantiated, chiefly because he voted against sending the original to the Judiciary Committee in the first place. The best possible explanation is that confusion arose on the committee and removal of the price raising prohibitions translated in the minds of pro-labor Senators as a labor exemption.

Additional evidence of this confusion is supported by the terms "restraint of trade" and "restraint of competition."[54] Restraint of competition was directed solely at corporate combinations and anti-competitive behavior. Contrarily, restraint of trade was far more inclusive; labor and business combinations could both restraint "trade." Senators used these two terms so frequently that they became interchangeable and when restraint of trade was selected over restraint of competition it raised no concerns. The legislative history does not reflect that the Sherman statute was meant to apply to labor, but exactly the opposite from all the available evidence in the act's legislative history the Sherman statute was solely meant to apply to corporate combinations. *Lochner* era jurists, however, decided otherwise.

EARLY JUDICIAL UNCERTAINTY WITH THE SHERMAN ACT: **THE LEGISLATIVE HISTORY OF THE SHERMAN ACT**

Embodying labor's agitation in 1910, twenty years after consistent judicial misapplications of the Sherman statute, Samuel Gompers' declared angrily: "We know the Sherman law was intended by Congress to punish illegal trusts and not the labor unions, for we had various conferences with members of Congress while the Sherman Act was pending, and remember clearly that such a determination was stated again and again."[55] Gompers was right insofar as Congress's intent was to strike at the "evils of massed capital"[56] and to free competition from the anticompetitive hold of monopolies. But Congress ultimately passed legislation that the courts used to strike at the workingman.

The first debates on the Sherman Antitrust bill began on February 4, 1889. Early on, Senators included price-raising prohibitions in the original drafts of the bill. These price-raising prohibitions were measures intended to make the Sherman Act more effective against business combinations. This is significant because all of these early prohibitions also were more effective against labor and farmer organizations, and this fear permeated the minds of pro-labor Senators.[57]

---

[54] Berman, 52-53.
[55] Samuel Gompers, "The Sherman Law. Amend It or End It," *American Federationist*. Vol. 17. No. 3 (1910): 187, 202.
[56] Berman, 7.
[57] Ibid.

When Senator John Sherman presented his bill to the Finance Committee, it was entitled, "A bill to declare unlawful trusts and combinations in restraint of trade (competition) and production."[58] Section 1 of that original bill stated explicitly that business combinations that restrained trade were illegal. On March 21, 1890, extensive debates began in the U.S. Senate. Senator Sherman delivered a forceful speech on the merits of the anti-price raising measures and its effectiveness in preventing trusts. His entire speech never mentioned any intent that his bill should reach labor unions.[59]

Senator Frank Hiscock, on the other hand, firmly believed that the bill was unconstitutional and argued that it was applicable to labor organizations. He stated "Will it be said that [labor] combinations are not made with a view of advancing costs and regulating the sale of property? Will it be argued that they do not directly do it?"[60] Many pro-labor Senators, like Hiscock, believed that a price raising prohibition made the Sherman bill applicable to labor unions. Specifically, it was the Reagan amendment, presented by Senator John Reagan, which increased the penalties of the Sherman bill and added a measure prohibiting combinations that raised prices. Senator Henry Teller offered a caveat on the proposed Reagan amendment, stating that the Farmers' Alliance would be adversely affected by it.[61]

The Farmers' Alliance was a national organization of farmers that increased the price of farm products. Under the Reagan amendment, the Farmers' Alliance would be in violation of restraint of trade when in actuality this organization was, most likely, economically beneficial. The Farmers' Alliance was instituted in response to postbellum monetary deflation and falling commodity prices. Deflation led to widespread debt among farmers, and many lost their farms because they were not able to sell their goods at high enough prices. The Farmers' Alliance was a cooperation of individual farmers who formed an agricultural cartel to eliminate middlemen and sell their merchandise at higher prices to larger commodity brokers.[62]

Senator James George informed Senator Teller that not only the Reagan amendment, but the Sherman bill as well had this same effect. Besides the Farmers' Alliance, Teller concluded that the Knights of Labor would also be within the prosecutorial reach of the Sherman bill. The Knights of Labor, Senator George observed, increased the wages of its members and this increased the price of labor and eventually employers compensated by raising prices on products. Senator Reagan, as reflected by the Congressional debates, clearly had no intention of his amendment affecting the Farmers' Alliance or the Knights of Labor and offered a proviso to exempt these organizations. "Therefore, I suggest," Reagan stated, "…by a little modification it may be possible to relieve the bill of any doubt on this point."[63] In response to Reagan's labor exemption, Senator Sherman explained the nature of his bill. He said,

> It [the Sherman bill] does not interfere in the slightest degree with voluntary associations made to affect public opinion to advance the interests of a particular trade or

[58] Ibid.
[59] Ibid., 12.
[60] Ibid., 14.
[61] Ibid., 14; Peritz, 15.
[62] J.E. Bryan, *The Farmers' Alliance: Its Origin, Progress and Purposes*, Fayetteville: Arkansas, 1991: 157.
[63] Berman, 17.

> occupation… [such organizations] are not business combinations…And so the combinations of workingmen to promote their interests, promote their welfare, and increase their pay…are not affected in the slightest in the words or intent of the bill as now reported.[64]

This assurance, however, did not quell the concerns of pro-labor Senators. Senator William Stewart responded to Senator Sherman and stated that without the exemption the bill reached labor. Senator Teller agreed and argued that there was a great probability that labor and farmers' organizations faced prosecution under the Sherman bill.[65] "Strong corporations," he warned," were more likely to evade prosecution.

On the next day, March 25, 1890, the Senate debate continued along with the debate on the price raising prohibition and its effect on labor also continued. After persistent pressure from pro-labor Senators, Senator Sherman offered a labor exemption, but qualified it by stating "I do not think it necessary, but at the same time to avoid any confusion, I submit it to come in at the end of the first section."[66] By placing the labor exemption in the first section, it stressed the significance of labor immunity. Sherman's confidence that his bill immunized labor, on first glance, raises the suspicion that he intended the opposite, but when looking at the language of his original bill, it is quite clear that it targeted business monopolies. The language "restraint of competition," Senator Sherman believed, was sufficient for the courts to interpret the law to embrace businesses and not labor. The labor exemption read as follows: "It is [Provided] that this act shall not be construed to apply to any arrangements, agreements, or combinations between laborers."[67] This amendment was immediately adopted without the need for a roll call or recorded vote, illuminating the general feeling of Congress.

After the inclusion of a labor exemption, the Sherman bill was then inundated by "encumbering amendments."[68] Congress adopted amendments which placed taxes on dealing in futures, and liquor products and prohibitions on certain types of gambling. The bill became so packed with amendments that confused the language that Senator Arthur Gorman declared the bill "worse than a sham and a delusion."[69] He insisted that the amendments made the bill ineffective, echoing the concerns of a growing number of Senators.

Senator Sherman also expressed this belief and was concerned that the amendments hindered passage of his legislation, prompting Senator Joseph Hawley to suggest that the bill be sent to the Judiciary Committee, which had the power to eliminate, modify, and smooth out the language of Sherman's bill. On a vote of 29 to 24, the Senate voted against Senator Hawley's proposal. On March 27th, the Senate held a vote to consider the amendments one-by-one. When Senator Sherman's labor exemption was considered, Senator George Edmunds argued against it, stating "this [is a] matter of capital…and labor is an equation."[70] Senator Edmunds did not see labor at a disadvantage as did the pro-labor Senators and argued vigorously that labor

---

[64] Ibid., 17; Peritz, 14.
[65] Berman, 19.
[66] Ibid, 21.
[67] Ibid., 21.
[68] Ibid., 22; Peritz, 18-21.
[69] Berman, 24.
[70] Berman, 24; Peritz 23.

combinations and business combinations were equals. But it was very clear to other Senators that labor and capital were not equals. Some years later, Frankfurter agreed with this reasoning and insisted that "There is no greater inequality than the equal treatment of unequals."[71] Senators Sherman and Eugene Hoar argued in defense of the labor exemption.[72]

Again hoping to resolve the conflict over the encumbering amendments, including the labor exemption, the Senate voted 31 to 28 to send the bill to the Judiciary Committee. It should be noted that during that Senator Edmunds voted against this measure. This is significant because he was the chair of the Judiciary Committee, and as someone who appeared hostile to labor organizations, he did not want to send it to the Judiciary Committee where he could have manipulated the language so that the bill could be applied to labor. Evidenced in the debate was that the labor exemption debate was one of many in which he participated.

The bill was sent to the Judiciary Committee and under Edmunds' direction, the committee crafted a new bill which was similar to the one that eventually passed. The Judiciary Committee changed the title of the bill from, "A bill to declare unlawful trusts and combinations in restraint of competition and production"[73] to the more inclusive title, "A bill to protect trade and commerce against restraint and monopolies." This title was the final alteration made by Senator Edmunds who initially sought to include labor under the purview of the Sherman statute.

On April 8, 1890, the Senate took up consideration of the Judiciary Committee's substitute bill without a labor exemption attached by Senator Sherman and without the price-raising prohibition attached by Senator Reagan. Agitated by legislative delays, Senator Sherman agreed to vote for the substitute bill to move along his legislation for final passage. He declared "I shall vote for it, not as being precisely what I want, but as best under the circumstances that the Senate is prepared to give in this direction."[74] The Senate passed the substitute bill 52 to 1. Prior to passage, no debate on the labor exemption's absence from the substitute bill took place, nor did any debate occur on the absent price raising prohibition. It is possible that pro-labor Senators thought they won a victory with the elimination of Reagan's amendment, which they deemed more harmful than the Sherman bill itself.

Debate on the Judiciary Committee's substitute bill focused on the effectiveness of the Sherman statute against business combinations. When the bill was referred to the House for passage, no extensive debates occurred on its broad language and possibility of reaching labor. A conference committee worked out minor changes and the bill passed the House on June 28th. On July 2, 1890, the Sherman Antitrust bill was sign into law by President Benjamin Harrison.

Regarding Congressional intent, did the omission of a labor exemption from the final bill mean that its organizations were within its scope? It seems unlikely. During Congressional debates, every mention of labor dealt with the "price raising prohibition." Since the bill that passed the Judiciary Committee was not debated, pro-labor Senators probably thought the labor exemption unnecessary. It was the "all-inclusive" potency of the price raising prohibition that

---

[71] Michael E. Parrish, *Felix Frankfurter and His Times: The Reform Years*, New York: The Free Press, 1982: 65.
[72] Berman, 26; Peritz 20.
[73] Berman, 11.
[74] Ibid., 29.

concerned pro-labor Senators. With its removal, the debates ended. None of the pro-labor Senators, including labor's most resolute ally, Senator Hoar, opposed the final passage of the substitute bill in debate. They were lulled into a false sense of security with the removal of the price raising prohibition.

Moreover, even though Senator Edmunds, Chairman of the Judiciary Committee, saw labor as an equal to business, his views did not reflect the Senate as a whole. The Judiciary Committee was assigned the task of eliminating superfluous amendments and streamlining Sherman's bill. Therefore, the theory that Senator Edmund cleverly outmaneuvered his pro-labor opponents through the Judiciary Committee can not be substantiated, chiefly because he voted against sending the original to the Judiciary Committee in the first place. The best possible explanation is that confusion arose on the committee and removal of the price raising prohibitions translated in the minds of pro-labor Senators as a labor exemption.

Additional evidence of this confusion is supported by the terms "restraint of trade" and "restraint of competition."[75] Restraint of competition was directed solely at corporate combinations and anti-competitive behavior. Contrarily, restraint of trade was far more inclusive; labor and business combinations could both restraint "trade." Senators used these two terms so frequently that they became interchangeable and when restraint of trade was selected over restraint of competition it raised no concerns. The legislative history does not reflect that the Sherman statute was meant to apply to labor, but exactly the opposite from all the available evidence in the act's legislative history the Sherman statute was solely meant to apply to corporate combinations. *Lochner* era jurists, however, decided otherwise.

THE SHERMAN ACT

The 1890 Sherman Antitrust Act's initial legal application was solely confined to corporate monopolies. Consistently, however, beginning in 1893, judges gave legal sanction for its use against labor unions. The law itself, when read broadly, did allow for such prosecutorial measures, despite the Congressional intent that it only applied to business combinations.
Section 1 of the Sherman Act states:

> Every contract, combination in the form of trust or otherwise, or conspiracy, in restraint of trade or commerce among the several States, or with foreign nations, is hereby declared to be illegal.

Section 2 states:

> Every person who shall monopolize, or attempt to monopolize, or combine or conspire with any other person or persons, to monopolize any part of the trade or commerce among the several States, or with foreign nations, shall be deemed guilty of a misdemeanor.[76]

This legal language is broad insofar as it does not exclusively apply to "corporate" monopolies, but to any organization that "monopolized" to restrain commerce, and this reading of the

[75] Berman, 52-53.
[76] See Berman.

Sherman Act led to numerous cases against organized labor. Labor unions, on the other hand, protested vociferously stating that their organizations were not in the purview of the antitrust statute, and the original purpose of the legislation was to curtail the predatory practices of corporate monopolies.[77]

When found guilty of the Sherman Act, the courts could apply three penalties: (1) criminal prosecution, leading to incarceration, (2) injunctive relief sought by the government, and (3) punitive damages, granted by the courts. In the early Sherman cases, labor was subjected to all of these weapons. When the 1914 Clayton Act allowed for injunctive relief to be sought by "private parties," it became the primary weapon in an employer's arsenal to disrupt and preempt labor strikes.[78]

Conservative Attorney General Richard Olney dubbed the Sherman statute "an experimental piece of legislation,"[79] and rightly so. In 1892, the draymen's union in New Orleans which was affiliated with Workingmen's Amalgamated Council, a larger labor organization, went on strike. Soon after, numerous other unions went on strike in sympathetic strikes intended to aid the draymen. Consequently, these strikes had a crippling effect on the business of the city and its transportation of goods. The strikes were so pervasive, city official stated, that interstate and foreign commerce was "totally interrupted."[80] In response, federal attorneys brought suit for an injunction, charging that the strikers were violating the Sherman Act. The U.S. attorneys asserted that the striking unions represented "a gigantic and widespread combination of the members of a multitude of separate organizations for the purpose of restraining the commerce among the several states and with foreign countries."[81]

On March 25, 1893, the federal Circuit Court for the Eastern District of Louisiana rendered its decision in *U.S. v. Workingmen's Amalgamated Council*. Judge Edward Coke Billings' opinion, said:

> I think the Congressional debates show that the statute had its origin in the evils of massed capital; but, when the Congress came to formulating the prohibition, which is the yardstick for measuring the complainant's right to the injunction, it expressed it in these words: "Every contract or combination in the form of trust, or otherwise in restraint of trade or commerce among the several states or with foreign nations, is hereby declared to be illegal."[82]

The union argued that it was not in the purview of the Sherman statute, but Judge Billings thought otherwise. He further stated that the legislators "made the interdiction [prohibition] include combinations of labor as well as of capital."[83] Judge Billings granted an injunction

---

[77] Ibid.
[78] Section 20 of the Clayton Act permitted the issuance of injunctions to prevent "injury to property, or to a property right," that is, private property, Berman, 100; Jones, 207; Bernstein, 395.
[79] David Ray Papke, *The Pullman Case: The Clash of Labor and Capital in Industrial America,* Lawrence: University of Kansas Press: 1999: 72.
[80] *US v Workingmen's Amalgamated Council*, 54 Fed. 994 (1893); Berman, 61.
[81] Berman, 61.
[82] *US v Workingmen's Amalgamated Council;* Berman, 61, 63.
[83] Ibid, 63.

against the labor unions and their activities were immediately stopped. With all the talk of equal distribution of the Sherman statute to labor and business combinations, Judge Billings, a month earlier, had refused to issue an injunction against a business combination. Under the rules of jurisprudence, the *U.S. v. Workingmen's Amalgamated* decision became precedent for subsequent Sherman Act labor cases.[84]

In *U.S. v. Patterson* (1893), the government sued Massachusetts cash register manufacturers for violating the Sherman Act. The government charged that the cash register manufacturers were a combination that monopolized trade and used "violence, annoyance, and intimidation" to force out competitors.[85] The question that was presented before the Massachusetts court was whether the provisions of the Sherman Act extended to all interference with interstate trade or did an actual measurable monopoly have to exist? Elihu Root, an attorney representing the government, declared that the term "restrain of trade" referred to interference with commerce and that the government's position was that the Sherman statute was applicable to all combinations that "restrained trade."[86]

The Circuit Court of Massachusetts took a different view, stating that the Sherman statute, when taken as a whole, applied solely to business monopolies. The court stated that "monopolies" and "attempts to monopolize"[87] must be taken in conjunction with "restraint of trade," thereby limiting the law's scope. If subsequent courts had accepted this interpretation, then labor unions would have been excluded from the antitrust law. Instead of following the precedent established in the *Patterson* case, it was *U.S. v. Workingmen's Amalgamated Council* (1893) that set the legal standard for review. The previous cases are significant because they show two intermediate courts that arrived at entirely different decisions when interpreting the scope of the Sherman statute, and this judicial uncertainty spread.

THE INJUNCTION AT PULLMAN

This judicial uncertainty, however, started to fade when the most potent use of an injunction occurred in 1894 with the Pullman Strike. When Pullman Palace Car Company owner George Pullman reduced wages without an equivalent decrease in rent and other expenses in his company town, his employees initiated efforts to force Pullman to agree to arbitration. Pullman's era was marked by significant railway expansion, a product of an industrializing economy. By 1860 alone, the nation had thirty-one thousand miles of track, which were heavily subsidized by the U.S. government. In negotiations with Thomas Heathcoate, head of the workers' grievances committee, Pullman stated that rent prices had nothing to do with wages. Pullman argued that rents were determined by supply and demand and adamantly refused to a decrease.[88]

Pullman's employees were unable to distinguish from Pullman the employer and Pullman the landlord. Pullman's employees lived in the Pullman company town in which he provided the housing and other services. Although workers could have moved into non-company housing,

---

[84] Ibid.
[85] *US v. Patterson*, 150 US 65 (1893); Berman, 60-61.
[86] Ibid., 61.
[87] Ibid..
[88] Papke, 101; Berman, 64-65; Walter Licht, *Industrializing America: The Nineteenth Century*, Baltimore: The John Hopkins University Press, 1995: 171.

promotions and employment security were made contingent on whether a worker lived in company housing.[89] After Heathcoate's meeting with Pullman and his vice-president, several members of the workers grievance committee were dismissed from their jobs. Although Pullman stated that dismissals were not done in retaliation, Pullman employees were angry over the terminations. In March 1894, Pullman workers joined the American Railway Union headed by Eugene Debs. The union had gained tremendous popularity after its labor victory over the Great Northern Railroad in 1886. In May of 1894, as a result of failed negotiation and company retaliation, approximately three to four thousand Pullman workers went on strike.[90]

When the American Railway Union held its annual meeting in Chicago, from June 9th to June 26th, it attempted to force the Pullman Company to agree to arbitration.[91] Immediately after, plans went underway to carry out a secondary boycott. Debs was cautious and shied away from calling for a secondary boycott because of its national effects and negative impact on other businesses. He stated he did not "really like the term 'boycott.' [secondary boycott]…There is a deep-seated hostility in the country to the term boycott."[92] Instead of pursuing a boycott, the strikers, long with Debs, tried one last time to get Pullman to agree to arbitration.[93] These efforts failed and on June 22, 1894, six weeks after the start of the Pullman strike, the American Railway Union unanimously agreed to call for a secondary boycott. As Debs had feared, the public and press did not respond well to the secondary boycott. The *Daily Inter Ocean*, a major publication in Chicago, charged that "The railroad strike now on is one of the most foolish and inequitous [sic] ever ordered in this country…It is arbitrary, arrogant, and without a shadow of justification," but it was effective.[94]

Crucial in facilitating the secondary boycott were the switchmen who had joined the American Railway Union in large numbers. Loyal switchmen, Debs believed, would refuse to handle Pullman cars or place them on tracks. When loyal switchmen were fired for participating in the secondary boycott, their fellow workers walked out in solidarity, and this paralyzed more railroad companies. As Debs anticipated, the secondary boycott began slowly but soon progressed rapidly. By June 27th, fifteen railroads were stopped when five thousand workers went on strike. By June 28th, all the rail lines west of Chicago were frozen when forty thousand workers left their jobs. One day later, over one hundred thousand railway workers went on strike and almost twenty railroads were completely stopped.[95]

Debs, ultimately shocked by the effectiveness of the boycott, sent telegram after telegram urging local unions to avoid violence. Also, he declared that no trains should be stopped and reminded boycotters that the Pullman Company was the sole target and not all railroads. The press started to call it the "Debs Rebellion"[96] and hostility grew rapidly. To counter the boycott, the General Managers' Association, an organization of twenty-four railroads with and combined

---

[89] Papke, 26.
[90] Ibid., 26, Berman, 64.
[91] Papke, 27; Berman, 64.
[92] Papke, 24.
[93] Ibid.
[94] Ibid., 25.
[95] Ibid., 26; John Berwick Taylor, "The Politics of the Labor Injunction," (Ph.D. diss., Princeton University, 1972), 44-45.
[96] Papke, 27.

assets of over $818 million, 41, 000 miles of track and 221,000 employees, sought judicial relief.[97] Along with seeking legal assistance, the General Managers' Association recruited about twenty thousand strikebreakers, derogatorily called scabs. Industry-wide unionism had to be stopped. In further efforts to disrupt the strike, the general managers' intentionally attached Pullman cars to mail trains, thus disrupting train schedules. The general managers' plan was to gain as much public and governmental support as possible to fight the American Railway Union.

Their efforts were also helped by the spread of wildcat strikes (unauthorized strikes) and increasing violence.[98] Debs had the multiple tasks of trying to control 150,000 members of the American Railway Union, preventing violence, and halting wildcat strikes. All of this led to a severe disruption in the U.S. Postal Service. After some debate in his Cabinet, President Grover Cleveland decided to commit troops over the protest of General Nelson A. Miles, who was ordered to carry it out. Cleveland forcefully stated, responding to Miles' protest, that "If it takes every dollar in the Treasury and every soldier in the United States Army to deliver a postal card in Chicago [the primary hub for the strike], that postal card shall be delivered."[99] Central to committing federal troops was the legal authority to do so. Attorney General Richard Olney was given the responsibility to determine legality. Olney was no friend of labor and agreed to his appointment in Cleveland's cabinet on the condition that he be allowed to continue private practice providing legal assistance to railroads. While in private practice, Olney's legal expertise was essential in coordinating railroad mergers, consolidation, and management issues. While serving as Attorney General, Olney continued to receive substantial retainers from railroads.[100]

Olney petitioned for an injunction in United States Circuit Court of Chicago, a court in the federal system until 1911. To thoroughly understand the significance of the injunction, four scholars explain it well: John Berwick Taylor, David Ray Papke, Felix Frankfurter, and Nathan Greene. American jurisprudence draws heavily on English law.[101] Since the start of the Republic, state and federal judges heard petitions and occasionally granted injunctions. *Black's Law Dictionary* defines an injunction as "a court order commanding or preventing an action." Injunctions are not final decisions and are usually interlocutory (temporary).[102] Injunctions are subject to the "irreparable-injury rule," which as defined in *Black's Law Dictionary*, is "the principle that equitable relief [such as an injunction] is available only when no adequate legal remedy exists."[103] This is what Frankfurter called an "extraordinary legal tool."[104] For example, *Black's Law* states "a judge may enjoin [stop] a person from dumping waste into a pond until ownership of the pond is determined."[105] This would be the typical use of an injunction which constitutes the need for an immediate legal remedy.

---

[97] Ibid., 27.
[98] Licht, 173; Papke, 26-27; Berman, 26.
[99] Papke, 30.
[100] Ibid., 30.
[101] Taylor, 42; Papke, 39; Bernstein, 195.
[102] Bryan A. Garner, *Black's Law Dictionary*, St. Paul: West Publication Co, 2001: 349; Bernstein, 195; Frankfurter and Greene, 50, 80, 81.
[103] Garner, 372.
[104] Frankfurter, The Labor Injunction, 50, 80, 81; Bernstein, 195.
[105] Garner, 372.

Judges, while sitting in "equity jurisdiction," hear injunction requests. Article III of the United States Constitution gives federal courts the authority to hear cases in "law and equity." [106] Using this authority, the federal court in Chicago granted an injunction against Debs and his colleagues from engaging in strike and boycott activities. On June 2, 1894, federal judges Peter S. Grosscup and William A. Woods granted one of the most sweeping injunctions on record. Chiefly responsible for this successful petition was Attorney General Richard Olney, his assistant Edwin Walker, and the U.S. Attorney for Chicago, Thomas M. Milchrist. Judges Grosscup and Woods were *Lochner* era conservatives in the truest sense. Grosscup's brother was a lawyer for the Northern Pacific Railroad and Grosscup was on record as being hostile to labor

In a Declaration Day address, Grosscup declared that the American worker "has effectively sunk his will into the general will of his trade and has cast away for organization all the advantages and aspirations of independent individuality."[107] Grosscup made sure, however, to acknowledge that he was speaking as a private citizen and not a jurist. But as a private citizen or jurist, his hostility toward labor was made clear.

The Chicago federal court issued ordered the unionists to absolutely refrain from the following:

> in any way or manner interfering with, hindering, obstructing, or stopping any of the business of the railroads, or any trains carrying United States mails or engaged in interstate commerce; from interfering with or injuring the property of said railroads; from trespassing on such property for the purposes of said obstructions; from injuring, signals, switches, etc; from compelling or inducing or attempting to compel or induce, by threats, intimidation, persuasion, force or violence, any of the employees of any of the said railway companies to refuse or fail to perform any of their duties as employees in carrying mail or in interstate commerce.[108]

Put simply, this injunction ended the strike and the secondary boycott. It stopped union officials from convincing train workers to leave work and enjoined the physical abuse of "scabs" who worked for the railroads. The injunction was so expansive in scope, that even conservative members of the bar questioned its appropriateness. Charles Chaflin Allen, for example, a member of the then conservative American Bar Association, challenged the language of the injunction, specially the phrase "ten thousand strikers and all the [the entire] world besides."[109] The press also noted its expansiveness; the *Chicago Tribune* observed that on the day the injunction was issued it was "so broad and sweeping that interference with the railroads, even of the remotest kind, will be made practically impossible."[110]

With the injunction freshly in hand, General Nelson Miles, acting begrudgingly under the orders of President Cleveland, interrupted the strike in Chicago and around the country with two thousand U.S. troops along with hundreds of U.S. marshals. The troops were ordered primarily on the basis that the strikers interfered with the U.S. mail. But Debs did not blame the army for the break up of the Pullman strike. The Pullman strike, Debs declared, "was broken up by the

---

[106] Papke, 39; Bernstein, 195.
[107] Papke, 41.
[108] Berman, 66; Papke, 41.
[109] Ibid.
[110] Papke, 42.

Federal courts of the United States, and not by the Army, and not by any other power, but simply and solely by the actions of the United States courts…"[111] Noting the injunction, Debs sought the legal counsel of William E. Erwin, a staunchly pro-labor lawyer. Erwin informed Debs that he should carry on attempting to restrain the violence.[112]

With the government's success in Pullman, federal attorneys in districts throughout the West and Central United States obtained similar injunctions. Federal attorneys in virtually all the cases, including Pullman, used the Sherman statute as applicable law. The U.S. attorneys, along with seeking injunctions in equity jurisdiction, charged strikers with restraint trade and interfering with interstate commerce in violation of the Sherman statute. This allowed the courts to apply more legal remedies against the violating parties. Judge Woods even went so far as to state that the terms of the Sherman statute not only applies to railroad strikes, in which strikers directly interfered with interstate commerce, but Congress had intended the statute to be applied broadly against other labor activities.[113]

Two weeks after the enjoinment of the Pullman strike, Debs and his union vice president, George W. Howard, were charged with violating the injunction. Federal Judge William H. Seaman heard the government's argument. U.S. attorney for Chicago, Milchrist and an attorney working on behalf of the General Managers' Association, charged that Debs and his vice president were inciting others to resist the court's injunction and continue the strike.[114] The government provided telegrams sent by Debs to local union leaders. In abundance the telegrams appeared harmless, but when selectively chosen, they portrayed Debs as a forceful figure calling for more strikes and resistance against federal troops. For example, a telegram from Debs sent to O. L. Vincent, a strike organizer in Clinton, Iowa, declared "Don't get scared by troops or otherwise. Stand pat."[115] Further, historian David Papke suggests that since the telegrams were non-violent and gave no direct instructions to disrupt the rail lines, than saying that Deb's telegrams violated the injunction was a stretch.[116]

After federal attorneys read the most incriminating telegrams, Judge Seaman ordered the temporary incarceration of Debs and the other defendants. Seaman also set a three thousand dollar bail until a hearing on July 23rd. While in prison, Debs sought additional legal counsel from Clarence Darrow and Stephen S. Gregory, both pro-labor Chicago lawyers. After hearings, Debs' case came before federal Chicago U.S. Circuit Court Judge Woods in September.[117] Following three months of arguments, Woods found Debs and the other union officials in contempt. In his lengthy opinion, Woods acknowledged labor's right to a "peaceful" strike. "The right of men to strike peaceably, and the right to advise a peaceable strike, which the law does not presume impossible, is not questioned,"[118] Woods asserted. But to enter into an unlawful conspiracy and to engage in a violent strike and to restrain trade, Woods stated was unjustifiable. In his opinion, "whatever the facts might have been proved…to be, [they] could furnish neither justification nor palliation for giving up a city to disorder and for paralyzing the industries and

[111] Taylor, 42.
[112] Papke, 42.
[113] Ibid., 50.
[114] Ibid., 44, 101.
[115] Ibid., 43.
[116] Ibid.
[117] Ibid., 49-50.
[118] Ibid., 49.

'commerce' of the country."[119] In this statement, Woods was directly addressing the authorized and unauthorized secondary boycotts that occurred during the Pullman strike.

Further in his opinion, Woods discussed the court's jurisdiction, specially pointing to the Sherman statute. Disregarding the original intent of Congress, Woods thought that in the time since its passage, the scope of the Sherman statute had broadened sufficiently to embrace labor. Since switchmen, who were affiliated with the American Railway Union, refused to move Pullman cars and therefore interfered with interstate commerce, the Chicago court, so Woods reasoned, had proper authority under the provisions of the Sherman Act to cite Debs and the other unionists with contempt of a court-ordered injunction. On December 14, 1894, Debs was sentenced to six months and the other unionists received three months. In *In re Debs*,[120] the case that was later appealed; the Supreme Court did not directly address the applicability of the Sherman statute to labor, but on the safe constitutional ground of the federal courts' "equity jurisdiction."[121]

Darrow and Gregory appealed the lower courts' ruling in the Debs case and challenged the court's authority to issue an injunction. *In re Debs* was argued before the Supreme Court on March 25, 1895. In their briefs, both Darrow and Gregory noted that the Debs' telegrams did not incite or in any way advocate violence.[122] Darrow stated that Judge Woods' reliance on the Sherman statute was improper and that Congress intended it to strike at the abuses of corporate combinations. Although strikes had increased in frequency and magnitude as trusts and corporations had grown, Darrow strongly believed that the law was meant to strike "against capital."[123] The injunction, Darrow and Gregory insisted, was so expansive as to not just enjoin the Pullman strikers, but the right to strike itself. Gregory wrote in his brief, "This injunction was aimed at a strike; these men [Debs, et al.] were imprisoned because they were leaders in a strike."[124]

The labor lawyers were opposed by Attorney General Richard Olney, a social Darwinist who demonstrated little sympathy for labor. Olney's co-counsel was Assistant Attorney General Edward B. Whitney, a junior member of the Justice Department. In presenting the government's argument before the Supreme Court, Olney wanted to emphasize equity jurisdiction and escape the legal quandary of the Sherman statute. He believed that Judge Woods' reliance on the Sherman Act was shaky and believed that the case had been "decided rightly enough but upon the wrong [legal] ground."[125] Although he did not inform Whitney not to rely on the Sherman statute, Olney did stress that it was best to focus on the general equity jurisdiction of federal courts. Olney saw the Sherman statute as a legal window that the defense could exploit to show the Chicago court improperly applied the law.[126]

Whitney's brief was based on procedural questions concerning Debs' writ of habeas corpus. Also, Walker, Olney's assistant, wrote a brief for the government that upheld the federal

---

[119] Ibid.
[120] *In re*, according to *Black's Law*, is defined as "in the matter or case of; in regard to."
[121] Papke, 42; Bernstein, 195; Frankfurter and Greene, The Labor Injunction, 50, 80, 81.
[122] Papke, 60.
[123] Ibid., 65.
[124] Ibid.
[125] Ibid., 72.
[126] Papke, 72.

court's right to issue injunctions under equity jurisdiction. Walker wrote that the Interstate Commerce Act of 1887 provided sufficient legal authority for the court's injunction. Addressing other sensitive topics, Walker pointed out that the U.S. mail had been obstructed by the pervasive and negligent nature of the strike. He stated that the government was well within its authority to ensure the unobstructed transportation of the mail and the officers of the United States government were charged with this task.

To rebut Gregory's claim that the injunction targeted labor, Walker pointed out that the matter of Debs was a civil and not criminal case. "It [the injunction]," Walker insisted, "does not forbid a peaceful strike, nor does it forbid the exercise of all one's power to induce others, for lawful purposes, to institute a peaceful strike."[127] Walker went on, "The only persuasion specifically enjoined is persuasion of employees remaining in their employment not to do their duty."[128] In sum, Walker's position and therefore the government's position was that federal courts had the authority to prevent obstruction of the railroads and to stop interference with mail delivery. Federal courts, Olney and Walker believed, had the power under equity jurisdiction to "enjoin this menace,"[129] referring to the Pullman strike in general.

On March 25 and 26, 1895, the Supreme Court heard oral arguments from both Debs' attorneys and the government. In arguing against the government's jurisdictional claims, Gregory authoritatively stated that there was none and stressed the liberty of American citizens. He also mentioned that the government's use of the Sherman statute was inappropriate, noting that attempting to do so was equivalent to "judicial strabism."[130] When Olney responded to the defense, he stated that the single question before the Supreme Court was whether the lower federal court had jurisdiction to issue an injunction. In his argument, he focused little on the details of the strike or the Sherman statute, which he deemed "an experimental piece of legislation."[131]

Focusing primarily on "interstate commerce," Olney argued that trains and railroads have been recognized by federal legislation, the Interstate Commerce Act, as essential elements to commerce. This was being obstructed, and the government was allowed to act. With Olney's avoidance of the Sherman statute noted, Darrow criticized the government for abandoning its position on that statute. Darrow also criticized the government for the use of the Interstate Commerce Act, which according to Darrow, was railroad regulation and deemed it irrelevant to the state's jurisdictional argument.

On May 27, 1895, the Supreme Court issued its unanimous opinion in which it sided with the government. Although Debs' lawyers were passionate and moving in their pro-labor rhetoric, they did not rebut the government's argument of equity jurisdiction. Justice David Brewer wrote the majority opinion. He addressed the two most important questions of the case. The first was whether the federal government had the authority to prevent interruptions of interstate commerce

[127] Ibid., 69.
[128] Ibid..
[129] Ibid..
[130] Taylor, 45; Papke, 71.
[131] Ibid., 72.

and the transportation of mail.[132] The second concerned the authority of the federal courts to issue an injunction through its equity jurisdiction in support of efforts to protect interstate commerce and the mail delivery. The answer to both questions was yes according to the court.[133]

Brewer was convinced that the U.S. Constitution gave Congress authority to regulate interstate commerce and mails and to prevent any obstructions. He stressed that the Congress passed legislation suited to this task and that the federal court in Chicago was actually within its constitutional authority. "The strong arm of the national government may be put forth to brush away obstructions to the freedom of interstate commerce or the transportation of the mails,"[134] Brewer stated. Brewer's "strong arm" involved the right of the court to grant authority for the use of force in preventing these obstructions.

As for the second question, Brewer unequivocally wrote that the Chicago court was well within its authority to issue and injunction under equity jurisdiction. Brewer wrote:

> Grant that any public nuisance may be forcibly abated either at the instance of the authorities, or by any individual suffering private damage therefrom, the existence of this right of forcible abatement is not inconsistent with nor does it destroy the right if appeal in an orderly way to the courts for judicial determination, and an exercise of their power to writ of injunction and otherwise accomplish the same results.[135]

Put in simple terms, the federal government and the courts had the authority to grant injunctions under the Constitution.

Brewer did not consider the Sherman statute in his opinion. However, he did note that the court's failure to address the issue should not be taken as a dissent from the lower court's ruling concerning the scope of the Sherman statute. Instead, Brewer stated that the court chose to make an adjudication based on the broader ground of jurisdiction.[136] Despite Brewer's "clarification," it was evident that the Court eventually avoided addressing the complex and maybe even improper application of the Sherman statute and its use against labor. Numerous comments were made about the decision, but the most striking come from Debs himself. He declared that "both decisions are absolutely in the interest of corporations, syndicates, and trusts which dominate every department of the Federal Government, including the Supreme Court."[137] Debs continued by insisting that "Every Federal Judge is now made a Czar,"[138] and this was not too far from the truth with the eventual rise of what Frankfurter called "Injunction Judges."[139]

This case was significant because it not only involved the use of an injunction, but also because the injunction issue became a focus of much public attention. It illustrated how the court was hesitant to address the Sherman statute and in essence highlighted the questionable application of the law against labor unions. Although he approved of the outcome, Olney thought

---

[132] Papke, 72-73.
[133] Ibid..
[134] *In re Debs*, 158 U.S. 564 (1895)
[135] Ibid; Berman, 69-70; Papke, 76-77.
[136] *In re Debs*, 158 U.S. 564 (1895); Papke, 76-77.
[137] Berman, 70.
[138] Papke, 77.
[139] Frankfurter and Greene, *The Labor Injunction*, 0, 80, 81; Bernstein, 195.

that the Pullman injunction was granted initially at this district court level upon the wrong legal ground. This ambiguous "legal ground" forced the Supreme Court to interpret the scope of the Sherman statute, and its proper application.

THE ERDMAN ACT AND YELLOW-DOG CONTRACTS

After the very contentious Pullman strike, Congress passed the Erdman Act in 1898 with the objective of improving arbitration in railroad labor disputes. Attorney General Richard Olney presented a draft of the Erdman Act for consideration in Congress in 1895. Olney devised the bill at the request of Representative Lawrence E. McGann, chair of the House Labor Committee and United States Strike Commissioners, Carroll D. Wright and John D. Kernan.[140] Representative Constantine Erdman was the author of the first House committee's report on the bill, but did not play a substantial role in its development. The most important provision of the bill was Section 10, which made it illegal for an employer to require employees to sign "yellow-dog" contracts. The statute defined a "yellow-dog" contract as: "an agreement, either written or verbal, not to become a member of any labor corporation, association or organization."[141] There also was an anti-blacklisting provision which made it an offense to "conspire to prevent an employee from obtaining employment after the employee quit or was fired."[142]

The Erdman Act was also relevant because in *Hitchman Coal and Coke v. Mitchell* (1917), nine years after it was declared unconstitutional in *Adair v. U.S.* (1908), the Supreme Court ruled that federal courts could issue injunctions to prevent labor organizations from unionizing workers who had signed yellow-dog contracts.[143] This again was indicative of a *Lochner* era judiciary determined to expand the scope of labor activities that could be enjoined by injunctions. In *Hitchman*, the yellow-dog contract was transformed from what Lovell calls a "mostly symbolic" tool used to intimidate employees into a potent weapon against unionization.

The legislative history of the Erdman Act provides significant insight on this issue. Under the recommendation of the United States Strike Commission, Attorney General Olney drafted the original bill for consideration by Congress. Aside from the primary purpose of the bill, which was to improve arbitration in labor railroad disputes, the United States Strike Commission pushed for provisions prohibiting yellow-dog contracts and blacklisting. Surprisingly, however, during floor debates on the provisions of the Erdman Act, Section 10 was only mentioned twice, an indication that Congress attached very little importance to the effectiveness of Section 10 and its ability to withstand hostile judicial review, later substantiated by *Adair*.[144]

The first mention of Section 10 occurred when Representative J.H. Lewis voiced his support for the bill as a whole because of the prohibitions on yellow-dog contracts and blacklisting. Lewis was less confident about the arbitration sections which he deemed a "trap," but supported the bill because of Section 10.

---

[140] Lovell, 72; Frankfurter and Greene, The Labor Injunction, 147.
[141] Ibid., 74.
[142] Ibid., 74.
[143] Ibid., 79; Bernstein, 196-200.
[144] Lovell, 78.

> I have very little hope and less confidence that the arbitration feature of this bill will prove an advantage to anybody. But I have some hope of much reliance on the features of this bill which prevents corporations and employers from discharging or blacklisting their employees because they may be members of labor organizations. This provision may be effective. Therefore my support of this bill is rather in the line of the Merchant of Venice: 'I do a little wrong that I may do a great good.'[145]

When Lewis voiced his doubts about the arbitration sections of the bill he was not only echoing the concerns for other Congressmen, but of labor as well. After an extensive review of the legislation, Samuel Gompers came out against it. As president of the AFL, Gompers was concerned about Section 3, which gave the courts authority to issue injunctions to enforce arbitration agreements, and Section 7, which required workers to give thirty days notice before quitting after arbitration.[146]

The use of injunctions was also one sided. When Senator James C. George attempted to include an amendment that equalized the use of injunctions, it was swiftly defeated. The George amendment banned the right of the court to issue an injunction when employers, like the Pullman Company, refused to agree to arbitration prior to a strike. This was a reasonable amendment that reined in the judiciary's one-sided abuse of the injunction.[147] With Section 3 and 7 present in the bill, Gompers staunchly rejected the bill's passage. In a February 1897 article in the *American Federationist*, Gompers stated:

> The Erdman Arbitration bill, so called, is a piece of legislation destructive of the best interest of labor, ruinous to the liberties of our people, a step in the direction for the creation of an autocracy or an empire on the one side and a class of slaves or serfs on the other…We therefore urge…the defeat of this iniquitous bill by every means at the command of our people…[148]

When legislators offered AFL-affiliated unions immunity from the hostile sections of the bill, the AFL no longer spoke out against its passage. In particular, the seamen and the street railway workers were excluded from the operation of Section 3 and 7.

Congress also agreed to remove a section from Olney's original bill that gave the Attorney General the authority to request injunctions in railroad strikes. Olney, noting the experimental use of the Sherman statute in the Pullman strike, wanted a more reliable legislative tool.[149] Congress, however, thought this gave too much authority to the Attorney General and quickly removed the provision. After an internal fight, and with the removal of Olney's provision and immunity status for AFL-affiliated unions, the AFL decided not to publicly object to the final passage of the Erdman Act. The AFL did not give the bill its approval, but it did allow the bill to pass without another harsh editorial like Gompers' 1897 one in the *American Federationist*.

---

[145] Ibid., 79.
[146] Lovell, 89.
[147] Ibid.
[148] Ibid.
[149] Ibid., 88.

The only other mention of Section 10 during debates came from Senator Richard Allen. Allen insisted because of the difficulty with proving the existence of the "blacklist" it made Section 10 somewhat ineffective. Besides these two, no members of Congress ever brought Section 10 up for discussion or debate again.[150]

This attitude was also reflected by powerful labor organizations such as the AFL. Gompers received a detailed critique of the Erdman Act from labor lawyers who reviewed the bill at his request in 1887. The two lawyers wrote that Section 10 was of no "considerable importance," and that similar state level statutes failed because the "offenses" were of a "covert nature."[151] The intent of Congress to outlaw yellow-dog contracts in Section 10 of the Erdman Act remains somewhat of a mystery. Two explanations arise from reviewing the legislative history. The first is that Congress thought that Section 10 did not merit sufficient debate because it was clear that they had the constitutional authority to prohibit such practices.[152] The courts made their opinion clear in terms of state level legislation regulating economic matters in the private sphere. Under that interpretation, the Fourteenth Amendment only placed bans on state level interference in the economy. The second explanation involves the peripheral nature of Section 10. The primary purpose of the bill was to improve arbitration in wake of the disastrous Pullman strike and not to outlaw yellow-dog contracts or blacklisting.

Given this little Congressional attention, the Erdman Act did ultimately not withstand judicial review and was declared unconstitutional in *Adair v. U.S.* That particular case will be discussed in detail in the next section along with the Danbury Hatters' case, in which the Supreme Court officially included labor in the purview of the Sherman statute. Those two cases demonstrated a clear judicial hostility toward labor and also show how *Lochner* era jurists opted to disregard the intent of Congress, but were assisted by ambiguous pieces of legislation.

THE COURTS GAIN CONFIDENCE: THE DANBURY HATTERS, GOMPERS AND ADAIR CASES

The Danbury Hatters' case (*Loewe v. Lawlor, 1908)* was the most significant decision rendered by the Supreme Court on the Sherman Act's applicability to labor. For the first time the Court took a definitive position on the Sherman Act's scope and purpose when used against labor. In the Danbury Hatters' case, the Brotherhood of United Hatters of America initiated a strike involving 250 employees from Loewe & Company after the company refused to agree to a closed shop.[153] During the strike, the union encouraged a secondary boycott[154] against the

---

[150] Ibid., 86.

[151] Ibid., 86: The AFL's objections are outlined in the most detail in legal opinion given to Gompers by two attorneys. See Siddon and Ralston letter to Gompers, January 23, 1897, *American Federation of Labor Records: The Gompers Era*, reel 59, frame 290-299.

[152] Lovell, 95-96.

[153] A "closed shop" is a business or industrial company whose workers are required to be union members as a precondition to employment. An "open shop," on the other hand, is the refusal to hire workers because of their membership in a union or the lawful refusal to give union members preference in hiring.

[154] *Black's Law Dictionary* states that a secondary boycott is a boycott of an employer's products that a union does not have a direct dispute with. Secondary boycotts are generally used against management to add additional pressure to negotiate in a labor dispute by seeking the assistance of other unions. A primary boycott, on the other hand, occurs when a labor organization encourages it members and the general public not to purchase products of the

company's products. The Hatters' union even secured the help of the AFL. Two types of secondary boycotts were administered, a direct and indirect boycott. The "direct" secondary boycott was conducted by union leaders who traveled all over the country convincing other unions and dealers not to purchase Loewe's hats. The "indirect" secondary boycott involved general advertisements which included pamphlets and labor publications advising sympathetic unions and customers not to deal with Loewe & Company. This distinction is significant because Samuel Gompers was later held in contempt under the Sherman statute for orchestrating an indirect secondary boycott.

Outraged by losses totaling $88,000, Loewe & Company filed a lawsuit under the Sherman Act in the Circuit Court of Hartford, Connecticut. That court subsequently dismissed the company's complaint, arguing that although the Hatters' union facilitated a secondary boycott, the union never actually obstructed the "transportation" of the company's products. [155] Hence, the court reasoned, there was no restraint of interstate commerce and no violation of the Sherman statute.

The deciding judge in the case, Robert Platt, stated "there is no allegation… which suggests that the means of transporting plaintiff's product was obstructed," and therefore no restraint of trade.[156] Judge Platt stated that the real question "is whether a combination which undertakes to interfere simultaneously with both actions is one which directly affects the transportation of hats... to the place of sale."[157] Judge Platt answered by stating "It is not perceived that the Supreme Court has as yet so broadened the interpretation of the Sherman act…that it will fit such an order of facts as this complaint presents."[158] Put simply, Judge Platt stated the Supreme Court did not expand the scope of the Sherman statute to declare illegal secondary boycotts.

In response, the company appealed to the Supreme Court. On February 3, 1908, the court handed down its decision. Chief Justice Melville Fuller wrote the opinion, declaring that "the combination described in the declaration [Hatters' Union] was a combination in 'restraint of trade.'" The Court stated further that the Sherman Act prohibited secondary boycotts, which "essentially obstruct the free flow of commerce."[159] The labor union protested stating that its actions affected only intrastate commerce.[160]

James M. Beck and Daniel Davenport, who were attorneys for Loewe & Company, asserted in their brief, that Congress refused to exempt labor from the purview of the Sherman Act. When reviewing the legislative history of the Sherman Act, their position seems to hold only partial merit. They stated, when Senators Reagan and Sherman first introduced the Sherman Act, it contained no exemption for labor. On March 24, 1890, Senators John Teller and Robert Hiscock expressed concerns that the act would inevitably reach labor unions. The next day,

---

company involved in the labor dispute. Primary boycotts are generally used as a tool by labor unions to force management to negotiate.

[155] Julia E. Johnson, *Trade Unions and the Anti-Trust Laws*, New York: The H.W. Wilson Company, 1940: 41; Berman, 78.

[156] Berman, 77-85.

[157] Ibid., 79.

[158] Ibid..

[159] Berman, 83; *Loewe v. Lawlor*, 208 US 274 (1908)

[160] Berman, 83; Bernstein, 202-203.

March 25, 1890, included a labor exemption provision which was subsequently adopted. On April, 2, 1890, the Sherman Act was amended by the Senate Judiciary Committee, which issued a substitute bill that removed the labor exemption.

Their brief then stated that a heated debate occurred between Senator John Sherman and other Senators. However, the 55th Congress ultimately agreed to pass the Sherman Act without the labor amendment. Beck and Davenport further stated that after the act became law, six other bills were introduced with the purpose of making the Sherman Act not applicable to labor organizations. While one of the six bills (H.R. 10539, Sec. 7) actually passed the House during the 56th Congress, none ever became law. Thus, Beck and Davenport concluded that the Sherman Act as passed did not discriminate. Their brief stated that the act applied to "'every' contract, combination or conspiracy in restraint of trade."[161]

The Supreme Court, using the legislative history supplied in Beck and Davenport brief, stated in its opinion that "the records of Congress show that several efforts were made to exempt, by legislation, organizations of farmers and laborers from the operation of the act and that all these efforts failed, so that the act remained as we have it before us," [162] without a labor exemption. The Supreme Court ultimately held in favor of Loewe & Company and issued an injunction against the Hatters' union.

But the brief presented by the company's attorneys made a number of misleading assertions about the Sherman Act's legislative history. First, the brief gives the impression that the labor exemption was omitted as a result of Congressional debate. However, the Sherman bill was originally sent to the Senate Judiciary Committee because it contained a number of constitutionally questionable add-on amendments and needed "a thorough overhauling."[163] Second, only one Senator actually objected to the adoption of a labor exemption. During the Congressional debates, prior to the bill being sent to the judiciary committee, Senator John Sherman stated about the labor exemption: "I do not think it necessary, but at the same time to 'avoid any confusion,' I submit it to come at the end of this first section."[164] Numerous other Senators took the opposing view and the Senate accepted the labor exemption on two occasions. Third, there was no direct debate about the Sherman Act's applicably to labor unions. Fourth, the brief asserted that after the Sherman Act's passage various other labor exemption bills were presented and all subsequently failed to pass.

The brief neglects to point out, however, that five of the six bills were proposals to strengthen the antitrust legislation by clearly prohibiting predatory pricing. Only one bill proposed amending the Sherman Act to include a labor exemption. This bill never made it out of committee, suggesting that Congress favored the broader language of the Sherman Act as passed. Edward Berman argues effectively, however, that the failure of this labor exemption bill might have been "lost in the legislative hopper" along with other amendments.[165]

---

[161] Ibid, 85.
[162] Johnson, 41.
[163] Berman, 83.
[164] Julia E Johnson, *Trade Unions and the Anti-Trust Laws,* New York: The H.W. Wilson Company, 1940: 174
[165] Berman, 84

The *Loewe v. Lawlor* (1908) case established three important interpretive rules: (1) the Sherman Act applied to all combinations, including labor; (2) secondary boycotts were a violation of the Sherman statute; and (3) lawsuits for damages can be brought against individual unionists, primarily those who orchestrated the "conspiracy."[166] The hatters' company was awarded $252,000 in damages. In *Loewe v. Lawlor*, the judiciary established a legal precedent that would stand a long time. With this newly gained confidence, *Lochner* era jurists in case after case broadened the scope of the Sherman statute to include labor organizations. The judiciary further stretched its support for business in the next two cases— *Adair v. U.S.* (1908), in which the Supreme Court struck down the Erdman Act, and the Gompers contempt case, in which the Court reaffirmed the framework established in *Loewe v. Lawlor*. The hostility of the judiciary toward labor is evident and rigid judicial construction begins to take shape.

ADAIR V. UNITED STATES

In *Adair v. U.S.* (1908), the Supreme Court advanced further with its conservative economic philosophies and struck again at progressive labor legislation. In this case, William Adair, a master mechanic who supervised employees at the Louisville & Nashville Railroad, fired O.B. Coppage because he was a member of labor organization called the Order of Locomotive Fireman. Adair was charged and convicted of a misdemeanor.[167] Adair's actions were in direct violation of Section 10 of the Erdman Act which made it illegal for employers to "threaten any employee with loss a loss of employment" or to "unjustly discriminate against any employee because of his membership in…a labor corporation, association, or organization."[168]

Upon appeal, the Supreme Court overturned Section 10, citing that it violated the "liberty of contract" guarantee of the Fifth Amendment. In rendering its decision, the Court first ruled that Section 10 interfered with the "liberty of contract," and second, that Congress did not have sufficient constitutional authority (as outlined in Article 1 Section 8 of the U.S. Constitution) to regulate the liberty of contract as exercised by the railroad industry.[169] Although Adair was only guilty of violating the anti-discrimination clause of Section 10, the Court's decision invalidated the entire section.

To establish a new "liberty of contract" doctrine that applied to federal legislation, the Court used the Fifth Amendment due process clause. In earlier liberty of contract cases, the Court struck down state legislation by using the due process clause of the Fourteenth Amendment; however, this same doctrine did not apply to the Erdman Act, federal legislation. The Court, therefore, expanded the liberty of contract doctrine by using the Fifth Amendment. The Court imposed the liberty of contract doctrine of the Fourteenth Amendment due process clause onto the Fifth Amendment due process clause so it would apply to federal legislation. In effect, the Court struck down the Erdman Act because the Court believed Congress was going outside its constitutional authority to regulate interstate commerce. The majority stated that employment relations were local "man toward man"[170] and this was definitely out of reach of federal regulation.

---

[166] Berman, 86.
[167] Lovell, 74-75; Bernstein, 199, 398, 406.
[168] Ibid., 74; Frankfurter and Greene, The Labor Injunction, 147.
[169] Lovell, 75.
[170] Peritz, 49.

This was inconsistent, however, because one month earlier in the Danbury Hatters' case the Court applied the Sherman statute (federal legislation) to enjoin the hatters' union strike.[171] On the one hand, the Court limited Congress's latitude to regulate under the commerce clause through the Erdman Act, and on the other, the Court gave Congress wide latitude to prosecute labor organizations under the Sherman statute. With this reasoning, it appears the Court only recognized Congress's ability to regulate commerce when it done in accordance with views espoused by conservatives. This definitely illustrates an employer biased Court. Subjectivity and conservative economic philosophies dominated *Lochner* era jurisprudence. Both *Adair* and the Danbury Hatters' case illustrated the Supreme Court's inconsistency when it involved Congressional authority to regulate labor relations. Although the Court frequently restricted Congress's power to regulate manufacturing industries, the Court usually allowed Congress wide latitude to regulate the railroads as part of interstate commerce.

In defense of its reading of the commerce clause (Article 1 Section 8 of the U.S. Constitution)[172] in *Adair*, the Court reasoned that Congress could regulate only activity that had a "substantial connection" to interstate commerce, adding more to the pattern of rigid judicial construction. To demonstrate that the activities banned in Section 10 were not substantially connected to interstate commerce, Justice John Harlan, writing for the majority, asked: "what possible legal or logical connection is there between an employee's membership in a labor organization and the carrying on of interstate commerce?"[173] Harlan answered by stating "Such relation to a labor organization cannot have, *in itself*, and in the eyes of the law, any bearing upon the commerce with which the employee is connected by his labor and services."[174] In short, Harlan insisted there was no logical connection and thus no activity regulated in Section 10 had a substantial connection to interstate commerce. Harlan's view won the day and the Court in a decision of 6-2 struck down Section 10 of the Erdman Act as unconstitutional.

Justices Joseph McKenna and Oliver Wendell Holmes Jr. wrote vigorous dissents in which they criticized the majority for reading too narrowly the commerce clause. In his opinion, McKenna, who was known to be a centrist, asserted that although the Fifth Amendment did guarantee liberty of contract but it did have limitations. Those limitations were recognized by the

---

[171] Peritz, 49; Bernstein, 398.

[172] Article I, Section 8, Clause 3 of the United States Constitution, known as the Commerce Clause, empowers the United States Congress "To regulate Commerce with foreign Nations, and among the several States, and with the Indian Tribes." During the New Deal, the clause was a matter of great conflict between the U.S. Supreme Court and the of Franklin D. Roosevelt administration (1935-1937). The Court struck down several of the FDR's "New Deal" reforms on the grounds that they encroached upon "intrastate" commerce. After winning the 1936 election by a landslide, FDR proposed a plan to appoint an additional justice for each unretired Justice over seventy. Given the justices ages, this permitted a Court population of up to fifteen. Roosevelt claimed that this was not to change the rulings of the Court, but to lessen the load on the older Justices, who he claimed were "slowing the Court down." There was widespread opposition to this "court packing" plan, but in the end the New Deal did not need it to succeed. In what became known as "the switch in time that saved nine," Justice Owen Josephus Roberts and Chief Justice Charles Evans Hughes switched sides in 1937 and upheld the National Labor Relations Act, which gave the National Labor Relations Board extensive power over unions across the country. Ellis Wayne Hawley, *New Deal and the Problem of Monopoly: A Study in Economic Ambivalence*, Princeton: Princeton University Press, 1966: 306

[173] Lovell, 75.

[174] Ibid.

Court when it applied to the railroad industry, which he deemed a "quasi public business."[175] McKenna insisted that the railroad industry was, to an extent, in the public domain and not strictly private. He reasoned, therefore, that Congress had the authority to regulate it. The railroad industry, McKenna noted, was also substantially connected to interstate commerce, noting that the Court had recognized this in previous decisions. To that end, he asked:

> I would not be misunderstood. I grant that there are rights which can have no material measure. There are rights which, when exercised in a private business, may not be disturbed or limited. With them we are not concerned. We are dealing with rights exercised in a quasi public business, and therefore subject to control in the interest of the public. [176]

McKenna was convinced that since the railroad industry was a quasi public business that it was subject to regulation by Congress and Section 10 was not unconstitutional. Unlike manufacturing businesses, where the courts gave Congress very little latitude to regulate, the judiciary did recognize time and again that the railroad industry was a unique entity, as in the Pullman strike in which the Supreme Court upheld the decision of a lower court's use of federal legislation to enjoin strikers.

In a more forceful dissent, Holmes announced clearly: "I also think that the statute is constitutional, and, but for the decision of my brethren, I should have felt pretty clear about it."[177] Holmes, who dissented in *Lochner v. New York* (1905), thought that the Court was stretching an economic philosophy which stripped Congress of its power to legislate and workers of their right to bargain collectively. Harlan wrote that Congress had the power to regulate only activity that had a "substantial connection" to interstate commerce.[178] Harlan did not agree that yellow-dog contracts were substantially connected. Holmes, on the other hand, thought contracts involving the railroad industry were substantially connected. He stated:

> I suppose that it hardly would be denied that some of the relations of railroads with unions of railroad employees are closely enough connected with commerce to justify legislation by Congress. If so, legislation to prevent the exclusion of such unions from employment is sufficiently near.[179]

Holmes went on to write that Section 10 was so narrow in scope that it was improper to suggest that it unduly interfered with a right to free contract. Because Section 10 only prohibited the discharging of an employee who joined or associated with labor organizations, Holmes insisted that this regulation was too narrow to violate the Fifth Amendment's "liberty" guarantee. A doctrine that Holmes thought the Court was stretching to the "extreme" as it had done in *Lochner v. New York* with the Fourteenth Amendment.

Holmes, like Justice McKenna, stated that since Section 10 did not overreach in its regulation of the railroad industry the statute was constitutional.

---

[175] *Adair v United States*, 208 US 161 (1908).
[176] Ibid.
[177] Ibid.
[178] Lovell, 75.
[179] *Adair v United States*, 208 US 161 (1908).

> It does not require the carriers to employ anyone. It does not forbid them to refuse to employ anyone, for any reason they deem good, even where the notion of a choice of persons is a fiction and wholesale employment is necessary upon general principles that it might be proper to control. The section simply prohibits the more powerful party to exact certain undertakings, or to threaten dismissal or unjustly discriminate on certain grounds against those already employed.[180]

The railroad was the more powerful party and Holmes noted that since no other statutory prohibitions or regulations were made of the employer, Congress was within its authority. But Holmes also thought that the "liberty of contract" doctrine grafting into the Fifth Amendment was indicative of more judicial activism. To this end, Holmes stated "So I turn to the general question whether the employment can be regulated at all. I confess that I think that the right to make contracts at will that has been derived from the wor[d] 'liberty' in the Amendments has been stretched to its 'extreme'…"[181] by the Court.

The *Adair* decisions significantly expanded the protection of property rights and liberty of contract. These conservative economic doctrines became entrenched in *Lochner* era jurisprudence and laid the foundation for more rigid judge-made law. Later in *Coppage v. Kansas*[182] (1915), in which the Supreme Court overturned state legislation banning yellow-dog contracts, Frankfurter wrote Holmes praising him for his well anticipated dissent as he had done in *Adair*. Frankfurter wrote on January 27, 1915, "Dear Justice Holmes, I'm keenly awaiting your dissent in the Kansas case. In the meantime, for the fact of dissent and the smell of your opinion, at this distance even, my thanks…I *was* happy when I saw you drive another spike into the *Adair* case."[183] Although during the time of this correspondence Holmes had not yet written a dissent in the Kansas case, Frankfurter eagerly thanked him in advance.

GOMPERS HELD IN CONTEMPT

The second major appearance of a case involving labor and antitrust occurred on May 15 1911. *Gompers v. Bucks Stove and Range Company* originated out of a long dispute between the molders' union and the stove company. As a result of the extended labor dispute, the AFL, under the direction of Samuel Gompers, placed in 1907 the name of the company in the "We Don't Patronize List" of the *American Federationist.*[184] This resulted in national secondary boycott of the stove company by unions and consumers, which caused significant financial losses for the company. The legality of this indirect secondary boycott was still in question; that is, did mere

---

[180] *Adair v United States*, 208 US 161 (1908).
[181] Ibid.
[182] *Coppage v. Kansas*, 236 U.S. 1, 27 (1915) The 6-3 majority opinion by Justice Mahlon Pitney held that a Kansas law outlawing yellow-dog contracts was an interference with the freedom of both employers and employees to set terms of their own labor. Like he did in *Adair*, Holmes vigorously dissented: "Whether in the long run it is wise for the workingmen to enact legislation of this sort is not my concern, but I am strongly of the opinion that there is nothing in the Constitution to prevent it…If that belief, whether right or wrong, may be held by a reasonable man it seems to me that it may be enforced by law in order to establish the equity of position between the parties in which liberty of contract begins."
[183] Mennel and Compston, 25-26.
[184] *Gompers v. Bucks Stove & Range Co*., 221 US 418 (1911); Frankfurter and Greene, 9; Berman 87; Bernstein, 194.

advertisements amount to a violation of the Sherman statute as it was interpreted in the Danbury Hatters' case?

In December 1907, the company sought and was granted an injunction by the Supreme Court of the District of Columbia against the AFL and its principal officers, including Gompers. The count injunction enjoined the "We Don't Patronize" list from calling attention to and endorsing a secondary boycott. However, in direct violation of the injunction, the AFL listed the stove company again in its January 1908 "We Don't Patronize" list. Subsequently thereafter, Gompers, John Mitchell, and Frank Morrison were cited in contempt of court and all received prison terms. The sentences ranged from one year to six months. Gompers' lawyers immediately appealed the decision to the Court of Appeals.[185]

In March 1909, the Court of Appeals limited the scope of the injunction to just prohibiting the printing of the stove company's name in the "We Don't Patronize" list. Regardless of this limitation, the court also upheld the contempt sentences against Gompers and the other principal officers of the AFL. Gompers' lawyers then merged the contempt and injunction cases and appealed to the Supreme Court. When the Bucks Stove and Range Company came under new management in 1910 and the labor dispute was settled, the company requested that the injunction proceedings be dropped. Gompers' contempt case, however, proceeded to the Supreme Court and on May 15, 1911 the Court rendered a decision.[186]

The Court dismissed the contempt cases against Gompers and his associates on legal technicalities, but did provide a decision on the issue of indirect secondary boycotts. In their argument before the Supreme Court, Gompers' lawyers asserted that no court had the right to enjoin a secondary boycott if "spoken words or printed matter were used as one of the instrumentalities by which it was made ineffective."[187] The Court, however, thought otherwise and made its position clear in its opinion. Justice Joseph Lamar, writing for the Majority, asserted that if their argument was valid no court could enjoin a secondary boycott "even if interstate commerce was restrained by means of a blacklist, boycott, or printed device to accomplish its purpose."[188] Lamar pointed to the Danbury Hatters case which found unlawful both the direct and indirect secondary boycotts. Lamar went on to say:

> The principle announced by the court was general. [The Sherman Act] covered any illegal means by which interstate commerce is restrained…we think also whether the restraint be occasioned by unlawful contracts, trusts, pooling, arrangements, blacklists, boycotts, coercion, threats, intimidation, and whether these be made effective, in whole or in part, by acts, words or printed matter. The court's protective and restraining power extend to every device whereby property is irreparably damaged or commerce is illegally restrained.[189]

---

[185] Berman, 88.
[186] Ibid..
[187] Ibid
[188] *Gompers v. Bucks Stove & Range Co*., 221 US 418 (1911)
[189] Ibid.

Lamar also noted that if the courts were limited in enjoining all acts that restrained trade then the Sherman statute would be rendered impotent. The Pullman strike, Lamar noted, for the injunction to be effective, had to enjoin all avenues by which restraint of trade was accomplished, even peaceful ones.[190] Although most of Lamar's comments were dictum, Lamar and the Court were explicit that even peaceful means of boycotting were still enjoinable if they restrained trade. But the Court did not stop with *Gompers*, it established even more subjective judicial doctrine when applying the "rule of reason" to labor organizations.

LITERALISTS VERSUS RULE OF REASONISTS

For twenty years, the Court worked its way to a more fixed doctrine to establish a "rule of reason" in which business combinations were not *per se* illegal. But this also meant that the Sherman statute's application against labor unions was viewed more subjectively. Over a period of decades, the Standard Oil Company of New Jersey had purchased virtually all the oil refining companies in the U.S. The company's early success was first driven by superior refining technology. But then after acquiring more companies, Standard Oil used a number of anticompetitive tactics to solidify market dominance.[191] Standard Oil's management used their market share to secure favorable transportation rates from railroads, putting pressure on less organized and smaller refineries. This, in turn, compelled their competition to sell out or face insolvency. Among Standard Oil's anticompetitive tactics included predatory pricing (underpricing) and threats to suppliers and distributors who did business with its competitors. In response, the government sought to prosecute Standard Oil for violating the Sherman Act.

In *Standard Oil Co. of New Jersey v. United States* (1911), the Court held that Standard Oil was an illegal combination under the provisions of the Sherman statute and forced it to split into smaller competing companies. The most relevant part of the Court's decision, however, was the enshrinement of the "rule of reason" in *Lochner* era jurisprudence. Since the Sherman statute's enactment in 1890, the Court was influenced strongly by "Literalists" who prohibited literally *every* combination and contract that restrained trade. Literalists read the Sherman statute so broadly that it not only outlawed "price fixing cartels," but also labor and farmer organizations, partnership arrangements, and simple contracts for the sale of goods. The legislative history of the Sherman Act clearly demonstrates, however, that Congress did not intend for such a broad reading.[192]

In *Standard Oil*, the Court acknowledged that taken "literally" the term "restraint of trade" could outlaw any number of contracts no matter how innocuous they were to the public. After embarking on a lengthy exegesis of English authorities to define "restraint of trade," the Court determined that "restraint of trade" referred to a contract that resulted in a "monopoly" and "its consequences."[193] The three most adverse consequences recognized by the Court were high prices, reduced output, and reduced quality.[194] Thus, the Court concluded that any contract that resulted in one of these three consequences "unduly" retrained trade in violation of the antitrust

---

[190] Ibid; Bernstein, 194.
[191] Phillip Areeda, *Antitrust Analysis: Problems, Text, Cases*, Boston: Little, Brown and Company, 1981: 148-149;Berman, 97-98; Peritz, 28; *Standard Oil Co. v. U.S.* 221 US 1 (1911)
[192] Peritz, 27.
[193] Areeda, 148-149; *Standard Oil Co. v. U.S.* 221 US 1 (1911)
[194] Ibid, 148-149.

statute. Offering a caveat, the "Rule of Reasonists" asserted that a broader reading prohibited innocuous contracts and thus infringed liberty of contract.[195]

Writing for the Majority, Chief Justice Edward Douglass White insisted that only contracts which unduly or unreasonably restrained interstate commerce were prohibited under the Sherman statue. He wrote:

> The statute [Sherman Act]…evidenced by the intent not to restrain the right to make and enforce contracts, whether resulting from combination or otherwise, which did not unduly restrain interstate commerce…but to protect that commerce from being restrained by methods, whether old or new, which would constitute and interference,--that is, undue restraint.[196]

White wrote that antitrust cases must be illuminated by the "light of reason"[197] and not by extreme Literalists interpretations which impeded liberty of contract. Thus the rule of reason emphasized that an illicit combination have a "direct, immediate, and (by implication) a material effect upon interstate commerce."[198] The Standard Oil case marked a shift in which the Rule of Reasonists, which included Holmes, became the majority and Literalists became the feeble minority.

Historian Rudolph J. R. Peritz contends that one of the most fundamental disagreements between the Literalists and Rule of Reasonists concerned the "political economy of competition," which was a clash between competing visions of society.[199] On the one hand, the Literalists, the early majority, believed that antitrust policy should promote unrestricted competition among roughly equal market participants. This was a more individualistic view supporting independent entrepreneurs or free workmen, without regard to the fairness or reasonableness of their business arrangements. The Rule of Reasonists, on the other hand, thought that antitrust policy should allow "large consolidations of capital"[200] as long as these arrangements did not unduly restrain trade and allowed for the fair return on property or what Peritz calls "some other traditional exercise of liberty of contract."[201] Given these two disagreements, it is difficult too discern which was less antagonistic to labor. Actually, the only issue on which both of these factions agreed was the on the treatment of labor under the antitrust statute.

While championing the sensibilities of reasonableness, the Rule of Reasonists still thought that labor unions were within the reach of the Sherman statute. Holmes' vigorous dissents in previous Sherman-labor cases, *prima facie*, appear inconsistent with his Rule of Reasonist's position. But Holmes saw both labor and business combination as judicial equivalents. In 1896 when Holmes was sitting on the Supreme Judicial Court of Massachusetts, he wrote in a dissenting opinion:

---

[195] Ibid, 148; Berman, 96, 98.
[196] *Standard Oil Co. v. U.S.* 221 US 1 (1911); Berman 96.
[197] *Standard Oil Co. v. U.S.* 221 US 1 (1911)
[198] Berman, 98; Peritz, 35.
[199] Peritz, 63.
[200] Ibid, 64.
[201] Ibid, 94.

> If it be true that workingmen may combine with a view, among other things, to getting as much as they can for their labor, just as capital may combine with a view to getting the greatest possible return, it must be true that when they combine they have the same liberty that combined capital has to support their interests by argument, persuasion, and the bestowal or refusal of those advantages which they otherwise lawfully control.[202]

Holmes clearly did not support immunity for labor, but notably was not as convinced as his colleagues that liberty of contract should be interpreted broadly. For in *Adair* (1908), Holmes acknowledged that liberty of contract doctrine was being defined to the broadest "extreme"[203] by the Court. It was this split in opinion which ultimately caused Holmes to support a new rule of reason as formulated by Justice Louis Brandeis in *Chicago Board of Trade v. U.S.* (1918).[204] The Brandeisian rule of reason (post-classical rule of reason) accommodated labor organizations unlike its original counterpart "classical" rule of reason. Holmes joined the majority in *Standard Oil* (1911) against one of the last holdouts of the Literalist faction, Justice John Marshall Harlan.[205]

Harlan concurred with the majority that Standard Oil was an illegal trust, but strenuously contested the Court's adoption of the rule of reason. Citing *United States v. Trans-Missouri Freight* (1897), Harlan argued that the Court held all combinations in restraint of trade, whether or not the effect was direct or indirect. In *Trans-Missouri Freight*, various railroad companies had organized to regulate prices charged for transportation. The federal government charged these companies with violating the Sherman Act.[206] The railroad companies argued the contrary because their organization was designed to keep prices low, not raise them. Taking the extreme Literalist view, the Court held that the Sherman Act prohibited all combination irrespective of purpose. Antitrust experts, like William Howard Taft and Robert Bork, on the other hand, argued that the decision in *Trans-Missouri Freight* was dicta and not binding precedent. Critics of Harlan's dissent emphasize *United States v. Joint Traffic Association* (1898) in which the Court began its early formulation of the rule of reason when it announced that "ordinary contracts and combinations" did not violate the Sherman statute because they were "indirect."[207]

After *Standard Oil* (1911), the rule of reason dominated *Lochner* jurisprudence and the judiciary's hostility toward labor remained the same, especially given how the Court tended to view labor unions. Although antitrust doctrine was substantially modified, the language describing labor unions was still embedded in most judicial opinions of the time. In labor disputes, while capital was described as "entrepreneurial entity" or "the employer," labor unions were described as "union" or a "combination of workers."[208] Chief Justice Fuller in the Danbury Hatters' case (1908), for example, wrote that "The United Danbury Hatters of North America, comprising about 9,000 members and including a large number of subordinate

---

[202] Ibid, 89.
[203] *Adair v United States*, 208 US 161 (1908).
[204] Peritz, 89; *Board of Trade of City of Chicago v. U.S.*, 246 US 231 (1918)
[205] Peritz, 89-90.
[206] *Standard Oil Co. v. U.S.* 221 US 1 (1911); Berman 96; Peritz 32.
[207] *Standard Oil Co. v. U.S.* 221 US 1 (1911)
[208] Peritz, 92.

unions…combined with some 1,400, 000 others…"[209] This very language was suggestive of guilt and unlawful activity on the part of labor.

Although a friend of labor, Brandeis added another layer to the mounting judicial construction and antitrust jurisprudence. His judicial construction, however, was more of a doctrinal deferral than judicial activism insofar as his interpretation brought the Court closer to the original intent of Congress. In *Chicago Board* (1918) and after, an argument developed between the Classical Rule of Reasonists and the pro-labor, Post-Classical Rule of Reasonists. Whereas the Post-Classical Rule of Reasonists distinguished between "good" trusts and "good" labor organizations, that is, whether their practices were monopolistic, the Classical Rule of Reasonists made no such distinctions and deemed illegal all contracts and combinations that resulted in monopoly and its adverse consequences as spelled out in *Standard Oil*.[210]

In order words, because a majority of the Classical Rule of Reasonists possessed an anti-labor bias, they were less even handed in the application of the rule of reason. They allowed more exceptions for business combination than for labor organizations. Conversely, the Post-Classical Rule of Reasonists were more balanced in their application of the rule of reason. The Post-Classical Rule of Reasonist made distinctions between good or bad corporate and labor combinations. Eventually, the Post-Classical Rule of Reasonists developed a pro-labor bias, but did not become anti-business. They were just more apt to offer more exceptions for labor organizations, which inched the Court closer to the will of Congress. This argument continued for over a decade until the *Bedford Cut Stone Company* decision in 1927 in which the Court no longer concerned itself with such distinctions. After 1927, the Court focused more on labor practices and factual circumstances.[211] The Bedford Cut Stone Company case will be examined in more detail after substantial attention is paid to Frankfurter, the Clayton Act, and the *Duplex* decision (1921).

The Literalists vs. the Rule of Reasonists, the Classical Rule of Reasonists vs. the Post-Classical Rule of Reasonists all show a Court becoming more entrenched in rigid judicial construction. All of this judicial construction made more difficult labor's fight for recognition and, most importantly, immunity from the Sherman statute. Brandeis, a pro-labor jurist, despite his best intentions, assisted in the formulation of more rigid judge-made law. Of further significance is the fact that these two competing doctrines substantially shaped Frankfurter's thinking. Frankfurter was influenced greatly by Brandeis and Holmes and therefore Post-Classical Rule of Reasonists helped to form Frankfurter and his philosophy concerning the Sherman statute's application against labor unions.

THE MAKING OF A PRO-LABOR JURIST 1906-1914

Felix Frankfurter burst onto the legal scene at this time after graduating from Harvard Law School with one of the best academic transcripts since Louis Brandeis, someone whom Frankfurter deeply admired. This section will examine Frankfurter's beginnings as a Progressive era attorney and how he grew to adopt a pro-labor deference to legislative judgment. In 1906, Frankfurter became an assistant United States attorney working for Henry Stimson in the

[209] Ibid, 92.
[210] Ibid, 89.
[211] Peritz, 89.

Southern District of New York. Frankfurter was influenced greatly by both Stimson and Theodore Roosevelt who shared the Progressive concerns about irresponsible corporations and labor militancy. Roosevelt, like many other Progressives, blamed "industrial titans" (corporate monopolies) for, among other things, low wages and poor working conditions, which sparked social unrest.[212] Frankfurter embraced this view and saw massive corporate power as one of the primary forces causing social strife. While working with Stimson, Frankfurter helped to prosecute numerous cases, which he considered intellectually unfulfilling (smugglers, counterfeiters, gun runners, and gambling touts just to name a few).[213]

Frankfurter learned from Stimson that social and economic relevancy was more important than inert legal theory. After *Muller v. Oregon* (1908), Frankfurter and Stimson started to use empirical social and economic evidence to support their cases more than legal theory. The real world applications of legal decisions became a driving force behind their practice of law. Frankfurter greatly admired this legal method pioneered by Brandeis, who in 1908, successfully defended Oregon's ten-hour law before the Supreme Court. Using sociological data in his brief, Brandeis was able to illustrate for the court the physical and social ills that resulted from working too many hours. The "Brandeis brief" was used by many Progressive attorneys as a legal tool in their reform cases, especially Frankfurter and Stimson.

When Stimson became Secretary of War in 1910, Frankfurter joined him as the War Department's law officer. His primary responsibility in this post was to oversee matters involving seapower and the nation's overseas possessions, taking his part in Roosevelt's "white man's burden." During his time in the War Department, Frankfurter and Stimson absorbed the reformist ideas presented in Herbert Croly's *The Promise of American Life* (1909). This book was a powerful contribution to progressive thinking and espoused patriotism and domestic reform. Of particular interest to Frankfurter, was Croly's description of the "unfulfillment" of America's promise, which ultimately led to class conflict and societal unrest. Croly, like many other progressive writers of the time, blamed this unrest on a "concentrated wealth."[214]

Frankfurter was well known for giving heavy weight to the legislative intent and he espoused the concept that the Court has limited competence in political and social spheres. "The Court," Frankfurter insisted, must have "above all, the humility not to set up its own judgment against the conscientious efforts of those whose primary duty it is to govern."[215] It was Frankfurter's belief that when the Court enters the political and social spheres, its most detrimental impact occurs when legislative acts are challenged. Frankfurter's deference to the legislative branch grew directly from his first-hand experience in preparing and arguing cases before the Court.

In 1912, before he became Brandeis's understudy, he observed that the Court in determining the constitutionality of minimum wage laws was making decisions based on social factors rather than the law and social statistics. But this was not entirely improper in

---

[212] Michael E. Parrish, *Felix Frankfurter and His Times: The Reform Year*, New York: The Free Press, 1982: 62; Leonard Baker, *Brandeis and Frankfurter: A Dual Biography*, New York: Harper & Row, Publishers, 1984: 221.
[213] Parish, 29.
[214] Parrish, 29-32.
[215] Clyde W. Summer, "Frankfurter, Labor Law and the Judge's Function," *The Yale Law Journal*, Vol. 67, No. 2. (1957): 266-303.

Frankfurter's view. He recognized the importance of the Brandeis brief as a device which allowed the Court to give "due regard to the facts which induced the legislation,"[216] but still legislative intent remained supreme. Such a judicial approach, in Frankfurter's view, allowed the Courts to maintain judicial review of legislation while applying the proper facts. Frankfurter wrote in *The Zeitgeist and the Judiciary*:

> [The Brandeis brief would leave] still unimpaired the benefits of the reviewing power of the judiciary in our governmental system, for the reflex action of the *existence* of this power on the part of the courts to set aside legislation restrains unwise legislative action and induces the scientific attitude of basing legislation only upon adequately ascertained facts.[217]

Emphasized again in this excerpt was Frankfurter's belief in the effectiveness of the Brandeis brief in bringing real world facts into the legal arena. Instead of the jurist blindly deciding a case without regard to the social effects, the Brandeis brief allowed the jurist to see the "real world."[218]

In 1913, Frankfurter joined the Harvard Law School faculty and started to revamp the law curriculum. Part of those efforts, involved teaching his law students to use real world data in defense of their legal positions, and he strongly discouraged the use of abstraction. Frankfurter stated locating and solving social problems "require[d] adequate data, and correlated, prophetic thinking."[219] Also, while at Harvard, Frankfurter co-founded *The New Republic* (1914) a Progressive periodical with Croly, which called for various political and social reforms. It was Frankfurter's days as U.S. attorney, protégé to Stimson, and Harvard faculty member that later shaped his judicial views on labor. [220]

Frankfurter arose in the midst of what is considered to be the first Anti-Injunction Movement and aptly did his part. Frequently, while writing in *The New Republic*, Frankfurter condemned the use of injunctions, especially in labor disputes. When the Court, using the Fourteenth Amendment, struck down a state law limiting the use of injunctions in picketing, Frankfurter insisted: "It [the injunction] does not work…It neither mines coal, nor moves trains, nor makes clothing."[221] Failing to stimulate business, Frankfurter wrote, "the injunction has cut off labor from confidence in the rule of law and of the courts as it impartial organs."[222] Frankfurter went on to say that injunctions restrain clearly permissible conduct "like furnishing strike benefits, singing songs, and maintaining tent colonies,"[223] referring to some of the most absurd injunctions granted by courts.

After the establishment of the Federal Mediation Commission, one of Wilson's regulatory agencies, four copper districts in Arizona went on strike. In 1917, Frankfurter, while a

---

[216] Summer, 277.
[217] Ibid., 276.
[218] Ibid.
[219] Jeffery D. Hockett, *New Deal Justice: The Constitutional Jurisprudence of Hugo Black, Felix Frankfurter, and Robert H. Jackson.* Lanham: Rowman & Littlefield Publishers, Inc., 1996:147.
[220] Parrish, 29-32.
[221] Baker, 205.
[222] Ibid.
[223] Ibid., 206.

federal labor mediator, became deeply involved in the Bisbee incident and witnessed first hand corporate cruelty. During a labor dispute in Bisbee, Arizona, mine workers went on strike to protest working conditions and wages. Under the guise of stemming a violent strike, Sheriff Harry Wheeler cut off outside communication to the town of Bisbee, Arizona and with several thousand armed vigilantes forced over 1,185 strikers into cattle cars. Despite a vigorous protest from Frankfurter, the cattle cars were dumped in the middle of the New Mexico desert and left the strikers without food or water. The miners were left there for two days until federal troops rescued them. This had a tremendous impact on how Frankfurter viewed employers; most, he believed, did not recognize a worker's legal right to strike. [224]

During the Anti-Injunction Movement of the 1920s, Frankfurter proved vital in forwarding anti-injunction legislation and became a more vocal critic of *Lochner* era jurisprudence. Prior to this, however, Frankfurter also observed the rise of a new political ideal that promised meaningful reforms. Indeed, "industrial democracy"[225] saw the passage of the Clayton Act and less governmental hostility toward labor. However, this was short lived. Labor historian Daniel Letwin notes that from 1917 the "luminous prospect" of an "Age of Industrial Democracy" became "all-too-revocable" by 1921.[226] "Suspect" legislative reforms, like the Clayton Act, ultimately proved ineffective at curbing the abuse of *Lochner* era jurists, and the Woodrow Wilson Administration attenuated the gains won by labor.

LABOR'S POLITICAL CAPITAL AND THE PUSH FOR THE CLAYTON ACT: THE RISE OF INDUSTRIAL DEMOCRACY

With the coming of "industrial democracy," the prospect of reform seemed near. Before 1912, the term "industrial democracy" was "little heard outside Fabian and Social Gospel circles,"[227] but it all too soon provided hope in labor's fight against a hostile *Lochner* era judiciary. As early as 1906, the AFL, under the direction of Gompers, started to change its unyielding nonpartisanship into valuable political currency. Labor was under constant siege from open-shop employers and "injunction judges," and Congress failed to offer any consequential legislative relief. As a result, the AFL embarked on its first major Anti-Injunction Campaign [228] in order to prevent conservative jurists from enjoining strikes, a right the AFL deemed essential.

---

[224] Parrish, 81; Baker, 149-151.

[225] "Industrial Democracy" was a pre-WWI alliance of "Wilsonian Democrats, trade unionists, and left-wing progressives" with the aim of eliminating disruptive industrial conflict. During a time of unprecedented strikes, the Wilson-labor compromise established regulatory agencies that provided more rights and protections for workers in exchange for no labor militancy. McCartin argues, however, that three interpretations of "industrial democracy" arose. The first was proposed by a small group of conscientious employers, who supported company unions by which they could alleviate divisive labor issues. The second was promoted by the AFL, which was characterized by trade unionism and the Wilsonian compromise. The third was advanced by radicals who saw "industrial democracy" as being the adoption of socialism and class conflict. In effect, these various interpretations made "industrial democracy," and its practice, broadly defined, somewhat indistinct. Yet by 1916, the AFL forged an alliance with the Wilson Administration and the experimental democratization of industry became a lasting theme in labor history. Of primary importance to this analysis was how Wilson used "industrial democracy" to shape his approach to the antitrust-labor problem. Daniel Letwin, review of *Labor's Great War: The Struggle of Industrial Democracy and the Origins of Modern American Labor Relations, 1912-1921*, H-SHGAPE (1999, at: http://www.hnet.msu.edu/reviews/showrev.cgi?path=20213934921244); McCartin.

[226] Ibid.

[227] Ibid.

[228] Bernstein, 391; Taylor, 42.

The Republican leadership in Congress refused to address the grievances of labor, especially anti-labor Speaker of the House Joe Cannon, who rebuffed every labor appeal. Republicans no longer seemed appealing to labor, and the AFL drifted ever closer to the Democratic Party.[229]

In 1908, with the disastrous Danbury Hatters' decision, Gompers approached the leadership of both major political parties and proposed that they include in their platform a pledge to grant labor immunity from the Sherman statute and substantially limit the power of the courts to issue injunctions.[230] The Republican Party flatly refused Gompers's request; however, the Democratic Party was more receptive and accepted Gompers' suggestion. With the AFL's assistance, Democrats won control of Congress in the 1910 midterm elections. The naming of Congressman William B. Wilson, a former official for the United Mine Workers (UMW), to chair the House Committee on Labor helped to solidify an alliance between the Democratic Party and the AFL. Gompers later declared that Wilson's appointment help make Congress "a potent power responsive to social and economic conditions."[231] Later while in this position, William B. Wilson argued that, under Democratic control, Congress had passed such a sweeping amount of pro-labor legislation that it had "never been equaled by any party, at any time, or in any country in the world."[232] This, though, was greatly disputed.

During the 1912 Democratic National Convention, the AFL endorsed the radically pro-labor Speaker of the House Champ Clark for the Democratic nomination for President. However, Woodrow Wilson won the party's nomination. Many labor activists did not want Woodrow Wilson as the Democratic pick for president because of his lukewarm and sometimes even cold attitudes concerning labor. While in academia, Wilson had retained a persistent suspicion of labor organizations, which he deemed "economically disastrous."[233] Wilson rejected the collective consciousness of labor and categorized labor strikes as socially divisive. Another notable opponent to Wilson's nomination was pro-labor activist Judge Alton B. Parker, who advised the AFL to endorse Clark. Regardless of these efforts, Wilson represented the Democratic Party, and with the eventual support of Gompers, the interests of labor in the 1912 presidential election.[234]

Despite protest within the AFL, Gompers convinced a majority of its members to support Wilson. Crucial in gaining the AFL's continued support after Clark's defeat in the primary was Wilson's pledge to keep the party's promise to Gompers. Gompers was determined to forge a workable alliance with Wilson in the hopes of significant reforms. To further quell fears, Wilson emphasized the record from his second term as a reformist governor of New Jersey and his support of a workers' compensation bill. In addition to his record as governor, Wilson also agreed to recognize labor's right to organize. Following Brandeis's recommendations, Wilson stated several times during his campaign that his administration intended to secure the fundamental rights of labor. During a speech at Fall River, Massachusetts, Wilson declared that the law was "one-sided" because it allowed for yellow-dog contracts and disallowed a right to

[229] McCartin, 11.
[230] Ibid, 11; Jones, 202.
[231] McCartin, 14.
[232] Ibid., 14.
[233] Ibid.,15.
[234] Jones, 209.

strike.[235] On another occasion, Wilson insisted that he was opposed to the unrestricted use of injunctions.[236]

By November of 1912, all of Wilson's rhetorical maneuvering paid off, and Gompers enthusiastically declared that Wilson was labor's choice for President. With labor's support, the Democratic Party won sweepingly. Wilson secured 435 electoral votes and Democrats won seats in both the House and Senate.[237] In office, Wilson created the United States Commission on Industrial Relations (USCIR) and appointed Representative William B. Wilson to head the Department of Labor. Radical labor activists declared that Wilson's appointment came "virtually at the instigation"[238] of Gompers, offering a view of their future relationship together.

Labor Secretary Wilson, who arrived in the U.S. at age eight, worked in the coal mines of north-central Pennsylvania. As a longtime labor activist, who had served as a masterworkman for the Knights of Labor, he joined the UMW and quickly gained a leadership position. In 1906, Wilson was elected to the House of Representatives and led a critical investigation by the House Labor Committee into Frederick W. Taylor's scientific management practices.[239] Under Wilson's leadership, the Labor Department symbolized the very essence of the alliance forged between the Democrats and AFL. "Industrial democracy" was alive and well at the Department of Labor, and Wilson hoped this department would effectuate cooperation between labor and capital for the "common good."[240]

The close relationship between the AFL and the Department of Labor concerned many business leaders. As one observer noted, an "impression became current in many places that the Department was controlled by the labor unions, and practically all of its personnel were or had been connected with organized labor."[241] And Secretary Wilson only exacerbated these concerns when he addressed the delegates of the 1913 AFL convention as "fellow trade unionists." Becoming increasingly alarmed at this relationship, business leaders demanded that President Wilson "restrain" his "anarchist" cabinet member.[242] Historian Joseph A. McCartin noted that one employer asked pointedly: "Why is Mr. [William B.] Wilson allowed to take the stand he does with the American Federation of Labor?"[243] With competing constituencies, labor on one end and capital on the other, Wilson began his dilution of pro-labor legislation, most notably the Clayton Act.

President Wilson's political principles outlined in his "New Freedom" program were inconsistent with granting labor immunity from the Sherman statute. The "New Freedom" program was a promise "to restore laissez-faire—with some modification—and to revive competition."[244] Wilson asserted that there were would be no "special privileges" for anyone and

---

[235] Ibid., 203.
[236] Ibid.
[237] McCartin, 15.
[238] Ibid.
[239] Ibid.
[240] Ibid.
[241] Ibid.
[242] Ibid.
[243] Ibid., 16.
[244] Jones, 203.

an elimination of all "class legislation."[245] There was no room in Wilson's "New Freedom" for radical pro-labor reforms. Given these principles, Wilson had to find a way to keep his pledge to aid labor while extending no special privileges, and strict governmental impartiality was the solution. The government remained impartial in labor disputes and did not aid employers in resisting labor unions. Wilson's labor constituency, however, refused to recognize this impartiality and demanded more positive protection.[246]

In 1912, "industrial democracy" was starting to inspire numerous reformers, but Gompers's fears persisted. In December 1912, the *Hitchman Coal and Coke Co. v. Mitchell* was argued before the Circuit Court of Appeals in which not just labor practices, but the United Mine Workers' union right to exist was challenged because of principles outlined in its constitution. In *Hitchman*, the appeals court overturned a lower courts' decision that dismantled the union as an "unlawful combination."[247] The lower court adjudicated against the UMW on the basis that its constitutionally-outlined objective to organize all mine workers' industry wide was unlawful under the Sherman Act. The appeals court overturned the decision, but Gompers' had serious reservations. He thought, regardless of the decision, that the labor unions' right to exist was in doubt so much so that it became an obsession of Gompers that labor unions' right to exist be spelled out in the law.

That same year, Gompers' concerns were evident when he appeared before a Senate committee considering the changes to the Sherman Act. He again expressed his belief that if an anti-labor administration rose to power that it could use the Sherman statute to "dissolve"[248] labor unions. This belief was the central theme behind most of his testimony before Congress. A couple of months later, when testifying before another committee, Gompers' declared: "Under the interpretation placed upon the Sherman antitrust law by the courts, it is within the province and with the power of any administration at any time to begin proceedings to dissolve any organization of labor in the United States…"[249]

Although Gompers did expect unions to be prosecuted for blatantly criminal acts, he was not concerned with the Wilson Administration. Underscoring the prevailing spirit of "industrial democracy," Gompers stated that he did not believe that the Wilson Administration would attempt to dissolve any labor organizations. Wilson, however, did not support total immunity for labor. Gompers insisted during his testimony that "We [labor unions] do not want to exist as a matter of sufferance subject to the will of or chances or the vindictiveness of any administration or of any administration officer."[250] Gompers was again emphasizing the dangers of an unfriendly administration and the judiciary's interpretation of the antitrust laws.

Gompers' told the committee members that all labor needed was the unfettered ability to negotiate in labor disputes; however, he stressed labor's existence more than immunity.

> We do not ask immunity for any criminal act which any of us commit; we ask no immunity from anything; but we have the right to existence, the lawful, normal existence

[245] Ibid..
[246] Ibid., 202-206.
[247] Ibid, 204; Bernstein, 196-200.
[248] McCartin, 204.
[249] Ibid.
[250] Ibid., 205.

> as voluntary association of workers, organized not for profit, but organized to protect our lives and normal activities.[251]

When Gompers insisted that labor wanted "no immunity from anything," he may have irreversibly hurt the campaign for a labor exemption from the antitrust laws. Perhaps not directly, but indirectly he shifted attention away from labor's fight for immunity, which was considered by some scholars to be the more important battle.

At one point, Representative John C. Ford asked, "What you desire is for us to give you a legal status under the law?" To which Gompers replied, "Yes, sir."[252] This is not to say that Gompers did not fully support immunity because he did support the pending Bacon-Bartlett bill, which excluded labor from the Sherman Act, defined property in labor disputes, and placed restrictions on the judiciary's power to grant injunctions. Historian Dallas L. Jones contends, however, that Gompers' support for the bill was "completely overshadowed by his emphasis upon the right to exist."[253]

"Industrial democracy" and labor's uncertain relationship with the Wilson Administration continued, especially with President Wilson's grudging support of the Sundry Civil Appropriations Bill. The AFL considered this bill important because it contained a rider prohibiting any of the funds appropriated in the bill for use in prosecution of labor under the Sherman Act.[254] Surprisingly, Wilson did not veto the bill; a similar bill had been vetoed by President William Howard Taft as "class legislation of the most vicious sort."[255] Upon affixing his signature and consistent with his "New Freedom" principles, Wilson strongly denounced "rider" legislation.[256] With this bill, it appeared that "industrial democracy" was working; however, it only intensified opposition to labor's exclusion from the Sherman Act, opposition that was clearly reflected in the legislative history of the Clayton Act.

The Sundry Civil Appropriations Bill did not restrict the use of regular Justice Department funds, and Wilson spent the next five months blocking other similar types of legislation.[257] Initially, when Wilson outlined his antitrust program before a joint session of Congress, it mentioned nothing of labor's objectives. Both labor and labor Congressmen[258] were infuriated by President Wilson's attempt to submit antitrust measures to Congress without keeping the party's promise to Gompers. Labor-sympathetic Congressmen also made it clear that unless labor's demands were considered they would block all of Wilson's antitrust measures. By mid-March 1914, when four antitrust measures had been introduced in Congress by the Wilson Administration without the provisions that labor requested, Gompers' angrily declared, "Without

---

[251] Ibid., 205.
[252] Ibid., 205; Joseph Kovner, "The Legislative History of Section 6 of the Clayton Act," *Columbia Law Review,* Vol. 47, No.5. (1947)
[253] Jones, 216.
[254] Jones, 204.
[255] Ibid..
[256] Ibid., 204.
[257] Lovell, 109; Jones, 205.
[258] Jones, 206.

further delay the citizens of the United States must decide whether they wish to outlaw organized labor."[259]

President Wilson's New Freedom principles were impeding the hopes of "industrial democracy," especially where vital anti-injunction legislation was needed. Although "industrial democracy" considerably weakened Wilson's New Freedom programs, there was little indication that Wilson was prepared to budge on the antitrust issue let alone support total immunity. Wilson's position in the business community was another factor motivating his inaction on the antitrust-labor issue. With a labor department control led by a radical labor activist and marked criticism for his proposed economic plans, this was not the most politically advantageous time for him to act. This also explains why Wilson did not immediately act against the business community after his inauguration.

Many business leaders opposed Wilson's candidacy, and prior to his inauguration, had insisted that his proposed economic policies led the country to depression. In the fall of 1913, a business recession had gripped the country, and the prognostications about the effects of Wilson's economic program seemed all too real. This prompted Wilson to slow down his zeal for reform and focus instead on changing the attitudes of the business community. Reverberating throughout his agenda was his campaign to ease the tensions between business and his administration. This could not be done through his support for a labor exemption, which was bitterly and persistently opposed by the business community. Changes to the Sherman Act, the business community argued would create business uncertainty and thus exacerbate the recession.[260]

Wilson was opposed to a labor exemption for both philosophical and practical political reasons but nevertheless had to take into account possible political retaliation for his inaction on the antitrust issue. Unlike Wilson, however, Democratic Congressmen were faced with recession era re-election in 1914, and many of them thought the wisest course of action was to drop the controversial antitrust program. Instead, the Democratic controlled Congress focused on more general reform legislation. However, since the time Wilson's submitted his first antitrust program to Congress, political pressure from labor increased significantly. [261]

President Wilson was still in the process of deciding what modifications were in store for his antitrust program. Wilson started in January 1914 with his antitrust program based on "New Freedom" principles, which provided more exact definitions of restraints of trade and increased the penalties for violation of the Sherman statute, but by mid-April 1914, his program was based on "industrial democracy," which provided regulation of industry by administrative agency.[262] Both Wilson and Congress had to act on the issue. President Wilson wanted his modifications to the Sherman statute enacted, and the only way he could secure Congressional approval was by addressing labor's demands. In light of this situation and Wilson's cautious faith in "industrial democracy," the time was ripe for the introduction of the Clayton Act in Congress. In his usual flare for hyperbole, Gompers called the Clayton Act "the greatest measure of humanitarian

[259] Ibid.
[260] Ibid., 206; McCartin, 16.
[261] Jones, 207.
[262] McCartin, 15-16; Jones, 207.

legislation in the world's history."[263] However, the Clayton Act proved to be one the most ineffective pieces of labor legislation ever passed by Congress.

THE CLAYTON ACT AND ITS LEGISLATIVE HISTORY

On April 13, 1914, the *New York Times* reported that President Wilson insisted upon passage of anti-injunction and anti-contempt legislation in order to keep the Democratic Party's promise to labor.[264] Simultaneously, Representative Henry D. Clayton, chairman of the House Judiciary Committee, announced that the Clayton Anti-Injunction and Anti-contempt bills would be submitted to the House for consideration and subsequent passage. The more effective Bacon-Bartlett bill, however, remained in the committee. The original Clayton Anti-Injunction bill restricted the courts use of injunctions.

It prohibited the issuing of injunctions and restraining orders "…in any case between an employer and employee, or between employers and employees, or between employees, or between persons employed and persons seeking employment, involving, or growing out of, a dispute concerning terms or conditions of employment, unless necessary to prevent irreparable injury to property, or to a property right…"[265] It also provided a section that listed labor activities that were not enjoinable by the courts. Some of these essential non-enjoinable rights included the right of a worker to quit, the right to collective bargaining, the right to have labor meetings, and the right to conduct primary boycotts (strikes).

Wilson was not entirely opposed to this compromise given that during his campaign he did mention that he was against the unrestricted use of injunctions in labor disputes. With restrictions on the use of injunctions moving forward in Congress, the President believed that this major victory would satisfy labor and end the opposition to his earlier antitrust programs.[266] In the *Democratic Text Book* (1912), Wilson's campaign declaration stated the following:

> Questions of judicial practice have arisen, especially in connection with industrial disputes. We [the Democratic Party] believe that the parties to all judicial proceedings should be treated with rigid impartiality, and that injunctions should not be issued in any case in which an injunction would not issue if no industrial dispute were involved.[267]

The Clayton bill was in line with this message and was far more conservative than the Bacon-Bartlett bill, inasmuch that the former did not give labor immunity from the Sherman statute. With the Clayton bill, Wilson was not subjected to as much criticism had he then went alone with the immunity bill.

The AFL was also reasonably satisfied with this bill, and the AFL Executive Council gave it approval.[268] On May 27, 1914, Gompers, speaking to members of the Executive Council, pushed for one amendment to the bill. He insisted that a concluding phrase should be added to

---

[263] Lovell, 99.
[264] Jones, 207.
[265] Berman, 99-100; Jones, 207; Lovell, 134.
[266] Jones, 207; McCartin, 14-15.
[267] Jones, 208.
[268] Jones, 207.

the bill: "nor shall any of the acts enumerated in this paragraph be considered or held unlawful in any court of the United States,"[269] emphasizing that the listed injunction restrictions applied to all courts. The Executive Council agreed to submit the proposal for the amendment to Congress. After changes in both the House and Senate, the final phrase read, "nor shall any of the acts specified in this section be considered or held to be violations of any law of the United States."[270] This final rewording was accepted by both Congress and the AFL.

Labor, however, was not totally appeased. Of significance was the fact that there were two different measures in Congress. The first was Wilson's antitrust proposal, and the second was the Clayton Anti-Injunction and Anti-Contempt bills. These were two separate initiatives in Congress until Arthur Holder, a member of the AFL's legislative committee suggested that the anti-injunction and anti-contempt measures be written into the President's antitrust bill in order to expedite passage.[271] Congress compromised and agreed to combine the anti-injunction and anti-contempt measure with the antitrust legislation. The antitrust bill included a new section based on Gompers' testimony before Congress which eventually became Section 6 of the Clayton Act. As presented by Representative Clayton, the original language of Section 6 stated:

> That nothing contained in the anti-trust laws shall be construed to forbid the existence and operation of fraternal, labor, consumer, agricultural or horticultural organizations, orders or associations operating under the lodge system, instituted for the purpose of mutual help, and not having capital stock or conducted for profit, or to forbid or restrain individual members of such orders or associations from carrying out the legitimate objects of such associations.[272]

At the time this section was introduced, it enjoyed the support of both labor Congressmen and the AFL. When this section was sent to the Judiciary Committee for approval, labor advocates called for stronger language. In particular, labor supporters wanted the substitution of the words "shall apply to," for the phrase, "shall be construed to forbid the 'existence' and operation of."[273] Wilson approved of the original language as presented, but he was opposed to the substitute language because it specifically excluded labor from the antitrust laws. The original language in Wilson's view only stated that labor unions could not be dissolved using the Sherman statute.[274] A stalemate subsequently ensued and after several days, in an attempt to break the deadlock, a committee of labor Congressmen in the House—Representatives David J. Lewis, Edward Keating,[275] John J. Casey and Isaac R. Sherwood—met with Wilson and Attorney General James Clark McReynolds,[276] who later became a devoted supporter of *Lochner* era jurisprudence.

---

[269] Ibid., 208.
[270] Ibid., 208.
[271] Gompers, *Seventy Years,* 2 vols, 295.
[272] Jones, 209.
[273] Ibid., 209.
[274] Ibid., 209.
[275] Edward Keating co-authored the Keating-Owen Child Labor Act of 1916, which a statute enacted by the Congress that "sought to address the perceived evils of child labor by prohibiting the sale in interstate commerce of goods manufactured by children." In 1916, it was signed into law by Wilson, but in *Hammer v. Dagenhart* (1918), the act was ruled unconstitutional: Stephen B. Wood, *Constitutional Politics in the Progressive Era: Child Labor and the Law*, Chicago: The University of Chicago Press, 1968.
[276] As an associate justice, McReynolds "was well known as a blatant anti-Semite and refused to sit near Louis Brandeis (the first Jew to sit on the Court) where he belonged on the basis of seniority for the Court's annual picture

On April 30, 1914, Wilson warmly received the pro-labor Congressional committee,[277] as Keating described the meeting later, they told Wilson that Gompers and other labor leaders, upon consultation with legal experts, had discovered that the section was not as strong as they initially thought. Wilson noted curiously that during a previous conversation with Gompers about the language both of them had agreed to accept it. After extended discussion, Wilson asked what caused Gompers to change his mind on the language. A member of the delegation then stated that Judge Alton B. Parker had pointed out to Gompers the weakness of the section. Keating then noted that upon hearing this, "the President face froze and from that point on he 'wouldn't yield an inch.'" According to Keating, the President immensely disliked Parker because he had opposed Wilson's nomination in the 1912 Democratic primary. [278]

Over a month had passed and the bill was still stalemated in the committee. During this impasse, Wilson had his leaders in the House resist every effort to include a labor exemption in the antitrust bill. On May 18, when the Judiciary again refused to consider labor's substitute language, Secretary Frank Morrison of the AFL declared that labor would carry the fight to both the House and the Senate. Simultaneously, labor Congressmen and other labor supporters continued to insist that they block the antitrust bill in its entirety unless the demands of labor were met. In response, Wilson's allies in Congress threatened to drop all of the labor sections from the bill if labor did not acquiesce in to keeping the original language. Gompers' earlier insistence that labor should be legally recognized arguably put the labor cause as a whole in jeopardy, especially labor's fight for immunity from the antitrust laws.[279]

Pointing to Gompers' testimony before Congress, Wilson's allies pointed out that labor was being unreasonable because Congress had acceded to labor's demands that trade unions be protected from dissolution. Representative John Floyd of the Judiciary Committee, an ally of Wilson's, pointedly asserted: "We are doing what Mr. Gompers asked. We are taking them out from the bad of the law that would make them liable to dissolution. This is a bill of rights for labor."[280] In addition to labor's original acceptance of language, Wilson's allies were now trying to paint Gompers as inconsistent and breaking faith with the political alliance. After Gompers testified before the House Judiciary Committee, the AFL presented a letter to Congress which unequivocally expressed labor's position on the passage of the Clayton Act.[281] Interesting

---

to be taken in 1924; Chief Justice Taft decided that the Court take no picture that year. McReynolds refused to speak to Brandeis for three years following his appointment and when Brandeis retired in 1939, did not sign the customary dedicatory letter sent to Court members on their retirement." During Benjamin Cardozo's swearing in ceremony, "he pointedly read a newspaper muttering "another one," and did not attend Felix Frankfurter's , exclaiming 'My God, another Jew on the Court!' He was also a confirmed misogynist. His fierce opposition in the face of Franklin Roosevelt's New Deal legislation to fight the Great Depression led to him being labeled, one of the 'Four Horsemen,' along with George Sutherland, Willis Van Devanter and Pierce Butler, all of which were hold outs from the *Lochner* era." McReynolds despised Roosevelt and never denied an attributed quote from him that stated, 'I'll never resign [from the Court] as long as that crippled son-of-a-bitch is in the White House. William F. Shughart II, "Bending Before the Storm: The U.S. Supreme Court in Economic Crisis, 1935–1937," *Independent Review* (2004): 80, fn. 56.

[277] Jones, 209.

[278] Ibid., 209.

[279] Ibid., 210; McCartin, 15.

[280] Ibid..

[281] Kovner, 755-757

enough, another point also arose during the Congressional hearings, and that concerned the clarity of the legislative language. The discussion concerned whether the language of the bill was not clear enough, especially in regard to Section 7 [subsequently Section 6].[282] Thus, two distinctly different interpretations arose in Congress.

Leadership changes in Congress, however, led to another compromise with labor. Two powerful members of the House—Representatives Robert L. Henry, chairman of the rules Committee, and Claude Kitchen, soon to become majority leader—had agreed to support labor's demands. The compromise phrase added to the section the following language: "nor shall such organizations or the members thereof, be held or construed to be illegal combinations or conspiracies in restraint of trade, under the anti-trust laws."[283] This compromise, however, led to even more confusion.

Immediately after submission, this phrase was given conflicting interpretation by Wilson's ally, Edwin Y. Webb, the newly appointed chairman of the Judiciary Committee. He declared that the phrase did not alter the substance of the original section and that with this new phrase the original section had just been rewritten. Webb stated it was rewritten "in such a way as to be more along the lines demanded by labor."[284] Labor Congressman, Robert L. Henry, on the other hand, gave a much different meaning to the new provision when he addressed the House to discuss how it had been formulated. Henry stated the he and several other representatives, not all members of the labor committee, were dissatisfied with the original provision because in their opinion it abandoned the party's promise to labor. Commenting sometime later, Frankfurter and Greene stated that "the debates in Congress looked both ways."[285] The pertinent promise outlined in their platform read:

> That there should be no abridgment of the right of wage earners and producers to organize for the protection of wages, and improvement of labor conditions, to the end that such organizations and their members should not be regarded as illegal combinations in restraint of trade.[286]

In response to these concerns, a group of representatives met in Henry's office and decided to change the substance of the original section so that the party did not renege on its campaign promise. After this meeting, AFL leaders were consulted to discuss the changes. Henry and the other representatives stated that their provision explicitly granted labor immunity from the antitrust laws.

In his statement in front of the House, Henry said that "they [labor officials] called their counsel into conference with us, and we concurred that this amendment added to section 7 gave them what these organizations long desired,"[287] immunity from the antitrust laws. Henry then went on that Section 7 "would clearly exempt labor organizations and farmers' organizations

---

[282] Kovner, 750.
[283] Jones, 213.
[284] Ibid., 212.
[285] Frankfurter and Greene, The Labor Injunction, 143.
[286] Jones, 210.
[287] Jones, 213; Kovner, 754.

from the provisions of the anti-trust laws."[288] This statement helps to explain why Gompers had such unyielding confidence in the final bill that passed Congress. In addition to relying on their own interpretation, leaders of the AFL sought legal counsel from labor lawyers and Federal Judge Alton B. Parker. With the assurance of legal counsel, Parker, and Henry, Gompers reported to the AFL Executive Council that an agreement had been reached between the President, the House Judiciary Committee, and the AFL. In Gompers' view, the agreement assured labor's exclusion from the Sherman statute.

Wilson, Webb, and the majority of the Judiciary Committee, on the other hand, did not accept this interpretation. Representative Webb and Floyd strongly asserted that the section did no more but make it impossible to dissolve labor unions under the antitrust laws, no immunity was given. Further, Webb insisted that unions were only removed "from the ban of the present law to the extent that in the future they cannot be dissolved as unlawful combinations. Their existence is made lawful and they are given a lawful status,"[289] nothing more. Supporting Webb's interpretation, Wilson in a public statement asserted that labor had not been given immunity from the Sherman Act, but were merely guaranteed the right to organize—a right to which there had been doubt, referring to Gompers' emphasis during his Congressional testimony.

Both Wilson and his allies in Congress were resolute in their position. The House debate that followed only reinforced the dispute over the different interpretations. Some representatives agreed with Wilson and Webb's interpretation and others agreed with Gompers and Henry's interpretation, whereas other representatives said that a precise interpretation was impossible because the section was too ambiguous. Supporting the argument made by George Lovell, one representative charged that Congress was "deliberately" avoiding plain English in order to pass policy making responsibility to the Supreme Court.[290] Thus, via a legislative deferral, Congress could not be held politically responsible for how the Court interpreted the section.

But the controversy over meaning was not confined to Section 6; there also was much debate over the interpretation of the injunction provision, Section 20. One Representative stated that the injunction prohibitions accomplished nothing because the language was limited to "employers and employees, and employer-employee relationships,"[291] which ceased when a strike occurred. It was also pointed out that there was no explicit definition of "property" in labor disputes, which could be defined as broadly as to mean "commerce" or as narrowly to mean "physical property."

Still other Representatives insisted that the section went too far because it legalized secondary boycotts. Webb, for instance, declared emphatically that he rejected the legalization of secondary boycotts. He stated:

> We did not intend, I will say frankly, to legalize the secondary boycott…It is not the purpose of this committee to authorize it, and I do not think any person in the House wants to do it. We do confine boycotting to the parties to the dispute, allowing parties to

[288] Jones, 213.
[289] Ibid., 213.
[290] See Lovell.
[291] Jones, 217-218.

> cease to patronize that party and *to ask others to cease to patronize the party to the dispute* [contradictory statement].[292]

Without realizing it, Webb made a contradictory statement and actually said that Congress did legalize secondary boycotts. Webb also stated that the section did legalize all the other acts mentioned in the section, which included, according to his statement, secondary boycotts.

After weeks of extended debate, both Gompers and Wilson held adamantly to their respective interpretations. When the House approved the measure, Gompers issued a press release that the bill secured "for America's workingmen freedom of self-protection."[293] He also wrote that labor had to resist every effort by the Senate to weaken the language. Additionally, Gompers refused to accept any other interpretation and was steadfast in his belief that labor was granted immunity from the Sherman Act. On one occasion, Gompers was asked whether he was certain that Section 6 granted labor immunity from the Sherman Act. He answered:

> …we have decided upon the amendment after a most careful consideration of the entire matter in conference with Judge Alton B. Parker, Attorney J. R. Ralston, of our Legislative Committee, Secretary Morrison…Not only that, but other eminent authorities have been consulted in the matter, and if Labor at last is deceived as to the provision of Section 7 [Section 6] there will be many others, some of high legal authority, who were equally deceived.[294]

Indeed, Gompers was told by numerous legal experts what the section meant, but so were Webb and Wilson. No clear interpretation existed, only various opinions on the meaning of Section 7.

As for Wilson, he maintained that his interpretation was the right one. When a business supporter questioned Wilson's "impartiality philosophy" regarding the controversial bill, Wilson replied, "The so-called labor exemption does not seem to me to do more than exclude the possibility of labor and similar organizations from being dissolved as in themselves combinations in restraint of trade."[295] Webb also emphasized this point when he asserted publicly that there was nothing "revolutionary or radical"[296] in the legislation. If Wilson endorsed a labor exemption, it would have been incongruent with how he viewed the purpose of "industrial democracy," which was to appease labor to a point to prevent militancy. Wilson was walking a fine political line between capital and labor. He was concerned with re-election in 1916 and understood that both labor and capital were needed to end industrial strife.

Upon consideration in the Senate, the bill's interpretation continued to be disputed. The Senate followed the same pattern as the House with Senators supporting Webb's interpretation and Senators supporting Henry's interpretation. Labor's right to exist was not in dispute, but whether the bill gave labor immunity and whether injunctions were successfully abated was fervently contested. Senator Charles A. Culberson, chairman of the Senate Judiciary Committee

---

[292] Jones, 212.
[293] Ibid., 213.
[294] Ibid..
[295] Ibid., 213.
[296] Ibid.

and Senator Key Pittman adamantly supported Henry's interpretation. Culberson, in reporting the bill, declared that "following the original purpose of the framers of the Sherman antitrust law, the bill proposed expressly to exempt labor…from the operation of the antitrust laws."[297] Pittman concurred with Culberson and insisted that if labor unions "cannot be construed to be illegal combinations or conspiracies,"[298] then they were not within the purview of the antitrust laws.

During Senate debate, Senator Jack Cummins attempted several times to strengthen the bill; however, all of his attempts failed.[299] But still the debate continued with Senator James A. O'Gorman declaring that Section 20 (the injunction prohibition section) did not diminish the courts' power. O'Gorman stated that Section 20 was merely a codification of the law. Supporting Henry, Senator Horace Chilton of the Judiciary Committee insisted that "the demands of labor organizations…were intended to be met in this section,"[300] referring to Section 6. What was accepted, however, was the now famous phrase at the beginning of Section 6 which declared, "the labor of a human being is not a commodity or article of commerce."[301] Indeed, this was a colorful phrase, but it still shifted attention away from the more pertinent issues, injunctions and immunity.

As for Gompers, he was convinced that Henry's interpretation was correct and grandly declared that the words of Section 6 and 20 "were sledgehammer blows to the wrongs and injustices so long inflicted upon the workers…[It] is the Magna Carta upon which the working people will rear their structure of industrial freedom."[302] This statement was also unappreciative of the fact that the bill contained numerous qualifiers, which did exactly what Gompers had feared before the bill reached the Senate. The qualifiers appeared in the bill after modifications in the Senate. The most pertinent modifications in terminology were the inclusion of qualifiers in both Section 6 and 20. In Section 6, the word "lawful" was added, and in Section 20, the word "lawfully" was added. Section 6 now read as follows: "or to forbid or restrain individual members of such organizations from "lawfully" carrying out the legitimate objectives thereof…," and Section 20 read: "or from ceasing to patronize or to employ any party to such dispute, or from recommending, advising or persuading others by peaceful and lawful means so to do…"[303]

The following offers a glimpse of the Clayton Antitrust Act as a whole and its most pertinent sections to labor:

Section 6 states: (Legalization of Labor Unions)

> That the labor of a human being is not a commodity or article of commerce. Nothing contained in the antitrust laws shall be construed to forbid the existence and operation of labor…organizations, instituted for the purpose of mutual help and not having capital stock or conducted for profit, or to forbid or restrain individual members of such organizations from <u>lawfully</u> carrying out thereof; nor shall such organizations, or the

[297] Ibid.
[298] Jones, 213.
[299] Kovner, 751.
[300] Jones, 213-214.
[301] Berman, 99; Jones, 214.
[302] Berman, 99; Jones, 214.
[303] Jones, 218.

> members of thereof be held or construed to be illegal combinations or conspiracies in restraint of trade under the law.[304]

Section 20: (Injunctive Prohibition Section)

> That no restraining order or injunction shall be granted by any court of the United States…in any case between an employer and employee [Proximate Relationship], or between employers and employees, or between employees, or between persons employed and persons seeking employment, involving, or growing out of, a dispute concerning terms or conditions of employment, unless necessary to prevent irreparable injury to property, or to a property right [the key escape clause], of the party making the application, for which injury there is no adequate remedy by law…[305]

Underlined in both Sections 6 and 20 were words and phrases in the bill that became the subject of great controversy in the courts. In *Duplex* (1921), the *Lochner* era jurisprudence remained the dominant practice of the Court and labor's plight as a judicial underdog continued.

It was also necessary to quote at length these two sections to prove a point. When one reads the Clayton Act, it appears as though labor was now totally exempt from the prosecutorial reach of the Sherman Act and "injunction judges." But one of the major underpinning of this bill was the use, by Congress, of extensive, confusing language. The Clayton Act labor exemption sections were not written in plain, non-ambiguous English. Partly to blame for this was the central focus of the bill itself. The main purpose of this act was to strengthen the Sherman Act's reach against corporate monopolies. This might explain some of the extensive, confusing language that anti-labor justices later exploited. With this immensely ambiguous language, Daniel Davenport, who for years was an exceptional attorney in cases against labor, and counsel for the Loewe company in the Danbury Hatters' case, insisted before the United States Commission on Industrial Relations that the Clayton Act gave labor no advantage that it did not already possess.[306]

After prolonged debate in both the House and Senate, Congress finally submitted the Clayton Antitrust Act to Wilson for his approval. On October 15, 1914, Wilson signed the bill into law. As for the correct interpretation of the Clayton Act, there was none. When the Supreme Court had to apply the Clayton statute in *Duplex* (1921), it had two different interpretations to choose from. No definitive Congressional intent was retrievable from an examination of the legislative history. Also, from reviewing the Congressional record, there was immense confusion over the issue of secondary boycotts.

Representative Webb stated blatantly that they were illegal; however, he contradicted himself and unknowingly stated the contrary. So much confusion arose from the labor immunity argument that the secondary boycott issue drifted into the periphery. The single most important reason why the bill was ineffective, besides the arguments about a legislative deferral, Gompers' emphasis on labor's right to exist, and the two interpretations in Congress, was the undue

---

[304] Berman, 99.
[305] Berman, 100-101.
[306] Ibid, 102.

interference by Wilson, whose role was pivotal to the bill's ultimate failure. While he was balancing between labor and capital, between "New Freedom" and Industrial Democracy, and between Wilson the reformer and Wilson the anti-labor academic, labor suffered as well as Congress's ability to express its intent.

DUPLEX AND THE PROXIMATE RELATIONSHIP DOCTRINE

By 1921, the "Age of Industrial Democracy," which showed promise for significant labor gains ended and a long string of labor injunctions crippled labor's effectiveness. The *Duplex* case was symbolic of the death of this political alliance and continued judicial hostility to labor practices. On January 14, 1921, Frankfurter sent Holmes a letter conveying his disappointment with the Court's recent *Duplex* decision. Near the end of the letter he praised Holmes' dissent and questioned how such an insightful jurist "came out of this part of the world." [307] Frankfurter wrote:

Dear Holmes,

> The Clayton Act case [*Duplex*] must have seemed a familiar rehash of *Vegelahn v. Guntner* and *Plant v. Woods*[308] issues though here there was a new phrase. To be sure, Congress was dishonest in the Clayton Act, and both Congress and the Presbyterian Pope (alas! what feeble Pope he, that dwells in the White House, is)[309] handed "Labor" a gold-brick. And yet, and yet for the Court to say that all those words mean nothing. It needed no prophet to foretell the result and yet, it is a strong dose…So far as the social consequences go, the decision might well teach Messrs. Gompers et al. a few things!
>
> I sometimes wonder how you ever came out of this part of the world. The answer is you came out of it. I wrote this because I had to and now goodnight.
>
> F.F[310]

When Frankfurter mentioned that Congress was "dishonest," he was referring to the highly ambiguous language of the Clayton Act and its predictable failure to withstand hostile judicial interpretation. According to Frankfurter, the lesson Gompers learned from the *Duplex* decision was to be cautious in championing legislative acts that supposedly benefited labor. As mentioned before, Gompers enthusiastically endorsed the bill irrespective of the two Congressional interpretations and Wilson's detrimental interference.

On January 20, Holmes replied to Frankfurter's letter and praised Brandeis's concurring dissent. Holmes wrote:

Dear Frankfurter,

> How many times your kind words have given me courage in despondency! I thank you often in my heart. The Clayton Act case was the one though that most stirred me in this batch. I thought Brandeis's opinion admirable and, although I had some

---

[307] Mennel and Compston, 101.
[308] Holmes's Massachusetts Supreme Court dissents, *Vegelahn v. Guntner* (1896) and *Plant v. Woods* (1900), supported labor's right to pursue it own ends by peaceful picketing even though the results might injury the interests of capital: Mennel and Compston, 100-101.
[309] Woodrow Wilson was a devoted Presbyterian who unduly interfered with the legislative process to enact the Clayton Act.
[310] Mennel and Compston, 100-101.

> misgivings as to what the New York Court would have said, to which if necessary there might have been further answers, I agreed with it joyfully or rather, sadly because of the small adherence it secured. I have been driven this week and therefore write but this line before going to my evening game of solitaire.
>
> Yours ever,
> O.W. Holmes[311]

Since the union involved in the *Duplex* case centralized its secondary boycott around New York City, the financial hub for the company, Duplex petitioned a lower court in that jurisdiction for injunctive relief. The District Court for the Southern District of New York heard Duplex's petition for an enjoinment of the boycott. The company charged that the union was an illegal combination that monopolized other unions in an unlawful secondary boycott. On April 23, 1917, Judge James Manton rendered a decision denying the company's petition. Manton held that since the conduct of the union was lawful, under the terms of the Clayton Act, the union could not be enjoined. The doubts that Holmes conveyed in his letter to Frankfurter concerned the peaceful nature of the strike, which was later challenged on appeal. Despite this, however, Holmes was convinced that the Duplex decision was an egregious case of judicial activism.

Duplex Printing Press v. Deering (1921) was the most substantial ruling after the passage of the Clayton Act and reaffirmed *Lochner* era jurisprudence. The Duplex Printing Press Company was a newspaper press manufacturer located in Michigan. There were three other such companies in the country. Between 1909-1912, the machinists' union convinced the other three newspaper press manufacturers to conform to an agreement allowing eight hour days and a reasonable minimum wage. The Duplex Printing Company, on the other hand, refused to agree to the machinists' union demands and operated on an open-shop basis. Additionally, the Duplex company required its employees to work ten hour days. Consequently, a portion of the Duplex employees went on strike. The three other manufacturers said that they terminated all business ties with Duplex Printing unless they signed the machinists' union agreement. Duplex Printing still refused to concede and the machinists' union instructed other machinists' unions at different company connected to Duplex Printing to boycott all business with the company. This was a secondary boycott.[312]

Duplex Printing appealed the decision and both the lower New York court and the Second Circuit Court of Appeals affirmed the lower court's judgment and rejected the company's petition for an injunction. On a decision of 2-1, the appeals court held that under the Clayton Act, the essentially peaceful activities of the union made the Sherman Act inapplicable. In addition it held that the Clayton Act legalized secondary boycotts because of the phrase "in 'any' case between employer and employees."[313] The appeals court reasoned that the inclusion of the word "any" applied to both primary and secondary boycotts.

Second Circuit Court of Appeals Judge James Rogers wrote a vigorous dissent. In his opinion, the secondary boycott was accompanied by violence and, therefore considering the qualifiers in the Clayton Act, declared that the union was an illegal combination under the

---

[311] Ibid, 101.
[312] Berman, 103-106; Jones, 218; Lovell, 140-144; *Duplex v.Deering,* US 443, 470 (1921)
[313] Berman, 104-105; Jones, 219.

Sherman statute. He insisted that the activities were as clear a violation of the Sherman Act as the Danbury Hatters' secondary boycott. Further, he emphasized that the Clayton Act only prohibited injunctions in labor disputes involving "an employer and his own employees" and therefore secondary boycotts were still illegal. Referring to the unions' plans to make Duplex "unmarketable," Rogers declared:

> If this can be done under the laws of the United States, then it seems that no manufacturer of printing presses in this country can maintain "open" shop, no machinist engaged in the manufacture of such presses can earn his living at his trade, unless he consents to join a union, and be bound to all its rules and regulations, and channels of interstate commerce are practically closed against the products of an "open" shop [non-union products].[314]

From capital's perspective, an open shop agreement was equivalent to a "yellow-dog" contract for employers. While the courts acknowledged an employer's right to enforce yellow-dog contracts, it rejected an "open" shop strike as an undue restraint on trade. Rogers insisted that when employers and employees from other companies were not allowed to handle open shop, that is, non-union goods, then it constituted a violation of the law, especially when a business was engaged in interstate commerce.

When Duplex Printing appealed to the Supreme Court, its petition for an injunction was granted by a vote of 6 to 3. The court stated that the machinists' union boycott was a violation of the Sherman Act despite the passage of the Clayton Act. The union's attorneys, conversely, argued that the unionists had no direct hand in enforcing the boycott. The members and its labor allies only refused to handle and transport Duplex's presses. Justice Mahlon Pitney, writing for the Majority, stated that Section 20 of the Clayton Act did not legalize secondary boycotts because the act only legalizes boycotts involving "employers and employees."[315]

Pitney reasoned that since Section 20 prohibited injunctions in cases involving boycotts between "employers and employees," it only forbade the granting of an injunction in "parties standing in 'proximate' relation to a controversy,"[316] and thus the secondary boycott was not legalized. This established the Post-Clayton "Proximate Relationship" standard, which was a reaffirmation by the Court that the judicial construction in the Danbury Hatters' case (1908) involving secondary boycotts would stand. Congress was to blame for this confusion because of the ambiguous language of the statute and its lack of attention to the secondary boycott issue. Pitney wrote further that secondary boycotts were not peaceful because they constituted a "threat" to immediate employers not engaged in the labor dispute. He wrote:

> To instigate a sympathetic strike in aid of a secondary boycott cannot be deemed 'peaceful and lawful' persuasion [as spelled out in Clayton Act]. In essence it is a threat to inflict damage upon the immediate employer, between whom and his employees no dispute exists, in order to bring him against his will into a concerted plan to inflict damage upon another employer who is in dispute with his employees.[317]

---

[314] Berman, 106.
[315] Bernstein, 191-193.
[316] Berman, 106
[317] Ibid, 107

Equating secondary boycotts with unlawful and injurious activities was a bit of a stretch; especially where the damage inflicted upon an immediate employer was financial. Whether the Duplex strikers were in violation of the qualified sections of the Clayton Act was greatly disputed in the Court.

Pitney then went on to insist that labor was not granted immunity from the Sherman statute because of the numerous qualifiers present in the language of the Clayton Act. Referring to the phraseology in Section 20, Pitney wrote: "The emphasis placed on the words 'lawful' and 'lawfully,' 'peaceful' and 'peacefully,' and the references to the dispute and the parties to it, strongly rebut a legislative intent to confer a general immunity for conduct [sic] violative of the Anti-trust Laws, or otherwise unlawful."[318] Pitney stated that there was nothing in the statute that did not hold labor accountable for illegal acts. He then proceeded to interpret Section 6 and make considerable critiques of the language in favor of Duplex Printing, stating that "there is nothing in the section to exempt such an organization or its members from accountability where it or they depart from its normal and legitimate objects and engage…in restraint of trade."[319] The Court enjoined the union and secondary boycott from interfering in any way with the operation of the Duplex company and its business transactions.

Justices Holmes, Brandeis, and John Hessin Clark vigorously dissented from with Pitney's interpretation. Speaking through Brandeis, they insisted that the Clayton Act was intended to improve the legal status of labor and agreed with the decision of the lower court. Using the concept of "common interest," they asserted that those engaged in a secondary boycott had a right to refuse "to expend their labor upon their standards of living and the institution they are convinced supports it." Brandeis emphasized that the phrase in the Clayton statute which prohibited injunctions "between employers and employees" legalized the secondary boycott. For according to the statute, a labor dispute could involve multiple employers and multiple employees, thus secondary boycotts were legal. Brandeis then wrote that the Duplex labor conflict was "not for judges to determine…this is the function of the legislature which, while limiting individual group rights of aggression and defense, may substitute processes of justice for the more primitive method of trial by combat."[320] In effect, the Court was overreaching and not providing sufficient deference for Congress to formulate an effective law to aid labor.

The Court's judgment in *Duplex* was undeniably the most significant since the Danbury Hatters' case (1908). It reaffirmed *Lochner* era jurisprudence and increased the means by which labor strikes could be enjoined. Further, it reiterated that secondary boycotts were illegal and that labor, regardless of the Clayton Act, was within the purview of the Sherman statute. In his opinion, Justice Pitney declared that the Clayton Act was "declaratory of the law as it had stood before."[321] Frankfurter and Greene later wrote that in interpreting the Clayton Act, "the Supreme Court had to find meaning where Congress had done its best to conceal meaning."[322]

---

[318] Ibid, 107; *Duplex v.Deering,* US 443, 470 (1921)
[319] *Duplex v.Deering,* US 443, 470 (1921)
[320] Mennel and Compston, 101.
[321] Lovell, 99.
[322] Bernstein, 207.

BEDFORD STONE CASE

The *Bedford Cut Stone Company* (1927) decision was substantial because it renewed academic and legal interest in the labor-antitrust controversy. Around this time, monographs like Berman's *Labor and the Sherman Act* and Frankfurter and Greene's *The Labor Injunction* reinvigorated legal debate. This decision also appeared to mark the victory of Classical Rule of Reasonists over the pro-labor, Post-Classical Rule of Reasonists, two Court factions that battled for about nine years since *Chicago Board* (1918). Following *Duplex* (1921), an immense paralysis, brought on by endless court injunctions, crippled labor's power to recruit, to organize, and to strike. In 1920, aggregate union membership peaked to a little over five million, but by 1923, union membership declined drastically by two million.[323] This trend continued until the Bedford Stone case galvanized the next great labor movement, the second "Anti-Injunction Campaign." With this movement, criticism of *Lochner* era jurisprudence intensified and jurists, like Holmes and Brandeis, became judicial symbols of labor's great battle.[324]

Prior to 1921, Bedford Cut Stone Company engaged in quarrying and cutting limestone headquartered in Bloomington, Indiana. The company operated under a trade agreement with the Journeyman Stone Cutters' Association of North America. In April 1912, the Stone Cutters' union was unable to obtain a contract renewal from the Bedford Cut Stone Company and a strike ensued. Around July first, Bedford, with the help of similar businesses, reestablished operations despite intense opposition from the Stone Cutters' Union. In its constitution, the national union stipulated that "No member of this association shall cut, carve or fit any material that has been cut by men working in opposition to this association."[325] As all members, whether at Bedford Stone or other similar companies were compelled to comply with this provision. When the national union enforced this provision in 1924, a secondary boycott halted the operations of other stone cutting business around the country.[326]

In response, Bedford Cut Stone Company and about twenty other businesses petitioned the District Court of the District of Indiana for injunctive relief and charged that the national union conspired to restrain interstate commerce. Judge James Anderson heard the companies' case and rejected the petition. The companies then appealed the decision to the Seventh Circuit Court of Appeals. On October 28, 1925, the court reaffirmed the holding of the lower court, citing insufficient evidence to establish that the union conspired to restrain trade in violation of the Sherman statute. The appeal's court cited that repetitious insufficient evidence was presented to prove that quarrying and cutting of stone or any associated operations were interfered with, with no evidence of violence or threats. Although the acts of the national union "may have tended somewhat"[327] to restrain trade, the court held that the national union was within its right to carry out such actions.

Upon appeal, on April 11, 1927, the Supreme Court held that the lower courts erred and granted the companies request for injunctive relief. The Court reasoned that, since 75 percent of

---

[323] Bernstein, 84.
[324] "Labor Plans War in Injunction Case," *New York Times*, 26 May 1927: 28.
[325] *Bedford Cut Stone Co. v. Journeyman Stone Cutters' Ass'n of North*, 274 US 37 (1927); Berman, 171; Baker, 208-209.
[326] Berman, 170-171; Baker, 208; Bernstein, 213-215.
[327] Berman, 171.

Bedford Cut Stone Company's "aggregate sales"[328] were made through interstate commerce, the secondary boycott violated the Sherman Act. Justice George Sutherland[329] wrote the majority opinion and emphasized that the evidence demonstrated "many instances of interference with the petitioners' stone by interstate customers and expression of apprehension on the part of such customers of labor troubles if it they purchased the stone."[330] Sutherland wrote that the secondary boycott threatened other employers with labor disputes if they required their employees to handle "unfair"[331] stone, and local unions were threatened with revocation of membership if they allowed their members to handle the "unfair" stone.

Sutherland went on to say that the local labor conflict with Bedford Cut Stone Company was not important and was just the means by which interstate commerce as a whole was restrained. Sutherland wrote: "In other words, strikes against the local use of the product were simply the means adopted to [sic] effect the unlawful restraint. And it is this result, not the means devised to secure it, which gave rise to the character of the conspiracy."[332] Applying the *Duplex* standard, Sutherland pointed out that both the *Duplex* and *Bedford Stone* cases were the same because "did not differ in essential character."

In *Duplex*, the Court defined the illegal secondary boycott as a "combination not merely by peaceful means to persuade complainant, or advise or by peaceful means persuade complainant's customers to refrain…but to exercise coercive pressure upon customers, actual or prospective, in order to cause them to withhold or withdraw patronage."[333] Sutherland was convinced that the Stone Cutters' union activities, regardless of local intent, were primarily aimed at narrowing Bedford Cut Stone Company's interstate commerce by taking away its customers, and argued that labor strikes were "necessarily illegal if thereby the interstate trade of another is restrained."[334] The Court granted the injunction, and public criticism of the Court increased as a result.

The rest of the Court, however, was not as convinced by Sutherland's reasoning. Justices Edward Terry Sanford and Harlan Fiske Stone wrote concurring opinions. They both agreed with the ultimate holding in the case but could not discern the criminal act to which the Sherman statute applied. Sanford wrote: "I concur in this result upon the controlling authority of Duplex v. Deering, 254 U.S. 443, 478…which, as applied to the ultimate question in this case, I am unable to distinguish."[335] Stone wrote: "As an original proposition, I should have doubted whether the Sherman Act prohibited a labor union from peacefully refusing to work upon material produced by nonunion labor or by a rival union, even though interstate commerce was affected."[336] Again, both Stone and Sanford were uncertain about the criminality of the acts but agreed that *Duplex*

---

[328] Ibid., 172

[329] While he was a Senator from Utah, Sutherland stated that secondary boycotts were "an evil thing," Baker, 209. During the FDR Administration, Justice Sutherland, along with James Clark McReynolds, Pierce Butler and Willis Van Devanter, was part of the conservative "Four Horsemen" who struck down New Deal legislation as unconstitutional.

[330] *Bedford Cut Stone Co. v. Journeyman Stone Cutters' Ass'n of North*, 274 US 37 (1927); Berman, 172.

[331] Berman, 173.

[332] Ibid., 173.

[333] *Bedford Cut Stone Co. v. Journeyman Stone Cutters' Ass'n of North*, 274 US 37 (1927); Berman, 174.

[334] Ibid., 174.

[335] *Bedford Cut Stone Co. v. Journeyman Stone Cutters' Ass'n of North*, 274 US 37 (1927); Berman, 174.

[336] Ibid.

was the proper standard applied. Stone emphasized that a lot of Sutherland's rationale was inconsistent with business antitrust cases and therefore he was in doubt over Sutherland's reasoning this case. Stone did agree, however, that the *Duplex* precedent applied to the criminal acts committed by Stone Cutters' Union and thus concurred with the majority.

Both Justices Holmes and Brandeis dissented. Writing for the minority, Brandeis paid significant attention to the application of the Rule of Reason. He wrote:

> I have no occasion to consider whether the restraint which was applied wholly intrastate, became in its operation a direct restraint upon interstate commerce. For it has long been settled that only unreasonable restraints are prohibited by the Sherman Law…And the restraint imposed [here] was, in my opinion, a reasonable one. The [Sherman] Act does not establish the standard of reasonableness.[337]

Brandeis criticized Sutherland for abandoning the Rule of Reason when it was established for both labor and business combinations. In basing his decision solely on the restraint and not its aggregate effects on interstate commerce, Brandeis argued that Sutherland was ignoring the very purpose for which the Rule of Reason was established. But Brandeis was not talking about the Classical Rule of Reason; he was applying his Post-Classical Rule of Reason, which was labor friendly. Brandeis wrote that by using the "[Brandeisian] Rule of Reason," "the propriety of the unions' conduct can hardly be doubted by one who believes in the organization of labor conduct."[338] The dissent in this case illustrated how both Holmes and Brandeis dabbled with judicial construction as a means to frustrate the majority, but they still strongly believed in judicial deference. The Rule of Reason was the closest the majority got to deferring to the legislative intent by showing that Congress did not intent to outlaw all contracts.

The Brandeisian Rule of Reason was the closest doctrinal deferral ever presented by the judiciary during the *Lochner* era. Brandeis stated that the national union was within its rights to enforce its contractual agreement with its members. Upon membership, stone cutters' were aware of its constitutional restrictions not to work on "unfair" stone. He observed that the stone companies were not weak and had large financial resources. On the other hand, their employees, Brandeis noted, had scattered membership with an average of 33 members per company and therefore it if standing alone they had no bargaining power. It was only through connection with the national union that they gained equivalence in bargaining power, especially in local labor disputes. Emphasizing the reasonableness of the stone cutters' actions, Brandeis wrote that the national union did not prohibit the handling of stone because it was an article of commerce, which was clearly illegal. It only enforced a contract among constituent unions not to handle "unfair" stone.[339] The union was not violent and it did not explicitly call for a secondary boycott, but only enforced an agreement among its members who were obligated to comply for self-protection against very strong employers.

On April 11, 1927, the same day the Court handed down its decision, Brandeis wrote a letter to Frankfurter in which he expressed his belief that the Bedford Stone decision would awaken the dormant labor movement. Brandeis wrote: "If anything can awaken Trade Unionists

---

[337] *Bedford Cut Stone Co. v. Journeyman Stone Cutters' Ass'n of North*, 274 US 37 (1927)
[338] Berman, 174; Peritz, 89, 93.
[339] *Bedford Cut Stone Co. v. Journeyman Stone Cutters' Ass'n of North*, 274 US 37 (1927)

from their lethargy, this should. And perhaps it needs a jolt of this kind to arouse them in this era of friendly cooperation."[340] Especially so in this case that involved a group of peaceful stonecutters who refused, in accordance with their constitution, to "handle" limestone cut by hostile stone cutter employers. Brandeisian historian David Levy called this decision "the high point in the trend toward utilizing the antitrust structure to curb labor activity."[341]

The Bedford Stone holding was a capstone of the long development in the application of the Sherman statute against labor. The decision in this case infuriated labor organizations and drew much publicity. Scathing criticism from the liberal press soon followed this case. One month later, the *New York Times* article entitled "Labor Plans War in Case" epitomized labor's agitation. In the article, AFL president William Green, while speaking before the National Civic Federation, declared that labor emphatically refused to accept the Court's decision in the Bedford Stone case.

While praising Brandeis and Holmes' vigorous dissents, Green insisted that the Court applied a "strange doctrine."[342] "In plains terms," Green asserted, "hundreds of men are being forced to work, by order of the Court, against their will and in spite of their protest…It means forced labor in a free country governed by a Constitution and where free Government derives its powers from the consent of the governed."[343] He went on that labor intended to seek substantive legislation "against the abuse of the writ of injunction."[344] Green echoed the sentiment of labor and soon Congress, who in the coming years developed just that legislation. The Bedford Cut Stone case added to the already significant judicial construction developed in the Duplex, and the Danbury Hatters' cases, representing *Lochner* era jurisprudence at its zenith.

THE ANTI-INJUNCTION MOVEMENT, FRANKFURTER, AND THE NORRIS-LA GUARDIA ACT:
LABOR'S WAR AND FRANKFURTER

"Indeed," Frankfurter and Greene articulated in 1928, "the use of injunctions in labor legislation furnishes the most striking instance, barring the history of the due process clause, of the luxurious development of the American legal doctrine."[345] Morris Ernst, an official for the American Civil Liberties Union (ACLU), told the Senate Judiciary Committee in 1928 that he uncovered that injunctions were used to enjoin prayer on the roadside, singing in groups, and required that picketers speak English.[346] These prohibitions demonstrated the absurd use and abuse of injunction by the judiciary. But the injunctions that infuriated labor the most were those issued to enforce "yellow-dog" contracts. Applying the *Hitchman* (1917) standard, courts granted employers the right to operate closed shops and to enjoin any attempts by their employees to unionize. Aside from the general use of injunctions under the Sherman statute, the granting of injunctions to enforce yellow-dog contracts fueled labor's agitation. The judiciary's

---

[340] Melvin I. Urofsky and David W. Levy, *Half Brothers, Half Son: The Letters of Louis D. Brandeis to Felix Frankfurter*, Norman: University of Oklahoma Press, 1991: 283-284.
[341] Ibid., 284.
[342] "Labor Plans War in Injunction Case," *New York Times*, 26 May 1927: 28.
[343] Ibid., 28.
[344] Ibid
[345] Bernstein, 393; Felix Frankfurter and Nathan Greene, "The Use of Injunctions in American Legal Controversies," *Law Quarterly Review*, 44 (1928), 44.
[346] Baker, 205; Bernstein, 393.

abuse of injunctions was fought by labor organizations, by liberal scholars, and by labor friendly politicians. Keeping with William Green's statement after the Bedford Stone case, labor launched an all out war on injunctions.[347]

Along with national unions, local unions also participated in the battle. In 1928, the AFL made the injunction a major issue in the presidential election. Early that year, Governor Alfred E. Smith of New York, the leading Democratic hopeful, supported legislation by the New York Federation of Labor. The Byrne-Lefkowitz bill prohibited the use of injunctions during strikes until appropriate arbitration addressed the concerns of both sides. This local state measure, however, was soundly defeated by conservative members of the New York state legislature. Smith clinched the Democratic primary and included in his platform a proposal to seek substantial legislative relief from the labor injunction. The Republican platform mentioned nothing of legislation but did strongly denounce its abuse. The Republican nominee, Herbert Hoover, did not explicitly state that he intended to seek legislation, but on numerous occasions during the campaign referred disparagingly to labor injunctions. Since legislation was already underway in the Senate, Hoover's victory was of no major concern to labor organizations.

In the periphery during the presidential campaign was federal anti-injunction legislation proposed by Senator Henrik Shipstead. On December 12 1927, Senator Shipstead introduced the Shipstead bill. The first significant line in the bill read: "Equity courts shall have jurisdiction to protect property when there is remedy at law."[348] Put simply, federal courts, standing in equity jurisdiction, were prohibited from issuing injunctions when sufficient time was available to address the matter in court. The second line read: "for the purpose of determining such jurisdiction, nothing shall be held to be property unless it is tangible and non-transferable, and all laws and parts of the laws inconsistent herewith are hereby appealed."[349] In other words, property was not broadly defined to include commerce and only material property was considered property at law. This line also repealed inconsistent sections of the Clayton Act which contradicted this new bill.

The driving force behind this bill was Andrew Furuseth, president of the International Seaman's Union. He thought that since property was broadly defined to include commerce and trade it allowed the courts to abuse injunctions.[350] He reasoned that if property was defined to mean only material, tangible property than no labor-injunction controversy existed. The Clayton Act attempted just such outcome with the opening statement of Section 6 reading "labor is not a commodity or article of commerce."[351] It was reasoned in that line that if employers could not broadly define property to include labor then workers could strike without infringing upon an employer's property rights and thus strikes were secure from injunctions.

Upon referral of the Shipstead bill to the Senate Judiciary Committee, Senator George Norris formed a subcommittee to investigate the practical application of such a law. Norris selected pro-labor Senators Tom Walsh and John J. Blaine to join him on the subcommittee. On

---

[347] "Labor Plans War in Injunction Case," *New York Times*, 26 May 1927: 28.
[348] Bernstein, 395; Lovell, 182.
[349] Ibid.
[350] Bernstein, 395; Lovell, 182.
[351] Berman, 99; Bernstein, 395; Lovell, 183.

February 8, 1928, when hearings commenced, conflicts between the unions immediately followed. Berstein notes that at a conference with over 127 AFL and railway unionists "sharp disagreement"[352] was clearly noticeable. The railway brotherhood chief counsel, Donald Richberg, warned the proposed Shipstead bill might cause more injunctions and protected "yellow-dog" contracts as transferable property. Even Furuseth's attorney, Winter S. Martin, commented that there was much opposition to the Shipstead bill.[353]

During the hearing, William Green made it clear that he was strongly opposed to the abuse of injunctions, but was not overly supportive of the Shipstead bill, and the conflict over the bill continued. Legal counsel for the United Mine Workers observed that bill was irrelevant to their problems. Joseph Padway, attorney for the Wisconsin Federation of Labor, insisted that the ambiguous language of the Shipstead bill rendered the bill ineffective. Morris Ernst, of the ACLU, supported the bill and said that any measure restricting injunctions could possibly help and urged the committee to support the bill. The American Patent Law Association was strongly opposed to the bill and warned that it undermined the law of patents, trades, and copyrights. And of course, conservative organizations like the National Association of Manufacturers, the American Bar Association, the League for Industrial Rights, and the Association of Railway Executives refused any statute that eliminated either yellow-dog contracts or injunctions, as they deemed them essential for protection against labor extremists.[354]

The subcommittee was overwhelmed by the opposition and agreed that the Shipstead bill needed a thorough overhauling. On February 18th, the Senators decided to drastically reshape the Shipstead bill despite the objections of Furuseth. Even Frankfurter, a strong advocate of anti-injunction legislation, was opposed to the Shipstead bill. Frankfurter and Greene wrote: "The Shipstead bill condemns many well-settled and beneficent exercises of equitable jurisdiction that do not touch even remotely the interests of labor."[355] Frankfurter thought that the measure was extreme insofar as it could restrict federal courts' use of injunctions in "extraordinary" circumstances which required immediate action. Even Senator Henrik Shipstead was not overly concerned with the bill that bore his name and only introduced it as a favor to his friend, Furuseth. With this type of opposition, the Furuseth anti-injunction measure was doomed to failure.

During the closing hearings, the subcommittee called in a group of injunction experts to help draft a new bill. Frankfurter was included in these experts along with Edwin E. Witte, a learned experts on the subject, Donald R. Richberg, counsel for the railway unions, and others. Collectively, these scholars provided the committee with the richest legal detail on how to pass an effective anti-injunction law. After their testimony, a new bill was drafted wholly different from the Shipstead bill. A publication of the time noted that "They [the injunction experts] locked themselves in and for forty-eight hours gave their undivided attention …to every court decision…They reviewed the decisions…with the most scrupulous case,"[356] as well as acute insight into the constitutional ramifications that might follow from an anti-injunction bill.

[352] Bernstein, 395.
[353] Ibid., 395-396.
[354] Ibid.
[355] Ibid.
[356] Bernstein, 397.

Knowledgeable of the fact that the bill had to face a hostile judiciary, the experts put the utmost care into drafting substantially effective language.

In addition, during debates, Senator Robert Wagner insisted that "The record should be complete so that when the Courts come to pass upon what we are doing here today they may be fully informed of the purpose which moved us and of the ends we desired."[357] Wagner, like Frankfurter and Greene, was arguing for a clear legislative history so that upon judicial review there would be no doubt about Congress's intent. Norris also insisted upon a clear legislative record. Citing *Duplex*, Norris maintained that the Court "when they were taking the life blood of the Clayton Act…quoted reports from the Committee on the Judiciary in the Senate, they quoted speeches and controversies taking place on the floor…"[358] In Duplex, the Court used Congressional records to establish that Webb's interpretation of the Clayton Act was the intent of Congress. Norris wanted to avoid giving the Court any ammunition for disturbing the intent of the Norris-LaGuardia Act.

As a result of these deliberations, the Norris measure was introduced on May 29, 1928. This measure served as the template for the final legislation. Section 1 denied jurisdiction to federal courts to grant injunctions in cases growing out labor disputes unless procedural requirements (which had expressed limitations and definitions contained in the statute) were met and the injunction conformed to public policy. Section 2 outlined the public policy for the United States as follows:

> Whereas under prevailing economic conditions, developed with the aid of governmental authority for owners of property to organize in the corporate and other forms of association, the individual unorganized worker is commonly helpless to exercise actual liberty of contract…[this segment included a list of how workers might express their liberty of contract]…therefore, the following definitions of, and limitations upon, the jurisdiction and authority of the courts of the United States are hereby enacted.[359]

This was the opening section to the rest of the bill which explicitly outlined injunctive prohibitions. Sections 3, 4, 6, 7, and 13 are essential because they are directly relevant to this analysis. Sections 5, 8, 9, 10, and 11, however, are not directly relevant and therefore will not be discussed or quoted at length.

Section 3 made yellow-dog contracts unenforceable in federal courts, effectively eliminating the *Hitchman* doctrine.[360] This section stated that such a contract was contrary to the public policy of the United States as spelled out in Section 2 and therefore legal authority could not enforce such contracts. The draftsmen did not explicitly declare yellow-dog contracts unlawful because they were hesitant about overturning the *Adair* decision, which struck down the Erdman Act. This section asserted that enforcing yellow-dog contracts did not provide legal or equitable relief to the employer.

---

[357] Lovell, 197.
[358] Ibid., 197.
[359] Bernstein, 397.
[360] Bernstein, 398; Lovell, 53.

Section 4 denied federal courts the authority to grant injunctions in a case growing out of a labor dispute which enjoined workers from doing "singly or in concert" the following acts:

(a) refusing to perform work or to remain in relation or employment;
(b) becoming or remaining a member of a labor or employer organization;
(c) paying or withholding strike benefits;
(d) by lawful means aiding a person involved in a labor dispute;
(e) giving publicity to a labor dispute by advertising, speaking, patrolling, or any other method not accompanied by force or violence;
(f) assembling peacefully to promote an interest in a labor dispute;
(g) advising any person of an intention to perform any of these specified acts;
(h) agreeing with other persons to do or not to do any of these acts;
(i) advising, urging, or causing to be performed without force or violence any of the acts heretofore specified.[361]

All of these activities were prohibited by the courts in previous injunction cases. For example, Section 4(e) was directly referring to the *Gompers v. Bucks Stove and Range Company* (1911) in which Gompers was enjoined for advertising the Bucks Stove and Range Company in the AFL's "We Don't Patronize List," which led to a secondary boycott of that company. Lovell provides an abbreviated list of these immunized activities as follows: "clause 4(a) striking; clause 4(e) and 4(g), picketing; clause 4(e), boycotting [secondary boycotts]; clause 4(c) and 4(d), paying benefits to strikers; clauses 4(e) and 4(f), assembling."[362]

Section 6 absolved officers and members of labor unions as well as the organizations themselves of liability for "unauthorized," unlawful acts such as violence and the destruction of property. This again was based on a previous decision that held and enjoined a labor strike for violent acts that were not authorized by either union officials or the organization itself. In effect, the qualifiers in the Clayton Act were limited in scope to only authorized unlawful acts, instead of the broad interpretation of the courts to enjoin strikes on the sole basis that violent acts followed.

Section 7 was a complete overhaul of the procedure for the issuance of injunctions by federal courts:

> No court of the United States shall have jurisdiction to issue an injunction in any case involving or growing out of a labor dispute…except after hearing the testimony of witnesses in open court [with the opportunity for cross-examination] in support of a complaint made under oath, and except after finding of fact by the court, to the effect—
> (a) That unlawful acts have been committed and will be continued unless restrained;
> (b) That substantial and irreparable injury to complainant's property will follow;
> (c) That as to each item of relief sought greater injury will be inflicted upon complainant by the denial of relief than will be inflicted upon defendants by the granting of relief;
> (d) That complainant had no adequate remedy at law; and
> (e) That the public officers charged with the duty to protect complainant's property are unable or unwilling to furnish adequate protection.

[361] Bernstein, 399; Lovell, 200.
[362] Lovell, 191.

> Such hearings shall be held after due personal notice thereof has been given, in such manner as the courts shall direct, to all known persons against whom relief is sought, and also to those public officers charged with the duty to protect complainant's property.[363]

In Section 7, the draftsmen eliminated the procedural abuse of the courts which had permeated throughout the federal judiciary in the form of the labor injunction. Section 7a prohibited injunctive relief in a labor dispute in which the employer himself failed to comply with the law "to make every reasonable effort"[364] to resolve the labor dispute. Bernstein asserts that this was part of the "clean hand" doctrine. Section 7b prohibited injunctive relief by the federal courts unless it had first made an effort to discern the facts of the case. Section 7(b) allowed for expeditious appeal to the circuit courts when injunctions were challenged. As for the remaining sections of the Norris bill, Section 8 allowed for trial by jury when unionists were charged with violating the non-violent provisions.[365]

The subcommittee accepted the Norris bill; however, due to the 1928 presidential campaign, the full Judiciary Committee took no action and Congress adjourned. During Congressional adjournment, the AFL took up consideration of the Norris bill. The AFL had its vast legal staff review the bill section by section and report back to the AFL's Executive Council with its recommendations. Matthew Woll, vice president of the AFL, was the chairman of this investigatory committee. On August 18, 1928, Woll reported that the AFL should endorse the proposed law with the inclusion of numerous amendments.[366]

The proposed amendments included Section 2 in which the committee wanted the language expanded somewhat. In Section 3, the committee did not just want yellow-dog contracts to be unenforceable in federal court. They wanted yellow-dog contracts to be outlawed altogether. As for Section 4, the committee wanted the following amendments to be added. It denied federal courts jurisdiction to issue injunctions for the following actions:

> (aa) Ceasing, failing or refusing to work upon handle or use any product or material made or produced, in whole or in part, by non-union or by a rival labor union, irrespective of whether such material has been shipped in interstate commerce;
> (aaa) Ceasing or refusing to patronize or employ any person participating and/or interested in a labor dispute, or any other person whatsoever, regardless of whether he stands in the relation of employer and employee or is participating and/or interested in a labor dispute.
> (j) Nor shall any of the act described in this section be considered or held to be unlawful acts.[367]

In addition, there were adjectives added to Section 4 which eliminated harmful qualifiers and made the language less subjective. The word "violence" qualified by the adjective "physical" violence and phrases like "by all lawful means" and "peaceably" were eliminated. Along with

---

[363] Bernstein, 399-400; Lovell, 187.
[364] Bernstein, 400.
[365] Ibid.
[366] Ibid., 401.
[367] Ibid..

these modifications, a new section was added to retroactively nullify outstanding injunctions, and the language of Section 7 was expanded to eliminate blanket injunction.[368]

Soon after, Norris circulated the AFL amendments to the draftsmen for their review. The committee members did not agree with a majority of the AFL amendments. Protecting the statute against a *Duplex*-type interpretation, explains why legal experts like Frankfurter were dead set on non-ambiguous language or encumbering AFL amendments.[369] Frankfurter and Witte in a series of memoranda insisted that two of the new sections raised constitutional concerns since equity jurisdiction was granted by the U.S. constitution it could not be eliminated. Frankfurter went on to say that the removal of "lawful" in Section 4 served no purpose and that the adding of "physical" gave the impression that some forms of violence were acceptable. Additionally, Frankfurter warned the proposed paragraphs (aa) and (aaa) only served to intensify opposition in Congress and provoke judicial activism. Richberg, on the other hand, was willing to accept Section 4 (aa), (aaa), and (J). Richberg questioned the legality of the retroactive amendment and asserted that the expansion of language in Section 2 offered no substantive benefit.[370]

When Norris introduced the revised bill on May 19, 1930, although it differed somewhat from the 1928 version, it contained none of the AFL amendments. Most of the changes dealt with matters of organization. Section 12 was added which enabled defendants to challenge to conduct and character of a judge sitting in equity jurisdiction and to request a substitute. Section 13 was added and defined cases "growing out of labor disputes" as cases involving:

> persons who are engaged in the same industry, trade, craft, or occupation; or have a direct or indirect interests therein; or who are employees of the same employer; or who are members of the same or an affiliated or organization of employers or employees [Section 13(a)].[371]

Section 13 provides that a person or organization should be held to be a "person participating in a labor dispute" if

> relief is sought against him or it, and if he or it is engaged in the same industry, trade, craft, or occupation in which such disputes occurs, or has a direct or indirect interest therein or is a member therein…[Section 13(b)].[372]

Section 13 also defined the term "labor dispute" as

> any controversy concerning terms or conditions of employment, or concerning the association or representation of person in negotiating, fixing, maintaining, changing, or seeking to arrange terms or conditions of employment, *regardless of whether or not the disputants stand in the proximate relation of employer and employee* [Section 13(c)].[373]

Responding to *Duplex*, Section 4 was crafted to work in conjunction with Section 13 which explicitly denies federal courts power to enjoin secondary boycotts. The Proximate Relationship

---

[368] Ibid., 401; Lovell, 183-189.
[369] Bernstein, 401; *Duplex v.Deering*, US 443, 470 (1921); William E. Forbath, *Law and the Shaping of the American Labor Movement*, Cambridge: Harvard University Press, 1991: 161-162.
[370] Bernstein, 402; Lovell, 247.
[371] Lovell, 201.
[372] Ibid., 202.
[373] Ibid

doctrine was effectively eliminated with these two sections. By spring, 1930, modifications were completed on the anti-injunction legislation, and despite the omission of the AFL amendments, organized labor endorsed the measure. Since the legislative drafting of the bill was complete, all that was required now was major political action.

CONGRESS DEBATES JUDICIAL ACTIVISM

On February 3, 1930, Hoover elevated Charles Evan Hughes to succeed Taft as Chief Justice of the Supreme Court. Hughes was a distinguished Republican and intelligent lawyer. He was the former progressive governor of New York and a member of the Supreme Court until he resigned to run for President in 1906.[374] On February 10th, Norris declared "there were three legislative bodies: the house, with over 400 members, the Senate, with 96, and 'another…called the Supreme Court, of nine men; and they are more powerful than all the others put together."[375] Although he was in the minority, Norris decided to vote against Hoover's nominee to spark debate over the role of the Supreme Court. Whether Hughes was the right subject for his attack was irrelevant to Norris; what was relevant was the debate in general.

Norris argued that the justices were guided by their social predilections rather than the rule of law. "No man in public," Norris argued, "so exemplified the influence of powerful combinations in the political and financial world as does Mr. Hughes."[376] Senator Robert M. La Follette agreed with Norris and asserted that "We…are filling the jury box, which ultimately will decide the issue between organized greed and the rights of the masses."[377] "Under the Fourteenth Amendment," Senator William E. Borah declared, "the Supreme Court becomes really the economic dictator in the United States."[378] After examining every aspect of his fortune and his prior decisions in favor of business, the anti-judicial activism Senators proclaimed that Hughes' appointment placed a man who lived a one sided life on the Court. A man whose service to "powerful industry" placed him in a seat of power from which Norris declared he would ignore the plight of "the men who toil and the men who suffer."[379]

Hughes was confirmed by the Senate by 52 to 26 regardless of the best efforts of Norris and the other anti-judicial activism Senators. But a more important battle was on the horizon which pitted Senator Norris and his Senate supporters against an unquestionably pro-injunction judicial nominee. On March 21, 1930, Hoover nominated Judge John J. Parker for the Supreme Court. The "insurgent Senators," having found their attack on Hughes popular with the country, focused their next attack on Parker.[380] Unlike Hughes, Parker was an undistinguished circuit court judge and someone described as simply "technically proficient."

Parker was much despised by labor organizations for his rendering in the 1927 Red Jacket case. In the Red Jacket case, the UMW was enjoined from "trespassing upon the prosperities" or "inciting, inducing, or persuading employees of the plaintiffs to break their

---

[374] Bernstein, 403-404.
[375] Ibid., 404-405; Howard Zinn, *LaGuardia in Congress*, Ithaca: Cornell University Press, 1959.
[376] Bernstein, 405.
[377] Ibid., 406.
[378] Ibid.
[379] Ibid.
[380] Parrish, 253.

[yellow-dog] contract of employment."[381] The plaintiffs were an amazing 316 coal mine companies with a combined 40,000 employees in southern West Virginia. This meant that the might have been able to obtain 40,000 new members and increased bargaining power with the coal mine industry; however, Parker's granting of the companies' injunction ended all these plans.

During confirmation hearings, Parker attempted to explain away his Red Jacket decision by arguing that he was bound by the *Hitchman* doctrine. Parker asserted: "I followed the law laid down by the Supreme Court…It is, of course, the duty of judges of the lower Federal courts to follow the decisions of the Supreme Court."[382] In addition to Parker's argument, his supporters denounced yellow-dog contracts and suggested that legislation should be enacted to outlaw such practices, but Parker should be confirmed because he followed the rules of the judiciary. Parker's reasoning, notwithstanding, both Norris and the AFL continued to mobilize against his appointment.[383] The Senate Judiciary Committee was flooded with letters from various labor organizations that opposed Parker's nomination. One letter declared that Parker, with his Red Jacket judgment, delivered "fifty thousand (50,000) free Americans into indentured servitude."[384]

On April 11, AFL president William Green approached Hoover with one last request that he nominate another person to fill the Court vacancy. Hoover adamantly refused and insisted that the labor movement was misled about Parker's character. In response, Green argued that someone would have to go all the way back to the Dred Scott decision to find a parallel with the *Hitchman* decision, which was unconscientiously supported by Parker's decision in the Red Jacket case. To Green, Parker's decision in that case demonstrated that he actually approved of yellow-dog contracts.

On May 7, 1930 the Senate rejected Parker's appointment by 41 to 39. The vote was close but marked a major victory for the labor movement and its supporters in Congress. Frankfurter later wrote that Norris's role in preventing Parker's appointment was "extremely wholesome and for the best interests of the Supreme Court."[385] Before Parker's failed nomination, the general public was unfamiliar with yellow-dog contracts. But after Parker, public outrage about yellow-dog contracts and the *Hitchman* doctrine grew significantly. This debate was significant because it brought attention to the inappropriateness of judicial activism. Green's war was well on its way and the failed Parker appointment was a major victory in that struggle.

CONGRESS DEBATES NORRIS'S BILL

Due to the political composition of Congress, Norris was unable to introduce his bill for a year and a half. In the elections of 1930, the Great Depression brought about major political changes.[386] For one, Democrats significantly reduced the Republican majority in the Senate from

---

[381] Bernstein, 407
[382] Ibid., 407.
[383] Parrish, 253-254
[384] Bernstein, 407.
[385] Ibid., 409.
[386] Ibid., 410. In the election of 1930, Democrats won 52 seats in the U.S. House; Democrats won 5 seats in the U.S. Senate. In the election of 1932, liberal Democrats won sweepingly in the election of 1932; Franklin Roosevelt won 472 electors to Hoover's 52, winning approximately 60% of the popular vote; Democrats won 97 seats in the U.S. House for a majority of 313 to 117; Democrats won 12 seats in the U.S. Senate for a majority of 59 to 36.

eleven to one and won the House by five seats. This was in sharp contrast from the previous Republican majority that held a lead of over one hundred seats. During the elections, the AFL seized on the opportunity to promote the Norris bill and advertise the failed Parker nomination as a test of its growing power. The Great Depression started a political resurgence of liberals and members of both parties inched closer and closer to the left. These developments meant that the composition of the Senate Judiciary Committee had also changed, now consisting of more pro-labor Congressman. Later in 1930, the National Committee on Labor Injunctions was formed with the help of the ACLU. The committee was charged with the responsibility of supporting the Norris bill and drafting a state model bill based on the federal version. The committee then lobbied in state legislatures for passage of the anti-injunction measure.[387]

Even with major political changes, states moved more rapidly on anti-injunction legislation than the federal government. In April 30, 1930, New York enacted its own anti-injunction law based on the model of the Norris bill drafted by Nathan Greene and Frankfurter. Under the leadership of Governor Philip La Follette, Wisconsin passed the "little Norris La-Guardia Act."[388] In July 1931, Pennsylvania passed a measure to increase restrictions on the power to issue injunctions. In addition, Ohio, Arizona, Colorado, and Oregon sought legislation outlawing yellow-dog contracts. Indeed, these were the progressive years for most states. In late 1931, the AFL made one last ditch effort to forward anti-injunction legislation at the federal level and to gain acceptance for the Woll committee's amendments. The reconstituted Woll committee attempted to convince Norris to accept the AFL amendments. Again, Frankfurter and Witte wrote memoranda reiterating their original objections to the AFL amendments. Consequently, Norris informed the AFL that he did not intend to accept the amendments based on the recommendations of legal experts. And in December 1931, the AFL conceded and finally gave unqualified support to the Norris bill as originally drafted.[389]

In January 27, 1932, the Senate Judiciary Committee voted 11 to 5 to send the Norris bill to the Senate for full passage. Since 1927, Norris had waited to introduce his anti-injunction for passage and the opportunity arrived in February 23, 1932. The debate in the Senate was inconsequential because the opposition to the bill was small and mostly incompetent when it came to injunctions. The pro-labor Senators all gave magnanimous speeches supporting the Norris bill. The opposition, small and unprepared, submitted numerous recommendations from the American Bar Association that had protested the passage of the Shipstead bill. Opposition leader, Senator Felix Herbert, denounced yellow-dog contracts but then tried to halt the Norris legislation with "crippling amendments."[390] All the amendments were soundly defeated.

The only real obstacle was presented by labor Senator Walsh, who wanted Section 7(a) amended to allow courts to grant injunctions for "threatened" as well as actual violence. The AFL was opposed because it thought that such an amendment allowed judges to issue sweeping injunctions. Walsh was steadfast and eventually Norris and the other labor Senators conceded. Norris did, however, persuade Walsh to confine the courts' power to only persons and organizations making the threats. Walsh agreed and the revised Section 7(a) read as follows:

---

[387] Ibid., 411.
[388] Ibid.
[389] Frankfurter and Greene, 207-228; Bernstein, 410.
[390] Bernstein, 412.

> The unlawful acts have been threatened and will be committed unless restrained or have been committed and will be continued unless restrained, but no injunction or temporary restraining order shall be issued on account of any threat or unlawful act excepting against the person or persons, associations, or organizations making the threat or committing the unlawful act or actually authorizing or ratifying the same after actual knowledge thereof.[391]

Eventually, the AFL considered this revision acceptable because it did limit to only persons and organizations making threats and did not allow federal courts to issue blanket injunctions as they had done in the Pullman Strike.

On March 1, 1932, the Senate overwhelmingly passed the Norris bill by a vote of 75 to 5. All the Senate Democrats and a majority of the Republicans voted for the measure including the opposition leader, Herbert. This was a clear sign of the changing political atmosphere in which conservatives were greatly detested for their inability to mitigate the effects of the Great Depression. The bill was then forwarded to the House for consideration and passage. A liberal Republican, Representative Fiorello H. La Guardia introduced the bill in the House and therefore won the right to include his name on the bill.[392]

On March 8, 1932, the House began debate on the anti-injunction bill. A majority of the representatives were unfamiliar with the injunction controversy and had little interest in debating the merits of the bill itself. Most of the House debates focused on whether the AFL was for or against Communism. Supporters of the bill announced that since the AFL was opposed to Communism, a bill protecting the AFL was only beneficial for the anti-Communism campaign. Only one Representative, James Beck, substantially spoke out against the measure. Beck was a Republican and former Solicitor General, who supported yellow-dog contracts. Continuing the same irrelevant Communism argument, Beck insisted that the Norris-La Guardia bill constituted "a long march toward Moscow."[393] His amendments were overwhelmingly defeated and the bill passed the House by a staggering 362 to 14.

Although most of the bill's supporters expected a presidential veto, Hoover grudgingly signed the Norris La Guardia Act into law on March 23, 1932. There were three reasons why he signed the bill. First, the House made it clear that any presidential veto could and would be swiftly overridden. He wanted to remove himself from a hot button political topic in anticipation of the tough presidential election. Second, Hoover did not think the bill eliminated the courts power to issue injunctions to enjoin racketeering, extortion, and violence. Third, Hoover and his conservative Attorney General, William D. Mitchell, thought that antitrust suits to enjoin conspiracies were still permissible.[394]

With the Norris-La Guardia Act, yellow-dog contracts were significantly curtailed and the courts' power to issue injunctions was substantially restricted. Legal scholar Lovell writes

---

[391] Ibid., 413.
[392] Ibid., 413; Lovell, 170.
[393] Bernstein, 413.
[394] Ibid., 414.

that "Measured by its ostensible goal of curtailing injunctions and ending yellow-dog contracts, Norris-La Guardia Act was a success in precisely the areas where the Clayton Act and Erdman Act had failed."[395] But the Norris-La Guardia Act also marked a major victory over the use of antitrust legislation to enjoin labor strikes and enforce an employer's property rights, which was defined in the broadest possible sense by the Supreme Court. Labor lawyer Thomas Geoghegan went so far to say that the Norris-La Guardia Act allowed labor to "run naked in the streets."[396] This law was eventually tested in two landmark antitrust-labor cases.

FRANKFURTER: THE HAVARD LAW PROFESSOR AND NEW DEALER

Throughout the 1930s, Frankfurter worked in the Roosevelt Administration as a New Deal attorney. During this time, Frankfurter began to further refine elements of his judicial philosophy. He firmly believed in the Holmes philosophy that justices should practice judicial restraint. Holmes once declared "a law should be called good if it reflects the will of the dominant forces of the community even if will take us to hell."[397] As a New Dealer, Frankfurter was a respected member of Franklin Roosevelt's inner-circle of advisers. He advised Roosevelt on numerous legal matters, especially those involving labor relations. One journalist, John Franklin Carter, called Frankfurter the "legal master-mind of the New Deal."[398] In 1932, when Frankfurter was nominated for the Supreme Judicial Court of Massachusetts, Roosevelt called to offer his congratulations. Roosevelt said: "Felix…I haven't been able to tell you how happy I am…I wish it were the Supreme Court of the United States—that's where you belong."[399] Frankfurter, however, turned down the appointment and chose to remain at Harvard.

When Roosevelt asked Frankfurter to join his administration full-time, Frankfurter refused and again decided to continue teaching law at Harvard. But he remained an influential advisor for Roosevelt's New Deal, which he fully supported. Frankfurter was part of Roosevelt's Brain Trust and believed firmly in a rigorous anti-depression program. Frankfurter's anti-depression views drew heavily from the prescriptions of Brandeis and John Maynard Keynes.[400] It advocated a drastic attack upon massed wealth through progressive taxation and increased expenditures to help fund programs to employ idle workers. More specifically, Frankfurter outlined an anti-depression strategy in the 1933 issue of *Survey Graphic*. In addition, Frankfurter recommended the hiring of an army of legal talent to defend the New Deal programs from hostile judicial review. Frankfurter said the government should have "socially sound taxing system" to help pay for public works programs "even larger and more ambitious than the one [Senator Robert] Wagner sponsored."[401] "The nation's courts," historian Michael E. Parrish insists, were "the last bastion of institutionalized Republicanism following the party's crushing defeat in 1930 and 1932." [402]

When offered the position of Solicitor General, Frankfurter again turned Roosevelt down even though the President once mentioned that it was easier to put a Solicitor General on the Court than a Harvard professor. But the lawyers he trained gave him great pride. In one 1936

[395] Lovell, 161.
[396] Ibid., 162.
[397] Hockett, 144.
[398] Parrish, 221; Baker, 287.
[399] Baker, 277.
[400] Parrish, 221-223; Baker, 297.
[401] Parrish, 230.
[402] Parrish, 232.

Fortune magazine article, "The Young Men Go to Washington," Frankfurter hailed them as "the best men of the graduating classes of the leading law schools."[403] He emphasized that they were intellectually equipped to tackle entrenched conservatives in the judiciary.

Brandeis conveyed the same attitudes as Frankfurter. He advocated a public works program of "great magnitude"[404] funded first through deficit spending, but then through progressive taxation. As a whole, both Brandeis and Frankfurter disliked the National Recovery Administration (NRA), but endorsed strongly its beneficial labor provisions. In part, the program provided huge government partnership with industry and Brandeis regarded the act as impossible to enforce. Brandeis also concluded that the program had "a terrible record of putting men back to work,"[405] and Frankfurter shared these reservations. Even though Frankfurter had his greatest influence on Roosevelt between 1935 to 1936, Roosevelt still held back on increasing government expenditures for public works. Both Frankfurter and his friend Keynes pushed for significant fiscal stimulus. The 1937 recession was, perhaps, indicative of Roosevelt's failure to institute all the programs as recommended by Keynes who spoke through Frankfurter.

Despite these setbacks, the New Deal programs provided meaningful reform for both industry and labor, especially with the passage of the 1936 Wagner Act. The Wagner Act definitively recognized labor unions' right to exist and to exercise strikes for improved working conditions and benefits. How far workers could take collective bargaining and who could participate was still in question, especially with labor organizations still within the purview of the antitrust laws.

THE FALL OF LOCHNER ERA JURISPRUDENCE **FROM ROBERTS TO PARRISH (1937)**

One day in 1936, while walking along a Washington D.C. street, Justice Harlan Fiske Stone encountered a former student of his from Columbia Law School. "How are you getting on, John?" Stone asked. "Pretty good, Mr. Justice," replied John. "I was with the legal division of the NRA last year, then I transferred to the AAA, and now I am in the legal division of the Securities and Exchange Commission." Stone smiled. "I see," he said, "keeping just one jump ahead of us."[406] The Supreme Court struck down both the NRA and the AAA as unconstitutional because they interfered with property rights or so the Court reasoned. During the *Lochner* era, the Court used the Fourteenth Amendment and the commerce clause to assert its broad authority over the will of state legislatures and Congress to regulate economic iniquities.

This struggle reached its height during 1936 with the Court challenging the democratically elected branches of the federal government and states. Historian Michael E. Parrish asserts that it became "a full-blown crisis that pitted president, Congress, and forty-eight state legislatures…against a majority of the justices, whose narrow constitutional vision threatened the institution of judicial review itself."[407] The composition of the Court at this time still saw a conservative majority; however, that soon changed. Justices Charles Evans Hughes, Brandeis, Robert Stone, and Benjamin Cardozo composed the liberal minority and Justices

[403] Ibid., 229.
[404] Ibid., 250-251
[405] Ibid., 251
[406] Drew Pearson and Robert S. Allen, *The Nine Old Men*, New York: Vanguard Press, 1936: 44.
[407] Parrish, 252-253.

William Sutherland, Willis Van Devanter, James McReynolds, Pierce Bulter, and Owen J. Roberts were the conservative majority.[408]

Before Stone was appointed to the bench, he was deeply rooted in the Wall Street crowd, but he soon fell under the influence of Brandeis and Holmes who moderated his once conservative stance on issues. Stone was not completely proselytized by Brandeis and Holmes's judicial philosophy, but he was ripe enough to recognize that the Court should occasionally exercise restraint. When Roberts was appointed to the bench, Frankfurter was initially optimistic that with his intellectual aptitude he could be shaped like Stone into more moderate thinking, despite his past dealings with Wall Street. Roberts represented numerous corporations, but was well respected for his tenacious prosecution of those involved in the Teapot Dome scandal.[409] This, in Frankfurter eyes, made Roberts ripe for liberal proselytizing. Upon Roberts' appointment, Frankfurter commented that "I do not believe there are any skeletons in his mental closet." He reported in *The New Republic* that "Facts will find ready access to his mind."[410] Joe Cotton, on the other hand, offered extensive caveats insisting that "anyone who takes Owen Roberts for a liberal is going to be mistaken."[411]

Frankfurter remained convinced, however, that Roberts was another Stone. He wrote daily letters to Stone praising him for standing against the conservative jurists and grew to accept them. Frankfurter later humorously recalled: "If he [Stone] didn't get a letter of praise by Wednesday on a Monday opinion that he thought I ought to approve, he would grouch to L.D.B. [Brandeis]." After Roberts joined the Court, Frankfurter intended to give him the letters of praise and approbation for just decisions. But with the "Welfare State" on the rise, Roberts, much to Frankfurter's alarm, frequently voted with the "Four Horseman of the Apocalypse," Bulter, McReynolds, Sutherland, and Van Devanter. In rare decisions, Roberts voted with the liberals and received Frankfurter's unyielding praise. In one decision in which Roberts voted with the liberals, Frankfurter wrote: "He swept away all the rubbish that had accumulated around *Munn v. Illinois*."[412]

Increasingly agitated by judicial interference with his New Deal legislation, Roosevelt devised a Court packing scheme. The scheme's aim was to make Court more receptive to economic reform legislation by appointing more justices. Roosevelt's plan was denounced by a vast majority of Congress and faced an uphill battle. Roosevelt never pursued this plan because of the landmark case in 1937 known as "the switch in time that saved nine." *West Coast Hotel Co. v. Parrish* (1937) marked the beginning of the end for *Lochner* era jurisprudence. The Court no longer recognized "substantive due process" and judicial protection of *laissez-faire* was in its last throes.

In *Parrish*, the Court upheld the constitutionality of a Washington minimum wage law and thus allowed the government, despite *Lochner v. New York* (1905), to regulate the economy. The Court reasoned that the Constitution permitted the restriction of freedom of contract by state

---

[408] *West Coast Hotel Co. v. Parrish*, 300 US 379 (1937); Baker, 332; Parrish, 253-257.
[409] Parrish, 254.
[410] Ibid., 190.
[411] Ibid., 254.
[412] Ibid., 257.

law where such limitations protected the community, health and safety or vulnerable groups. Citing *Muller v. Oregon* (1908), where the Court allowed for regulation of women's work hours, the Court held that the same rationale should be applied generally to every property right, including employer labor practices. The decision was made possible by Roberts, who agreed with the liberal jurists that the government was constitutionally permitted to regulate economic matters.

In a bitter dissent, Justice Sutherland wrote for the Four Horsemen that "Mr. Justice Van Devanter, Mr. Justice McReynolds, Mr. Justice Butler, and I think the judgment of the court below should be reversed."[413] He explained that the Court was given the jurisdiction to determine whether the Constitution authorizes laws that interfere and prohibit liberty of contract. Sutherland stated that the Court made the determination in case after case that Congress did not have this right. In addition, Sutherland's dissent contained a poorly veiled admonition of Roberts' switch and characterized it as betrayal. Sutherland wrote:

> Under our form of government, where the written Constitution, by its own terms, is the supreme law, some agency, of necessity, must have the power to say the final word as to the validity of a statute assailed as unconstitutional. The Constitution makes it clear that the power has been entrusted to this court when the question arises in a controversy within its jurisdiction; and so long as the power remains there, its exercise cannot be avoided without *betrayal of the trust*.[414]

Roberts' switch, regardless of Sutherland's scathing dissent, stood as a major defeat for judicial activism and became symbolic of the downfall of *Lochner* era jurisprudence. The reinterpretation of the substantive due process clause was only one victory in this trend.

The issue of antitrust and its applicability to labor soon faced its greatest battle ever with entrenched *Lochner* era jurists. *Apex* and *Hutcheson* were symbolic of this fight and labor's momentous victory in 1941. With the sudden death of Cardozo in 1939, a Supreme Court vacancy arrived and Roosevelt nominated Frankfurter. Frankfurter no longer had to stand on the sidelines while labor faced an assault from the right-wing judiciary. He now became an active player in restraining judicial activism and proved his worth in the fight against entrenched *Lochner* era conservatives and labor's prosecution under the Sherman statute.

APEX AND JUDICIAL SPECULATION

The *Apex Hosiery Co. v. Leader* (1940) decision was the first major step the Court took on the road to recognizing labor's immunity from the Sherman statute. It represented an intermediate step in the battle ground between rigid judicial construction and judicial restraint, between continued Court speculation and a judicial deferral to the legislative intent. Despite *West Coast Hotel v. Parrish* (1937), there were still *Lochner* era jurists entrenched in the Supreme Court and they refused to give up without a fight. In April 1937, the Pennsylvania company, Apex Hosiery Corporation was operating a nonunion shop. Apex employees, who were members of the AFL, demanded that the company operate on a closed shop basis. When the company's management adamantly refused, the Apex employees affiliated with the AFL ordered a general

[413] *West Coast Hotel Co. v. Parrish*, 300 US 379 (1937)
[414] Ibid.

strike on May 4, 1937. Subsequently thereafter, on May 6, 1937, the company's factory was shut down by members of the union. With the general strike under way, the AFL made a further demand for Apex to operate a closed shop.[415]

When the company refused the second time, strikers seized the plant and AFL leaders ordered "a sit down strike."[416] Immediately after, violence broke out and the striking employees forced control of the entire plant. The strikers locked all the gates and entrances to the plant and only strikers were given keys to the facilities. During occupation, the strikers supplied themselves with an abundance of provisions and the AFL paid the Apex employees involved in the labor dispute strike benefits. While occupying the factory, the strikers destroyed machinery and extensively sabotaged Apex's manufacturing equipment. As a result, all manufacturing in the plant ceased. On June 23, 1937, the company's owner immediately petitioned the Third Circuit Court of Appeals for injunctive relief. Before the employees seized Apex's factory, the owner tried to enjoin an initially non-violent strike. The lower level Pennsylvania trial court rejected the owner's request.[417]

But when the strike turned violent and the plant was seized, Apex petitioned for immediate injunctive relief. On June 23, 1937, the appeals court granted the company's request and ordered the strike enjoined. As a result, the workers were forcibly ejected from the plant and those that refused were arrested. When the company resumed operations on August 19, 1937, the financial damage to physical property, equipment, and lost production was enormous. The company then sought financial damages under the Sherman Act. The company charged that the labor union violated the Sherman statute and formed a conspiracy to restrain trade. The federal court sided in favor of the company and granted it punitive damages in the sum of $237,310.[418]

The Third Circuit Court of Appeals, however, reversed the decision on the ground that the strikers did not engage in acts that restrained interstate commerce, basing its decision primarily upon the fact that state laws already provided equitable remedy. Since local state laws provided remediation, the appeals court reasoned, federal courts have no jurisdiction. The appeals court also held that the company failed to prove that "interstate commerce was restrained or affected."[419] The court noted that since the total value of output was less than three percent of the total output industry wide the company did not sufficiently establish restraint of interstate. In addition, the appeals court held that the company failed to prove that the strikers' intent was to restrain interstate commerce—even though the company noted that for three months the strikers suspended the plant's operations and its flow of products into intestate commerce was completely stopped. The appeals court was still not convinced that interstate commerce was illegally obstructed.

The company immediately appealed the decision of the appeals court and on May 27, 1940 the Supreme Court affirmed the judgment of the intermediate court. In large part, the Court

---

[415] *Apex Hosiery Co. v. Leader*, 310 US 469 (1940)
[416] Ibid.
[417] *Apex Hosiery Co. v. Leader*, 310 US 469 (1940)
[418] Ibid.
[419] Ibid.

based its decision on the ground that the Sherman statute was not intended to "police"[420] interstate commerce, and that based on the "Rule of Reason" doctrine the union did not violate the Sherman statute. Justice Stone, writing for the majority, emphasized that to establish liability under the Sherman Act it must first be proven that the combination intended to restrain interstate commerce and that the conspiracy resulted in a substantial material outcome such as high prices, reduced output, and reduced quality.[421]

Without this, Stone insisted, there was no violation of the Sherman statute. Referring to similar cases, Stone wrote "in the application of the Sherman Act, as we have recently had occasion to point out, it is the nature [monopolistic intent] of the restraint and its effect on interstate commerce [material, direct, aggregate effect] and not the amount of the commerce which are the tests of violation."[422] This was previously spelled out in *Standard Oil v. U.S.* (1911) and by Brandeis in his dissenting opinion in *Bedford Cut Stone Co. v. Journeyman Stone Cutters' Ass'n of North* (1927).

Applying *Duplex* (1921), Stone first asserted that unions were not granted a blanket immunity from the Sherman statute. Like Pitney in *Duplex*, he argued that the inclusion of qualifiers such as "peacefully" and "lawfully" meant that Congress did not intend to give labor an exemption. Stone wrote:

> A point strongly urged in behalf of [the union] in…argument before us is that Congress intended to exclude labor organizations and their activities wholly from the operation of the Sherman Act. To this the short answer must be made that for the thirty-two years which have elapsed since the decision of *Loewe v. Lawlor*…this Court, in its efforts to determine the true meaning and application of the Sherman Act has repeatedly held that the words of the act…do embrace to some extent and in some circumstances labor unions …and that during that period Congress, although often asked to do so, has passed no act purporting to exclude labor unions wholly from the operation of the Act.[423]

Explicitly, Stone insisted that labor was not given an exemption and that the *Duplex* interpretation, insofar as it stated that Congress did not give labor immunity, was correct. Stone then proceeded to discuss briefly secondary boycotts. Highlighting both the Danbury Hatters and *Duplex* decision, Stone concluded that the distinction between secondary and primary boycotts was no longer relevant to the Sherman statute. According to Stone, what was more pertinent was whether the restraints upon trade were reasonable insofar as it was defined by the Standard Oil decision.

To Stone, monopolistic intent and "its consequences" were more important and thus distinctions like primary and secondary boycotts, violent and non-violent strikes, and violent and non-violent secondary boycotts were all irrelevant. The Sherman statute was only applicable to combinations that gave rise to a "monopoly" and "its consequences."[424] Referring to the Danbury

---

[420] Ibid,
[421] *Standard Oil Co. v. U.S.* 221 US 1 (1911)
[422] *Apex Hosiery Co. v. Leader*, 310 US 469 (1940)
[423] Ibid,
[424] *Standard Oil Co. v. U.S.* 221 US 1 (1911)

Hatters and *Duplex* cases, Stone wrote: "The only significance of the two cases for present purposes is that in each the Court considered it necessary, in order to support its decision, to find that the restraint operated to suppress competition in the market," and Stone insisted that this was not enough.

Further, Stone thought the idea of violence and non-violent boycotts and strikes also irrelevant to the operation of the Sherman statute. Verbosely, Stone cited example after example of state and federal legislation that was crafted to "police" interstate commerce, which he said was not the purpose of the Sherman Act. Stone wrote:

> It is in this sense that it is said that the restraints, actual or intended, prohibited by the Sherman Act are only those which are so substantial as to affect market prices [one of the three consequences]. Restraint on competition or on the course of trade [physical obstructions, i.e. violent interference] in the merchandising of articles moving in interstate commerce is *not* enough, *unless* the restraint is shown to have or is intended to have an effect upon prices…[425]

Citing the first and second Coronado cases where the Court held that even a violent strike, which in these cases shut down coal mines, was "normally too local in nature and extent to restrain interstate commerce."[426] These two cases both involved secondary boycotts being declared illegal. Unique about these two cases, however, was in both decisions the Court said that whether a strike is violent or non-violent has no bearing on the Sherman statute's application.

In the *First Coronado* (1922) case, the Court considered a case of a national labor union which sought recognition for a local coal miners' union. When their efforts were stalled, the miners went on strike. Thousands of tons of coal ceased to be transported between states. The court sided in favor of the coal miners, stating that although the effect of the strike was economically substantial, the coal miners were not in violation of the Sherman Act. The Court reasoned that as long as the union did not engage in secondary boycotts and convince other coal mine unions to join the strike then it was not illegal, regardless of violent or non-violent acts.[427] In the *Second Coronado* (1925) case, when it was later discovered that the national union planned just such a tactic, the Court declared it to be a "direct violation of the (Sherman) Act."[428] But again, the Court emphasized that violent and non-violent strikes were to a major extent irrelevant to the Sherman statute's application. Stone wrote in Apex:

> The Sherman Act is concerned with the character of the prohibited restraints and with their effect on interstate commerce [Rule of Reason]. It draws no distinction between the restraints effected by violence and those achieved by peaceful but oftentimes quite as effective means. Restraints not within the Act, when achieved by peaceful means, are not

---

[425] *Apex Hosiery Co. v. Leader*, 310 US 469 (1940)
[426] Edward B. Miller, *Antitrust Laws and Employee Relations: An Analysis of Their Impact on Management and Union Polices, Philadelphia*: Trustees of the University of Pennsylvania, 1984: 57.
[427] *United Mine Workers of America v. Coronado Coal Co*., 259 US 344 (1922)
[428] *Apex Hosiery Co. v. Leader*, 310 US 469 (1940); *Coronado Coal Co. v. United Mine Workers of America*, 268 US 295 (1925)

> brought within its sweep merely because, without other differences, they are attended by violence.[429]

In *Apex*, the Court's decision legalized secondary boycotts and focused instead on purpose and consequence. Purpose and consequences, Stone asserted, were the determining factors in a case applying the Sherman statute. When looking at the rule of reason, however, as it was applied in Standard Oil, it mentions nothing of intent or monopolistic purpose, although "contract that results in a monopoly" could be interpreted as having "monopolistic intent."

In a pungent dissent, Justice Hughes illustrated in detail the violent destruction and forceful occupation of the Apex plant. Hughes wrote: "There was thus [no] direct and intentional prevention of interstate commerce in the furtherance of an illegal conspiracy. This, I take it, the opinion of the Court concedes…With that conclusion I cannot agree."[430] Hughes argued that the majority was adding new levels of uncertainty to the Sherman statute after decades of painstaking judicial construction. Hughes cited various cases where violent interference with commerce constituted a violation of the Sherman statute. Although the Court never applied the Sherman statute, Stone cited the Debs contempt case as an example of the Sherman statute's application to enjoin a violent labor strike. Further, Hughes argued: "Restraints may be of various sorts… But when they are found to be unreasonable and directly imposed upon interstate commerce, both employers and employees are subject to the sanctions of the Act."[431] Violence, according to Hughes, was one of these many sorts of restraints and therefore the Sherman Act applied.

Hughes went on to insist that the "Rule of Reason" had nothing to do with "motive" and was more so directed at combinations and their aggregate effect on interstate commerce as the determining factor for liability. Hughes wrote:

> Nor does the "rule of reason" aid respondents. The test of reasonableness under that rule is the effect of the agreement or combination, not the "motives which inspire it." Leaders of industry have been taught in striking fashion that when the Court finds that they have combined to impose a direct restraint upon interstate commerce, their benevolent purposes to promote the interest of the industry, or to rescue it from a distressful condition, will not save them even from criminal prosecution for violation of the Sherman Act.[432]

This, however, is not entirely accurate because in Standard Oil, after a long exegesis of English authorities, the Court determined that for a combination to unlawfully restrain trade it must demonstrate a "monopoly" and "its consequences." Again, monopoly and the way the term was interpreted led to judicial confusion.

Hughes also asserted that the qualifiers in the Clayton Act indicated that statutorily permissible labor practices were legal only if they were "peaceful" and "lawful." On one hand, Stone argued that the qualifiers in the Clayton Act meant only that labor was not granted blanket

---

[429] Ibid.
[430] Ibid.
[431] Ibid.
[432] Ibid.

immunity. And on the other, Hughes argued that the qualifiers in labor meant that statutorily allowable labor practices were out of the reach of the Sherman Act only if they were carried out peacefully.

Both Stone and Hughes were centralists on the Court who split on the *Apex* case. They both insisted on maintaining rigid judicial construction and established precedent. One supported keeping the *Duplex* standard and the other supported the revival of the "Rule of Reason." Neither Stone nor Hughes attempted to apply the Norris-La Guardia Act to try to interpret further the will of Congress—perhaps intentionally, because another statute would have meant looking at its legislative history and the elimination of such cherished judge-made law. Although labor unions won this battle, they were still fighting the bigger war—the war against "unduly restrictive judicial construction."[433]

U.S. V. HUTCHESON: FOCUSING THE LEGISLATIVE LENS

"The underlying aim of the Norris-LaGuardia Act," Frankfurter declared, "was to restore the broad purpose which Congress thought it had formulated in the Clayton Act but which was frustrated, so Congress believed, by unduly restrictive judicial construction."[434] In 1940, *U.S. v. Hutcheson* appeared before the Supreme Court and ultimately marked a tremendous victory for the labor movement over conservative, judicial activism. In *Hutcheson*, two unions were engaged in a jurisdictional dispute, the United Brotherhood of Carpenters and Joiners of America and the International Association of Machinists. The dispute was over the erection and dismantling of machinery. Anheuser-Busch had an agreement with both organizations in which the Machinists received the disputed jobs and the Carpenters agreed to submit all their grievances to arbitration.[435]

But in 1939, the president of the Carpenters union and other union officials failed to settle a dispute with Anheuser-Busch. Anheuser-Busch operated a large plant in St. Louis and contracted with the Borsari Tank Corporation for the construction of a new facility. The Gay Container Corporation leased property to Anheuser Busch and entered into a similar contract with the Stocker Company for the erection of a new building. Among Anheuser-Busch employees were members of the United Brotherhood of Carpenters and Joiners of America and the International Association of Machinist.

These two labor organizations were affiliated with the AFL and were engaged in constant arguments over construction and dismantling of machinery, and most importantly, jobs. Anheuser Busch attempted to mitigate the dispute through arbitration; however, when the Carpenters' demands went unsatisfied, they went on strike. During the strike, the Carpenters facilitated both primary and secondary boycotts. The Carpenters' union sent out an official publication to other unions and the public requesting that they refrain from purchasing Anheuser-Busch beer. This was clearly a secondary boycott. Anheuser Busch sought legal action by claiming that strikers were in violation of the Sherman Act.[436]

---

[433] Padway, 13; *U.S. v. Hutcheson*, 312 U.S. 219 (1941)
[434] Miller, 57-59;*U.S. v. Hutcheson*, 312 U.S. 219 (1941)
[435] Ibid.
[436] Miller, 57-59; *U.S. v. Hutcheson*, 312 U.S. 219 (1941)

Anheuser-Busch charged that the Carpenters' union violated the Sherman Act's restraint of trade provision by engaging in a secondary boycott and a criminal conspiracy to restrain interstate commerce. As a result, Thurman Arnold, chief of the Antitrust Division of the Justice Department, filed suit and the case appeared before the Supreme Court in 1941. Arnold charged that the United Brotherhood of Carpenters, an AFL affiliated union, violated the Sherman statute by initiating a strike in an intra-labor dispute and calling for a secondary boycott through the circulation of anti-Anheuser Busch pamphlets.[437] Thus, the question presented before the Court was "whether the use of conventional, peaceful activities by a union in controversy with a rival union over certain jobs is a violation of the Sherman Law."[438] The Court answered no and gave labor blanket immunity from the operation of the Sherman statute.

Frankfurter believed that the Clayton and the Norris-La Guardia Acts worked together as "harmonizing" statutes in which labor unions were excluded from the Sherman Act. Frankfurter wrote for the majority: "Therefore, whether trade union conduct constitutes a violation of the Sherman Law is to be determined only by reading the Sherman Law and 20 of the Clayton Act and the Norris-LaGuardia Act as a harmonizing text..."[439] Frankfurter insisted that the Norris-La Guardia Act was a clarification by Congress of the language in Section 20 of the Clayton Act. Section 20 of the Clayton Act provided for a list of practices that were exempt from injunction and antitrust prosecution because they were in the best interests of labor. Frankfurter, one of the drafters of the Norris-La Guardia Act, was convinced that the Norris La-Guardia Act provided a list of exemptible labor practices so comprehensive that it gave labor full immunity from the antitrust laws.

As for the secondary boycott, Frankfurter criticized the *Duplex* decision for its restrictive interpretation of Section 20 of the Clayton Act and thus its restrictive deference to the will of Congress. Frankfurter wrote: "Such a view it was urged, both by powerful judicial dissents and informed lay opinion, misconceived the area of economic conflict that had best be left to economic forces and the pressure of public opinion and not subjected to the judgment of courts."[440] Again, Frankfurter charged that the majority in *Duplex* engaged in judicial activism and blatantly disregarded the will of Congress in favor of judicial construction. Frankfurter asserted that the emphasis placed on the illegality of secondary boycotts only involved the Court in more subjectivity and insisted that such distinctions were constituted by judge-made law, not Congress. "The Act [Norris La Guardia Act]," Frankfurter wrote, "…established that the allowable area of union activity was not to be restricted… as in Duplex...to an immediate employer-employee relation."[441]

Citing Section 13 of the Norris La-Guardia Act, Frankfurter specifically pinpointed where Congress allowed labor unions to engage in secondary boycotts. Section 13 provided that any person in the same industry could participate in a labor dispute, "regardless of whether or not

---

[437] Thurman Arnold, "Antitrust Law Enforcement, Past and Future." Law and Contemporary Problems Vol. 7, No. 1 (1940): 5-23; Alan Brinkley, "The Antimonopoly Ideal and the Liberal State: The Case of Thurman Arnold," *The Journal of American History* Vol. 80, No. 2 (1993), 557-579.
[438] *U.S. v. Hutcheson*, 312 U.S. 219 (1941)
[439] Ibid.
[440] Ibid.
[441] Ibid.

the disputants stand in the proximate relation of employer and employee."[442] This provision, when added by Congress, was directly referring to the Court's interpretation in *Duplex*. Using this reasoning, however, Frankfurter may have exaggerated Congress's will in the Clayton Act to offer labor an exemption.

The Clayton Act was an ambiguous and complex statute and evoked two competing interpretations in Congress. Ultimately, Frankfurter agreed that with the passage of the Norris La-Guardia Act "Congress cut through all the tangled verbalisms and enumerated concretely the types of activities which had become familiar incidents of union procedure."[443] The Clayton statute may not have explicitly given labor immunity, but much evidence exists to prove that implicitly Congress wanted a labor exemption. *Lochner* era conservative jurists ignored this implicit will. In *Hutcheson*, despite Roosevelt appointees like Frankfurter, the labor movement still faced entrenched opposition from activist judges. Frankfurter challenged these opponents and insisted that statutes like the Clayton Act must not be read "in a spirit of mutilating narrowness."[444]

In a series of letters, prior to the *Hutcheson* decision, Frankfurter attempted to convince Justice Stone that his use of the Norris-La Guardia Act was appropriate. Stone insisted that the Court not "overrule"[445] *Duplex* and keep in place decades of painstaking judicial construction. Beginning on January 21, 1941, Frankfurter urged Stone to consider the *Hutcheson* case without reliance on the *Duplex* standard. Frankfurter wrote:

Dear Stone:

> To take this indictment outside the ruling in the Duplex case would, for me at least, involve much more of a torturing of that decision than is the task of reading the Clayton Act in harmony with the Norris-La Guardia Act. Moreover, the latter procedure avoids giving the Duplex case further vitality even if only by accepting it as a basis for distinction. However, you have of course my blessings in winning the Court to your view.
>
> Faithfully,
> F.F. [446]

In this letter, Frankfurter urged Stone to consider the Norris-La Guardia Act instead of trying to interpret the judge-made law established in *Duplex*. Stone, on the other hand, did not want the Court to rely on the Norris-La Guardia Act because there was insufficient evidence to establish substantial restraint of interstate trade and thus no violation of the Sherman statute. Stone thought that the application of the Norris-La Guardia Act in the *Hutcheson* case was inappropriate. Stone replied the same day:

Dear Frankfurter:

---

[442] Lovell, 201.
[443] *U.S. v. Hutcheson*, 312 U.S. 219 (1941)
[444] Ibid.
[445] Frankfurter, Personal Papers; *Duplex v.Deering*, US 443, 470 (1921)

[446] Felix Frankfurter, *The Felix Frankfurter Papers, 1882-1965*. University Park, The Pennsylvania State University Microfilms, 1941.

> Mine was inspired by the assumption that I could write an opinion without reliance upon the Norris La-Guardia Act which our brethren [the remaining members of the Four Horsemen] could not plausibly challenge, and by my desire as a matter of judicial procedure to avoid, whenever possible, controversy in the Court about serious or important matters by selection…of an issue that will find unanimity or at least provoke only minor differences…
>
> Yours Faithfully,
> Harlan F. Stone[447]

In his reply, Stone urged Frankfurter not to pursue the "harmonizing text" options because it created "controversy in the Court." Stone reasoned that by applying, to some extent, the *Duplex* standard it made it harder for the more conservative jurists to challenge. Stone insisted that, in following "judicial procedure," the Court could avoid internal debates on *Hutcheson* and the judicial construction in *Duplex* remained secure.

On January 21, 1941, Frankfurter sent Stone another letter, again trying to persuade Stone to agree with his position. Frankfurter wrote Stone about the vagueness and uncertainty that arises from distinctions such as primary and secondary boycotts. Frankfurter asserted that the Court must move pass the uncertainties of judge-made law and acknowledge the Congressional intent as laid out in the Norris-La Guardia Act. Frankfurter wrote:

> Dear Stone:
>
> …The vice of the whole business from my point of view is that the cases and the Chief and Roberts talk about "secondary boycotts" with all the undefined and conflicting meanings attached to those phrases when the legislation which we are to apply does not use those terms. I really think that it is far better to try to apply the exact language of the *Clayton Act as illuminated by the Norris-LaGuardia Act* rather than as obfuscated by the Duplex and Bedford cases, *than to enter the extremely difficult and dark territory of judicial construction with references to labor conduct under the generalities of the Sherman law.*
>
> Yours Faithfully,
> F.F.[448]

Again, Frankfurter emphasizes that judicial construction and *Lochner* era precedents were impeding Congress's ability to express its intent. Frankfurter argued that when Congress passed the Sherman statute, even though it was vague, it mentioned nothing of outlawing secondary boycotts. Secondary boycotts, according to Frankfurter, were one of many examples of arbitrary

[447] Frankfurter, Personal Papers.
[448] Frankfurter, Personal Papers.

judicial construction in landmark cases like *Duplex* and *Bedford*. Frankfurter noted that the clearest way to recognize Congress's will was by looking at the Clayton and Norris LaGuardia Acts together.[449]

Stone, on the other hand, thought he settled the labor-antitrust issue in his opinion in the *Apex* case (1941). In *Apex*, Stone resurrected the Rule of Reason without eliminating the *Duplex* standard. Stone also did not want his opinion overturned by Frankfurter's formulation in *Hutcheson.* On January 22, 1941, Stone replied:

> Dear Frankfurter:
>
> …It has seemed to me that the Norris-La Guardia Act was possibly a springboard by which we might overturn Duplex, but here again Duplex has been so long on the books that I feel such a course embarrassing in view of what I said in the Apex case on the same subject, and in any case it seems to me not good judicial practice to overrule cases…
>
> Yours Faithfully,
> Harlan F. Stone[450]

Stone refused to overrule *Duplex* and he refused to eliminate his own cumbersome judicial construction in the *Apex* decision. These letters demonstrate clearly that Frankfurter was fighting the waning *Lochner* era judicial activists. After prolonged correspondence, Stone decided to write a concurring opinion in which he kept his judicial construction intact, even though he adhered to majority judgment.[451]

Frankfurter was at a unique advantage when he spoke about the intent of the Norris-LaGuardia Act and its overall purpose to clarify the Clayton Act. He helped draft the Norris-LaGuardia statute and thus had first hand knowledge of the intentions of Congress. Frankfurter highlighted this in his last letter to Stone. On January 23, 1941, Frankfurter wrote: "I speak from intimate personal knowledge regarding the drafting and the passage of the bill [Norris-La Guardia Act]."[452] He continued: "What we now have is what the proponents prepared and there is no opposition to what was the chief objective—the correction of the Duplex and Bedford constructions."[453] Indeed, this was a unique vantage point for a jurist.

In Justice Stone's concurring opinion, he strongly opposed Frankfurter's broad legal extrapolation. He was not overly dependent on the construction that he formulated in *Apex* mainly because in *Hutcheson* strike was an intra-labor dispute without monopolistic purpose and consequences. Further, Stone argued there was no reason to apply the Norris-LaGuardia Act because the Carpenters' union did not engage in a secondary boycott. First, Stone reasoned that the call for a boycott was not illegal because it was protected free speech in the First Amendment and second, since there was no strike against Anheuser-Busch distributors, the Carpenters' union only engaged in peaceful picketing. Stone wrote:

---

[449] Ibid.
[450] Frankfurter, Personal Papers.
[451] *U.S. v. Hutcheson*, 312 U.S. 219 (1941)
[452] Frankfurter, Personal Papers.
[453] Ibid.

> The second and only other type of restraint upon interstate commerce charged is the so-called 'boycott' alleged to be by the publication of notices charging Anheuser-Busch with being unfair to labor and requesting members of the Union and the public not to purchase or use the Anheuser-Busch product. Were it necessary to a decision I should have thought that, since the strike against Anheuser-Busch was by its employees and there is no intimation that there is any strike against the distributors of the beer…[454]

In reiteration, since the secondary boycott was protected by the First Amendment and the secondary boycott was never instituted, no violation of the law could be cited. Although Stone stressed in *Apex* that such distinctions were irrelevant, he felt the need to emphasis it in *Hutcheson.*

Using his *Apex* construction, Stone argued that the strike was not substantial and did not have a monopolistic effect on interstate commerce and therefore not a violation of the Sherman statute. Stone was not convinced that labor was granted immunity and instead opted to rely on the judicial construction formulated in *Duplex* and *Apex.* Stone wrote:

> We are concerned with the alleged activities of defendants, actual or intended, only so far as they have an effect on commerce prohibited by the Sherman Act as it has been amended or restricted in its operation by the Clayton Act. It is plain that the first type of restraint is only that which is incidental…[455]

Since the effect was "incidental," the Carpenters' union was protected from prosecution under the Sherman statute. Thus, Stone agreed with the holding in *Hutcheson*, but disagreed with Frankfurter's rationale. Stone ended his opinion by suggesting that he and the Court was strictly bound by already well-established judicial construction.

Justice Owen Roberts, who was a *de facto* member of the Four Horseman, wrote a scathing dissent in which he stated "I venture to say that no court has ever undertaken so radically to legislate where Congress has refused so to do."[456] Roberts further stated that the labor union "undeniably" facilitated a secondary boycott with the goal of restraining interstate commerce and asserted that the Norris-La Guardia statute was not meant as a total exemption of labor. Roberts wrote: "Without detailing the allegations of the indictment, it is sufficient to say that they undeniably charge a secondary boycott, affecting interstate commerce,"[457] stressing its illegality under the *Duplex* standard. A vast majority of Roberts' argument was based on the notion that the Court should strictly adhere to the construction established in *Duplex*. For *Duplex*, according to Stone, expressed the will of Congress not to exclude labor from the antitrust laws, but also to curtail the abuse of injunctions. This was the entire argument of the dissent; that is, *Duplex* was the controlling authority for all future labor-antitrust cases.

---

[454] Frankfurter, Personal Papers.
[455] Ibid.
[456] *U.S. v. Hutcheson*, 312 U.S. 219 (1941)
[457] Ibid.

In a five-two decision, labor was granted immunity from the Sherman statute after decades of judicial speculation. This judicial speculation was symbolized by overreaching *Lochner* era jurists who protected to an absurd extreme the property rights of employers and struck at labor for attempting to stand as equals. The Sherman Act was intended to strike against "massed capital,"[458] and not labor organizations. After a long battle, *Hutcheson* finally gave full consideration to the will of Congress and labor unions were wholly excluded from the antitrust laws as long as they did not combine with non-labor groups. While on a circuit court, Holmes argued that it was not an adequate discharge of the courts to ignore the implicit will of Congress. Throughout the *Lochner* era, the judiciary rejected this form of deference toward legislative intent. With *Hutcheson*, however, Frankfurter stood firm on the ground that judicial activism was a wholly inappropriate discharge of judicial authority.

[458] See Berman.

Bibliography

Adair v United States, 208 US 161 (1908).

AFL-CIO Pamphlets, 1889-December 1955, Held in the AFL-CIO Library: A Collection of the Official Publications of the American Federation of Labor and the Congress of Industrial Organizations from 1889 to the AFL-CIO Merger in December 1955. University Park: The Pennsylvania State University Microfilms, 1941-1942.

American Federation of Labor, History, Encyclopedia and Reference Book. Volumes I (1919), II (1924), III (1960). Washington, D.C.: American Federation of Labor.

Apex Hosiery Co. v. Leader, 310 US 469 (1940)

Andrews, Williams S. "The Labor Injunction." *Harvard Law Review*, Vol. 43, No. 6. (1930):974-976.

Areeda, Phillip. *Antitrust Analysis: Problems, Text, Cases.* Boston: Little, Brown and Company, 1981.

Arnold, Thurman. "Antitrust Law Enforcement, Past and Future." *Law and Contemporary Problems* Vol. 7, No. 1 (1940): 5-23.

Baker, Leonard. *Brandeis and Frankfurter: A Dual Biography*. New York: Harper & Row, Publishers, 1984.

Berman, Edward. *Labor and the Sherman Act.* New York: Russell & Russell, 1930.

Bernstein, Irving. *The Lean Years: A History of the American Worker 1920-1933.* Boston: Houghton Mifflin Company, 1966.

Bedford Cut Stone Co. v. Journeyman Stone Cutters' Ass'n of North, 274 US 37 (1927)

Breslin, Beau. "Review of Legislative Deferrals; Statutory Ambiguity, Judicial Power, and American Democracy." *Department of Government, Skidmore College*. Vol. 13 No. 11 (2003)

Brinkley, Alan. "The Antimonopoly Ideal and the Liberal State: The Case of Thurman Arnold," *The Journal of American History* Vol. 80, No. 2 (1993), 557-579.

Bryan, J.E. *The Farmers' Alliance: Its Origin, Progress and Purposes*. Fayetteville: Arkansas, 1991.

Christ, Jay Finley. "The Federal Courts and Organized Labor. III. Since the Clayton Act." *Journal of Business* 6. (1933): 157-261.

Cochrane, Cornelius. “Why Organized Labor is Fighting ‘Yellow Dog’ Contracts.” *American Labor Legislation Review* 15:227-232.

Coronado Coal Co. v. United Mine Workers of America, 268 US 295 (1925)

Dubofsky, Melvyn. *When Workers Organize: New York City in the Progressive Era.* (Amherst: University of Massachusetts Press, 1968.

Duplex v.Deering, US 443, 470 (1921)

Forbath, William E. *Law and the Shaping of the American Labor Movement*. Cambridge: Harvard University Press, 1991.

Frankfurter, Felix. *The Felix Frankfurter Papers, 1882-1965*. University Park, The Pennsylvania State University Microfilms, 1941.

Frankfurter, Felix and Nathan Greene. *The Labor Injunction*. New York: The Macmillan Company, 1930.

Frankfurter, Felix. *The Case Sacco and Vanzetti: A Critical Analysis for the Lawyers and Laymen.* New York: The Atlantic Monthly Company, 1927.

Frankfurter, Felix and Nathan Greene, “The Use of Injunctions in American Legal Controversies,” *Law Quarterly Review*, 44 (1928), 44.

Garner, Bryan A. *Black’s Law Dictionary*. St. Paul: West Publication Co, 2001.

Gifford, Daniel J., and Leo J. Raskind. *Federal Antitrust Law: Case and Materials.* Cincinnati: Anderson Publishing Co, 2002.

Gompers, Samuel. “The Sherman Law. Amend It or End It.” *American Federationist*. Vol. 17. No. 3 (1910): 187-202.

Gompers v. Bucks Stove & Range Co., 221 US 418 (1911)

Gompers, Samuel. *Seventy Years of Life and Labor: An Autobiography*, 2 vols. New York: E.P Dutton and Company, 1925.

Gregory, Charles O. “The New Sherman-Clayton-Norris LaGuardia Act.” *The University of Chicago Law Review*, Vol. 8, No. 3. (1941): 503-516.

Hawley, Ellis Wayne. *New Deal and the Problem of Monopoly: A Study in Ambivalence.* Princeton: Princeton University Press, 1966

Hockett, Jeffery D. *New Deal Justice: The Constitutional Jurisprudence of Hugo Black, Felix Frankfurter, and Robert H. Jackson.* Lanham: Rowman & Littlefield Publishers, Inc., 1996

Hofstadter, Richard. *Social Darwinism in American Thought*. Boston: Beacon Press, 1944.

Hunt, Henry T. "Make the Law More Explicit." *American Labor Review 16*. (1928): 309-311.

In re Debs, 158 U.S. 564 (1895)

Keifer & Keifer v. Reconstruction Finance Corp., 306 U.S. 381 (1939)

Johnson, Julia E., *Trade Unions and the Anti-Trust Laws.* New York: The H.W. Wilson Company, 1940.

Jones, Dallas L. "The Enigma of the Clayton Act." *Industrial and Labor Relations Review*, Vol. 10. No. 2. (1957): 201-221.

Joseph, Charles M. "The Sherman Act-A Menace to Freedom." *American Labor Legislation Review* 18. (1928): 297-301.

Kens, Paul. *Lochner v. New York: Economic Regulation on Trial.* Lawrence: University Press of Kansas, 1998.

Kovner, Joseph "The Legislative History of Section 6 of the Clayton Act," *Columbia Law Review,* Vol. 47, No.5. (1947).

"Labor Plans War in Injunction Case," *New York Times*, 26 May 1927: 28.

Letwin, Daniel. Review of *Labor's Great War: The Struggle of Industrial Democracy and the Origins of Modern American Labor Relations, 1912-1921*. H-SHGAPE (1999, at: http://www.hnet.msu.edu/reviews/showrev.cgi?path=20213934921244).

Licht, Walter. *Industrializing America: The Nineteenth Century*. Baltimore: The John Hopkins University Press, 1995.

Loewe v. Lawlor, 208 US 274 (1908)

Lovell, George I. *Legislative Deferrals; Statutory Ambiguity, Judicial Power, and American Democracy*. Cambridge: Cambridge University Press, 2003.

McCartin, Joseph A. *Labor's Great War: The Struggle for Industrial Democracy and the Origins of Modern American Labor, 1912-1921*. Chapel Hill: The University of North Carolina Press, 1997.

Mennel, Robert M., and Christine L. Compston. *Holmes and Frankfurter: Their Correspondence, 1912-1934.* Hanover: University Press of New England, 1996.

Miller, Edward B. *Antitrust Laws and Employee Relations: An Analysis of Their Impact on Management and Union Polices.* Philadelphia: Trustees of the University of Pennsylvania, 1984.

Padway, Joseph A. "Mr. Arnold Gets Stopped." *American Federationist* 13, (1941): 12-13.

Papke, David Ray. *The Pullman Case: The Clash of Labor and Capital in Industrial America.* Lawrence: University of Kansas Press: 1999.

Parrish, Michael, E. *Felix Frankfurter and His Times: The Reform Years.* New York: The Free Press, 1982.

Pearson, Drew and Robert S. Allen. *The Nine Old Men,* New York: Vanguard Press. 1936.

Peritz, Rudolph J.R. *Competition Policy in America: History, Rhetoric, Law*. Oxford: Oxford University Press, 1996.

Roberts, Owen J. "Wanted: Public Opinion." *The Public Opinion Quarterly*, Vol. 9, No. 7 (1945): 247-263.

Shughart II, William F. "Bending Before the Storm: The U.S. Supreme Court in Economic Crisis, 1935–1937." *Independent Review* (2004): 80, fn. 56.

Silverstein, Mark. "Felix Frankfurter: Judicial Restraint and Individual Liberties." *The American Historical Review*, Vol. 97, No. 5. (1997): 1621-1622.

Standard Oil Co. v. U.S. 221 US 1 (1911)

Stark, Louis. "High Court Holds Unions Exempt From Sherman Act in Own Disputes." *New York Times,* 4 February 1941, 1.

Stephen B. Wood, *Constitutional Politics in the Progressive Era: Child Labor and the Law,* Chicago: The University of Chicago Press, 1968

Spaeth, Harold J. "The Judicial Restraint of Mr. Justice Frankfurter—Myth or Reality." *Midwest Journal of Political Science*, Vol. 8, No. 1 (1964): 22-38.

Summer, Clyde W. "Frankfurter, Labor Law and the Judge's Function." *The Yale Law Journal*, Vol. 67, No. 2. (1957): 266-303.

Taylor, John Berwick. "The Politics of the Labor Injunction." Ph.D. diss., Princeton University, 1972.

Teller, Ludwig. “Federal Intervention in Labor Disputes and Collective Bargaining: The Hutcheson Case.” *Michigan Law Reviews,* Vol. 40, No. 1 (1941): 24-48.

Tomlins, Christopher. *The State and the Unions: Labor Relations, Law, and Organized Labor Movement in America, 1880-1960.* New York: Cambridge University Press, 1985.

United Mine Workers of America v. Coronado Coal Co., 259 US 344 (1922).

Urofsky, Melvin I., and David W. Levy. *Half Brothers, Half Son: The Letters of Louis D. Brandeis to Felix Frankfurter.* Norman: University of Oklahoma Press, 1991.

U.S. v. Hutcheson, 312 U.S. 219 (1941)

West Coast Hotel Co. v. Parrish, 300 US 379 (1937)

Witte, Edwin E. “Review of *The Labor Injunction*, by Felix Frankfurter and Nathan Greene.” *The American Economic Review,* Vol. 20, No. 3 (1930): 522-524.

Woll, Matthew. “The Attitudes of American Labor toward the Anti-Trust Laws.” *Proceedings of the Academy of Political Science in the City of New York.* Vol. 11, No. 4. (1926): 108-113.

Zinn, Howard. *LaGuardia in Congress*. Ithaca: Cornell University Press, 1959.

The Effect of BTP on the Development of Allergic Asthma in Mice

Alana Curry, McNair Scholar, Virginia State University
Faculty Advisor: Avery August, Ph.D
Associate Professor of Immunology
Department of Veterinary and Biomedical Sciences
Penn State University

Abstract

Allergic Asthma is an inflammatory disease that causes an increase in airway hyper-responsiveness to a variety of stimuli. Of the many treatments available today, immunosuppressive drugs are a promising option. Unfortunately, many of these drugs have dangerous side effects. In a recent search for safer drugs, a series of 3,5-bistrifluoromethyl pyrazole (BTP) derivatives have been found to be effective immunosuppressants. In these experiments, we have determined whether BTP affects the development of symptoms of allergic asthma in a murine model of this disease.

Introduction

Allergic Asthma is an inflammatory disease that causes an increase in airway hyper-responsiveness to a variety of stimuli. This inflammation causes breathlessness, chest tightness, wheezing, and coughing, particularly at night or in the early morning (1). Thirty million Americans are living with asthma (2). 12% of all asthma sufferers are children (2). This disease causes much distress and anxiety to both adults and children living with the asthma. Because most episodes occur during the night, many asthma sufferers have trouble functioning properly during the day due to interrupted sleep.

Allergic Asthma is a T helper type-2 (Th2) mediated disease. It is thought to result from the expansion of $CD4^+$ T cells that produce cytokines Interleukin 4 (IL-4) and IL-5. IL-13 shares a receptor component with IL-4 and is necessary for the expression of allergic asthma (3). When a person is first exposed to an allergen, Th2 cells develop and then produce IL-4. IL-4 then causes the production of anti-allergen IgE antibodies. These antibodies then attach themselves to mast cells. Once enough antibodies are present on the mast cells, the mast cells activate. Their contents, mainly histamine, are released, bringing with it an allergic reaction (4).

The disease also has detrimental effects on the lungs as well. A great deal of inflammation is present in the lungs and a large degree of airway hyper-responsiveness. Hyper-responsiveness is an abnormal response of the lungs to minor stimulants (5, see Figure 1). There is a substantial amount of mucous produced as a result.

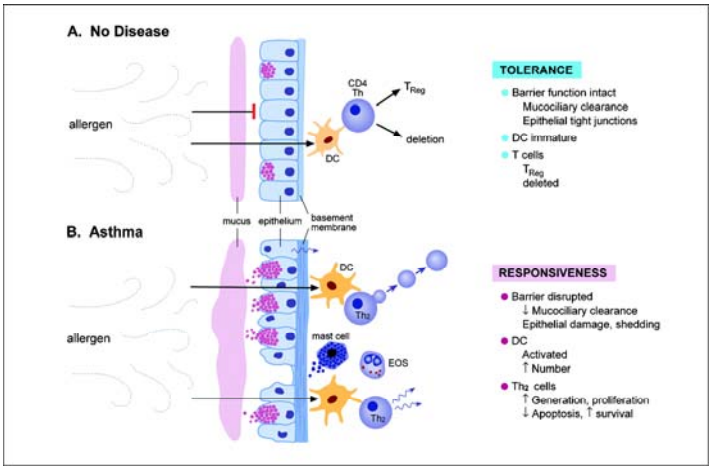


Figure 1. Fate of the airways after exposure to inhaled allergen. (A) In the absence of inflammation, inhaled allergen does not induce an inflammatory response because protective features of the respiratory tract insure immune tolerance. (B) In asthma, the inflamed airways promote immune responsiveness. Inhaled allergen stimulates further Th2 cell activation, activation of inflammatory cells, release of inflammatory mediators, and epithelial damage, thus leading to persistent inflammation and airway remodeling (6).

There is no cure for allergic asthma, but many treatments exist, most of which have very dangerous side effects. Most medications consist of glucocorticoids, which have been proven to bring on situations ranging in severity from cosmetic to life-threatening situations. Some potential side effects include gastric hemorrhage, Cushing's syndrome, glaucoma, hypertension, diabetes, growth retardation, and many more (7).

In a search for safer drugs, 3,5-Bistrifluoromethyl pyrazole (BTP) has been identified to inhibit the proliferation and gene transcription of both Th-1 and Th-2 cytokines (8). Because allergic asthma is a Th-2 mediated disease, we hypothesize that BTP should inhibit the production of the cytokines that produce the symptoms of allergic asthma, therefore reducing the symptoms of the disease.

To test this hypothesis, a murine model of the disease was used. The murine model has many similarities with the human form of the disease. Both models develop airway hyper-responsiveness and indicate the $CD4^+$ Th-2 cells are responsible for the onset of the symptoms of the disease.

Materials and Methods

Animals. T cell receptor (TCR) transgenic mice (OT-II) specific for ovalbumin (OVA) on a C57BL/6 background were used for these experiments. All guidelines set by the Institutional Animal Care and Use Committee of the Pennsylvania State University were followed.

Chemicals. Ovalbumin was obtained from Fisher Biochemicals, 3,5-bistrifluoromethyl pyrazole (BTP) was synthesized by Laurie Mottram (Department of Chemistry, Penn State University), methylcholine was from Sigma, RPMI 1640 media from Media Tech, ^{3}H-thymidine from ICN, PMA and Ionomyocin (ION), both from Sigma.

Induction of Allergic Asthma and Administration of Immunosuppressant Drug. OT-II transgenic mice were induced to develop allergic asthma as follows: Mice are anesthetized by inhaling Isoflurane, then intranasal doses of 50 μl OVA (at 5 mg/ml In PBS) were then administered. In animals treated with BTP, 10 μM of BTP in 50 μL sterile PBS was introduced intranasally to OT-II mice everyday for 4 days. Subsequent doses of 50 μl OVA were also given on these days. Twenty-four hours after the last treatment, airway hyper-responsiveness was tested via mechanical ventilation. Control mice were given 50 μl doses of OVA without BTP, but otherwise treated in the same manner as the mice given the drug.

Mechanical Ventilation. Mice were injected with pentobarbital (90 mg/Kg) until general anesthesia was reached. A cannula was placed in the trachea and secured. Mice were then placed on a mechanical ventilator to measure airway hyper-responsiveness. During the ventilation process, mice were given increasing doses of methylcholine (contractile agent) at 5-minute intervals through a nebulizer. Each dose was double the concentration of the previous dose, beginning at 1 mg/ml and ending at 100 mg/ml.

Lung Pathology. Immediately following the mechanical ventilation procedure, both lungs were removed from each mouse and placed in para-formaldehyde. Lungs were then sectioned by the Animal Diagnostic Laboratory at Penn State and stained with H&E for determination of airway inflammation. Lungs were also stained with PAS to determine production of mucous.

Spleen cell Proliferation. Splenic T cell proliferation was determined in response to OVA in vitro as follows: In protocol I, splenocytes from mice exposed to BTP were tested for proliferative response to OVA in vitro by putting cells in single cell suspension, followed by red blood cell lysis. The remaining cells were placed in a 96 well flat bottom plate (100 μl cell/media solution per well). Added to the cells are one of the following: media alone, PMA/ION, 10 μM OVA, or 100 μM OVA, each in 100 μl doses. Cells are then allowed to incubate for 72 hours. After this time, 25 μl of ^{3}H-thymidine is added to each well. Cells are allowed to incubate for another 24 hours. Cells are then cooled and harvested. T-cell counts are determined via liquid scintillation. In the second protocol, OT-II mice with no prior treatments were sacrificed; splenic T cell proliferation to OVA was determined in the presence or absence of BTP. Cells were again put in single cell

suspension and red blood cells lysed. Cell/media solution was then distributed in a 96 well flat bottom plate (100 µl of cell solution per well). The following was added to each well: media alone, PMA/ION, OVA, and/or BTP. BTP was present in four concentrations: 10 µM, 100 nM, 10 nM, and 1 nM. Proliferation was determined by ^{3}H-thymidine and scintillation counting.

Results

Effect of BTP on airway hyper-responsiveness. BTP has been shown to reduce cytokine production by T cells in vitro (8). We therefore used BTP in a murine model of the disease to test it's effectiveness in reducing the symptoms of the disease. Mice were challenged with OVA (a model allergen) and half of the mice were treated intranasally with the BTP drug, prior to being challenged with OVA. Airway hyper-responsiveness was then tested using mechanical ventilation in which the contractile agent methylcholine was used. Resulting airway responsiveness values were then plotted. The results showed that mice primed with OVA developed airways hyper-responsiveness (See Figure 2). However, mice treated with the BTP drug did not show any statistically significant difference to those not treated with the drug.

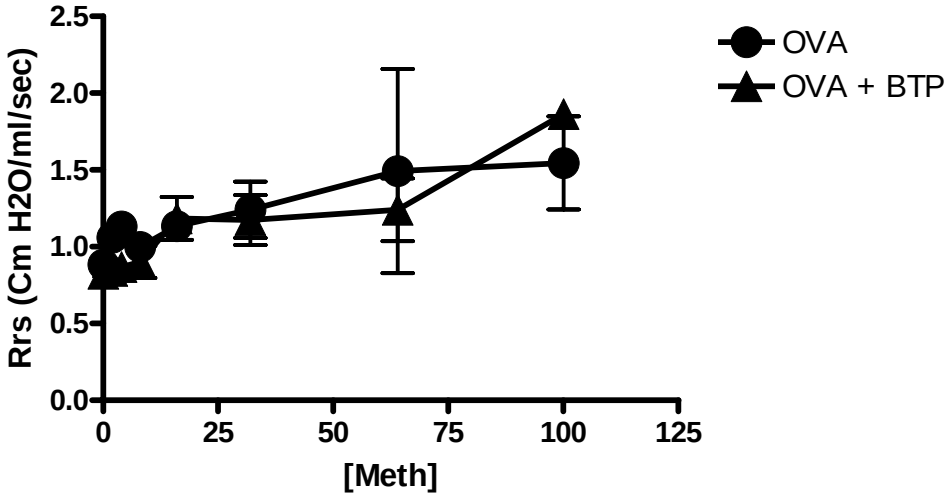


Figure 2. Effect of BTP on development of AHR. Mice were treated first with BTP and then challenged with OVA allergen for four days and compared to mice not given BTP. The BTP drug seemed to be effective when lower levels of methylcholine exposure (below 75 mg/ml) was analyzed.

Effect of BTP on lung pathology. The lungs were sectioned and stained with H&E (for analysis of lung inflammation) and PAS (for analysis of mucous production). They were then observed under a microscope to determine the amount of airway inflammation and mucus production. In the lungs of the mice treated with OVA alone, the effect of the allergen was clear. There was a great deal of cell infiltration, airway hyper-responsiveness, and much mucus is present. The bronchiole itself looks very constricted (see Figure 3A). In the lungs of the mice treated with the drug, symptoms consistent with OVA exposure were present, but not nearly as severe as the mice who were not treated

with the drug. There were some signs of constriction, hyper-responsiveness, and mucus as well, but less bronchioles in these mice seem to be affected (see Figure 3B).

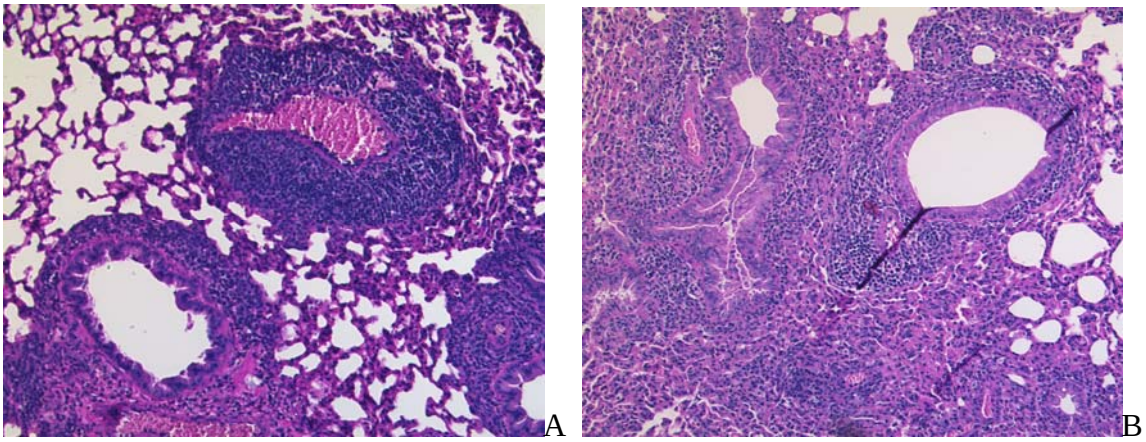


Figure 3. Effect of BTP on airway inflammation and mucous production in lungs of OVA exposed mice. Immediately following mechanical ventilation, lungs were removed. Lungs were later sectioned and stained with H&E and PBS. In mice exposed to OVA allergen (A) bronchical constriction is present. There is also a significant amount of mucus present. There is also much cell infiltration, indicating hyper-responsiveness. In mice exposed to the BTP drug (B) some constriction and mucus is also present, but at a much lesser extent than mice with allergen alone. More of the bronchioles are unaffected.

Effect of BTP on the proliferation of CD4$^+$ T cells. Allergic Asthma is caused by the proliferation of T cells when an allergen is introduced (5). We tested the effect of BTP on T cell proliferation in vitro. Mice with no prior treatments were sacrificed and spleens removed. Splenic proliferation to the OVA allergen was determined in the presence and absence of BTP. In cells treated with OVA alone, cells had high levels of proliferation. By contrast, cells treated with different concentrations of BTP did not proliferate (see Figure 4).

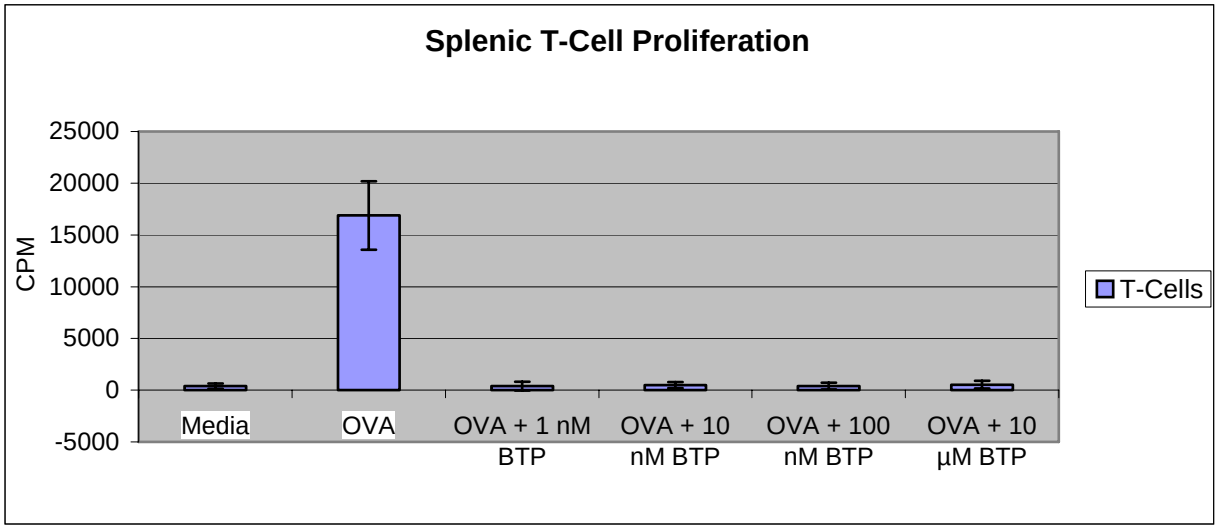


Figure 4. **Effect of BTP on antigen specific T cell proliferation.** Proliferation is higher in cells exposed to OVA alone. Proliferation was inhibited in cells treated with various concentration of BTP.

Conclusions

Reduced Airway Hyper-responsiveness. Mice exposed to OVA allergen showed increased AHR. Mice treated with the drug showed lower levels of AHR only when challenged with lower levels of methacholine. This suggests that BTP may be able to reduce the amount of AHR, even after exposure to OVA allergen. However, the amount of BTP may have to be increased to see effects at higher methacholine concentrations.

Histology. Lungs of mice exposed to the OVA allergen show much cell infiltration and mucus production. Lungs of the mice that were treated with the drug show less mucus and infiltration. This suggests that BTP improves lung condition by reducing the production of mucus and cell infiltration.

Inhibition of antigen specific T cell proliferation. Cell proliferation of T cells from mice exposed to OVA are much higher than the cells exposed to OVA and treated with the BTP drug. This demonstrates that the proliferation of the antigen specific T cells is inhibited, which would reduce the symptoms of the disease.

Discussion

This experiment shows much promise for those who are suffering from allergic asthma. This research data shows that BTP has a positive effect on the symptoms of the disease. BTP inhibits T cell proliferation, therefore greatly reducing the symptoms. These findings could lead to discovery of better and safer treatments for allergic asthma.

The results obtained from this experiment suggested that BTP could be an effective treatment for Allergic Asthma. However, in some experiments, the drug was less effective than originally anticipated. This could have been attributed to ineffective OVA or the concentration of the BTP drug.

Experiments with BTP are ongoing to further analyze its effect on the symptoms of Allergic Asthma. In the future, it would be interesting to administer the drug in different ways to determine if symptoms are affected any differently. It would also be beneficial to test the effectiveness of BTP in various concentrations to see which is most effective.

References

1. Murphy, S. (1997). Expert panel report II: Guidelines for the diagnosis and management of asthma. Retrieved from *Clearing the Air: Asthma and Indoor Air Exposures*. 2000. p 23.

2. Center for Disease Control National Center for Health Statistics. Retrieved on June 28, 2007 from http://www.cdc.gov/nchs/fastats/asthma.htm.

3. Wills-Karp, M., J. Luyimbazi, X. Xu, B. Schofield, T.Y. Neben, C.L. Karp, and D. Donaldson. 1998. Interleukin-13: Central Mediator of Allergic Asthma. *Science* 282, pp. 2258–2261.

4. Rosen, Fred and Raif Ceha. 2004. Case 23: Allergic Asthma. *Case Studies in Immunology: a clinical companion*. pp. 151-153

5. Ingram. 1991. Retrieved from *Clearing the Air: Asthma and Indoor Air Exposures.* 2000. pp. 23

6. Cohn, L., J.A. Elias, and G.L. Chupp. 2004. Asthma: Mechanisms of Disease Persistence and Progression. *Annual Review of Immunology* 22, pp. 789-815.

7. Schacke, H., W-D. Docke, and K. Asadullah. 2002. Mechanisms involved in the side effects of glucocorticoids. *Pharmacology & Therapeutics* 96:1, pp. 23-43.

8. Trevillyan, J., G.C. Chiou, Y. Chen, S.J. Ballaron, M.P. Sheets, M.L. Smith, P.E. Wiedeman, U. Warrior, J. Wilkins, E.J. Gubbins, G.D. Gagne, J. Fagerland, G.W. Carter, J.R. Luly, K.W. Mollison, and S.W. Djuric. 2001. Potent Inhibition of NFAT Activation and T Cell Cytokine Production by Novel Low Molecular Weight Pyrazole Compounds. *The Journal of Biological Chemistry* 276: 51, pp. 48118-48126.

Effects of Variation in Surgical Technique on Range of Motion in Total Knee Replacement

Dipnil Chowdhury, Ronald E. McNair Scholar, Penn State University

Dr. Stephen J. Piazza
Department of Kinesiology, Mechanical Engineering, Bioengineering, and Orthopedics and Rehabilitation
Penn State University

ABSTRACT

Surgical technique is an important factor that may limit range of motion (ROM) following total knee replacement. The purpose of this study was to use computer simulation to study the effects of resecting too little bone on knee ROM. Dynamic computer simulations of a supine ROM test were performed in order to determine the effects of these variations on ROM, as indicated by the force required to flex the knee, soft-tissue tensions, and articular contact forces.

INTRODUCTION

Total knee replacement (TKR) is a reliable and widely used surgical procedure that involves removal of diseased articular surfaces at the knee joint and replacement of these surfaces with prosthetic implants. According to the American Society of Orthopaedics Surgeons (AAOS), nearly 402,000 patients have undergone TKR in 2003. The number of procedures is predicted to increase nearly 475,000/year by 2030 due to more innovative designs and technological improvement leading to decreased failure rates in TKR.

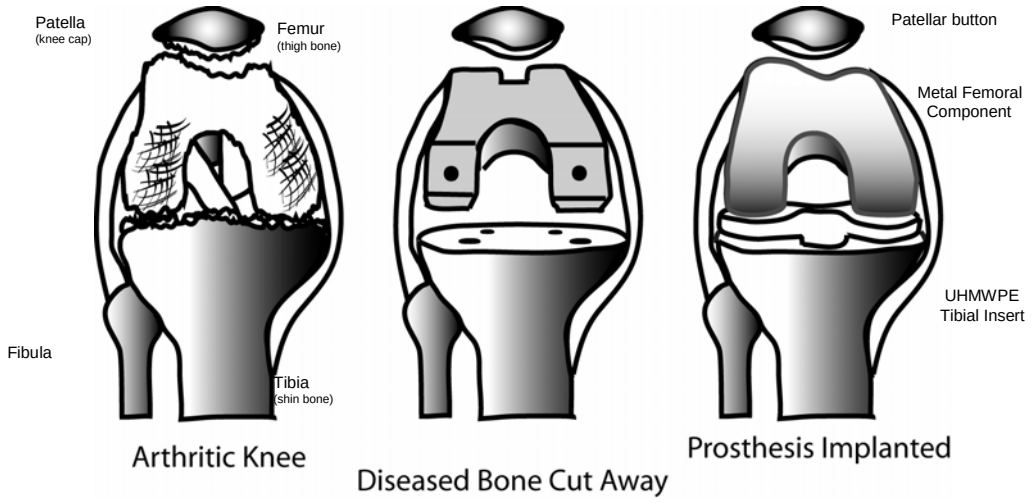


Fig 1. Diagram of "The Process of Total Knee Replacement" (Drawing by Mr. Ryan L. Landon).

Despite being generally accepted as an excellent treatment for osteoarthritis, total knee replacement is not free from problems. One of these problems, complications related to joint line restoration, has become an issue under frequent investigation[1,2,3,4,5,6,7]. The anatomical joint line consists of appropriate positioning of TKR bones with respect to ligament lengths. Previous research has shown that restoration of ideal knee geometry is most desirable and may lead to higher ROM following TKR[1,2,5]. Therefore, an improper joint line can lead to inadequate ligament balancing, abnormal tracking and increase in patellofemoral and tibiofemoral contact forces [3,4,5]. It has been reported that increase in overall patellar thickness leads to higher surface strain and contact force resulting in poor mobility [2,3]. Other studies showed restriction in extension and flexion mechanisms due to tightened collateral ligaments which were a result of minimal tibial cut or a thicker tibial component replacement [7]. This study utilized forward dynamic simulation and musculoskeletal modeling to investigate effects of "overstuffing" the knee by removing too little bone on knee ROM. The following component alignment variations were investigated:

- Femoral component moved inferiorly by 0-3 mm.
- Tibial component moved superiorly by 0-3 mm.
- Patellar component moved posteriorly by 0-3 mm.

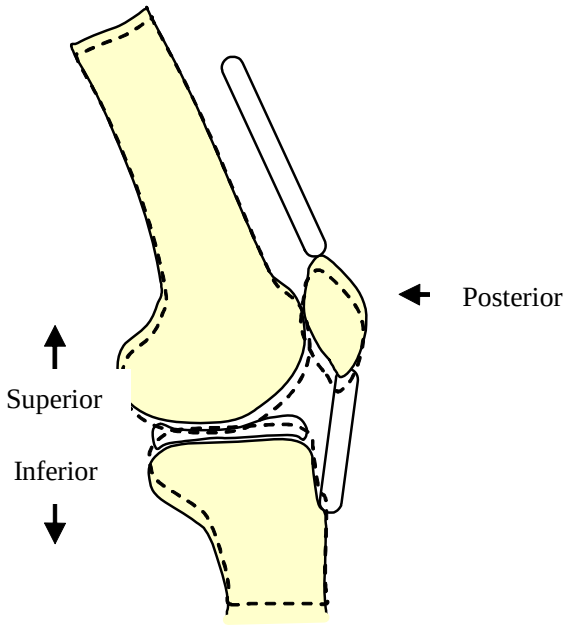


Fig 2. Overstuffing tibiofemoral and patellofemoral compartments.

METHODOLOGY

Preoperative TKR Testing

Preoperative testing of TKR is an integral part of maximizing knee ROM. Some tools available for evaluating implant designs include finite element analysis (FEA), multi-body dynamic simulations, and cadaver studies [8]. Drawbacks for these techniques are as follows:

Technique	Time Consuming	Expensive	May Not Be Reliable	May Not Measure All Variables of Interest
Cadaver Tests	✓	✓		✓
Multi-body Dynamic Simulations			✓	
FEA	✓		✓	✓

Table 1.Comparison of Preoperative Testing Techniques.

Multi-body dynamic simulations, as shown in Table 1, are an attractive alternative to cadaver studies and FEA for investigating knee replacement mechanics. A simulation in which acceptable modeling assumptions are made can provide a means for investigating TKR mechanics that is realistic, fast, and relatively less expensive[8]. This study utilized multi-body dynamic simulations to predict implant motions for a commercially-available TKR system under various surgical techniques.

Pre-Processing

CAD models of a commercially available TKR were obtained from a manufacturer. These models were created using ProEngineer, a 3D solid modeling software. Next the Pro/E models were used to create bone and IGES files necessary to conduct this study. TKR geometries, obtained from these IGES files, were utilized to place virtual springs on articular surfaces of bones. Afterwards, a forward dynamic simulation, where motion is predicted by forces, was implemented to calculate contact force and location between tibiofemoral and patellofemoral compartments using a Kelvin-Voigt model: *F=K*x+B*(xdot)*. The following figure is an example of a tibial component with springs placed on articulating surfaces.

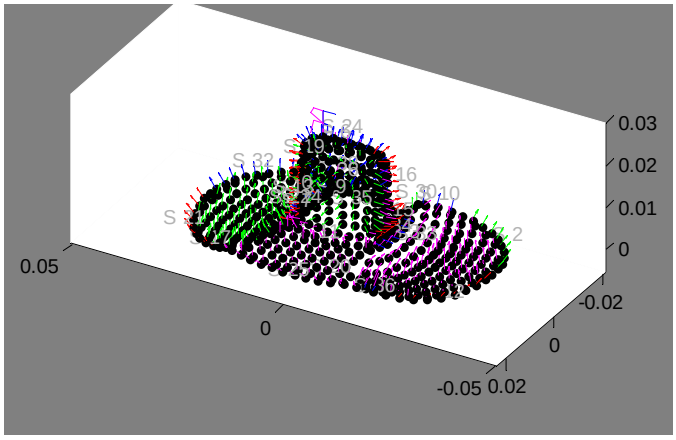


Fig 3. Springs placed on a tibial component.

Post-Processing

Implants with springs on articular surfaces were surgically implanted on a digitized lower extremity model using SIMM. SIMM (Software for Interactive Musculoskeletal Modeling) is a software system that enables users to create and analyze graphics-based models of the musculoskeletal system. In SIMM, a musculoskeletal model consists of a set of bones that are connected by joints. Muscle-tendon actuators and ligaments span the joints. The muscles and ligaments develop force, thus generating moments about the joints[9]. The following figure shows a placed TKR using a SIMM leg model.

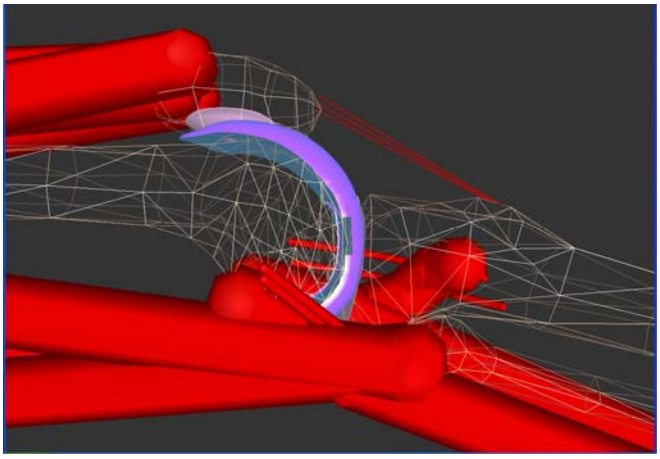


Fig 4. TKR placed on digitized leg model using SIMM.

A supine ROM test, during which a patient is lying on their back and a force is applied to the ankle to flex the knee, was simulated with placed implants. Dynamics Pipeline, a suite of software routines that help SIMM users build dynamic simulations of musculoskeletal structures, was utilized to conduct the rest of the study[10]. Finally, simulations with various overstuffing scenarios were simulated using SIMM and a forward dynamic model. Soft tissue tensions, force required to flex the knee, and articular contact forces were calculated from simulation output. The following figure shows the supine ROM test conducted using SIMM.

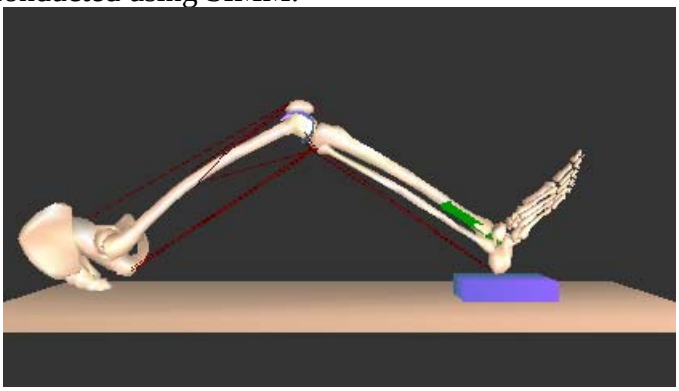


Fig 5. Supine ROM model using SIMM.

RESULTS

The knee extensor mechanism, located anterior to the femur, consists of the quadriceps muscles, the patella, and the patellar tendon. This mechanism becomes tight in deep knee flexion and is an important structure that determines post-operative knee ROM. Cutting away more of the patellar bone is one solution to loosen the extensor mechanism; this study however looked at effects of less bone resection on knee ROM. Another possible technique is partial resection of muscle belly and the tendinous from portions of the quadriceps[2]. The following results show the different components of the extensor mechanism with variations in the amount of overstuffing throughout supine ROM.

Forces on Quadriceps Muscles During Knee Flexion

The quadriceps femoris are located on the front of the thigh. These muscles consist of: the vastus lateralis, vastus intermedius, vastus medialis, and rectus femoris. During the supine ROM test, the quadriceps muscles produce a passive knee extension moment that resists the applied motion. The plot below is the sum of the vastus lateralis, vastus intermedius, and vastus medialis forces during the simulation.

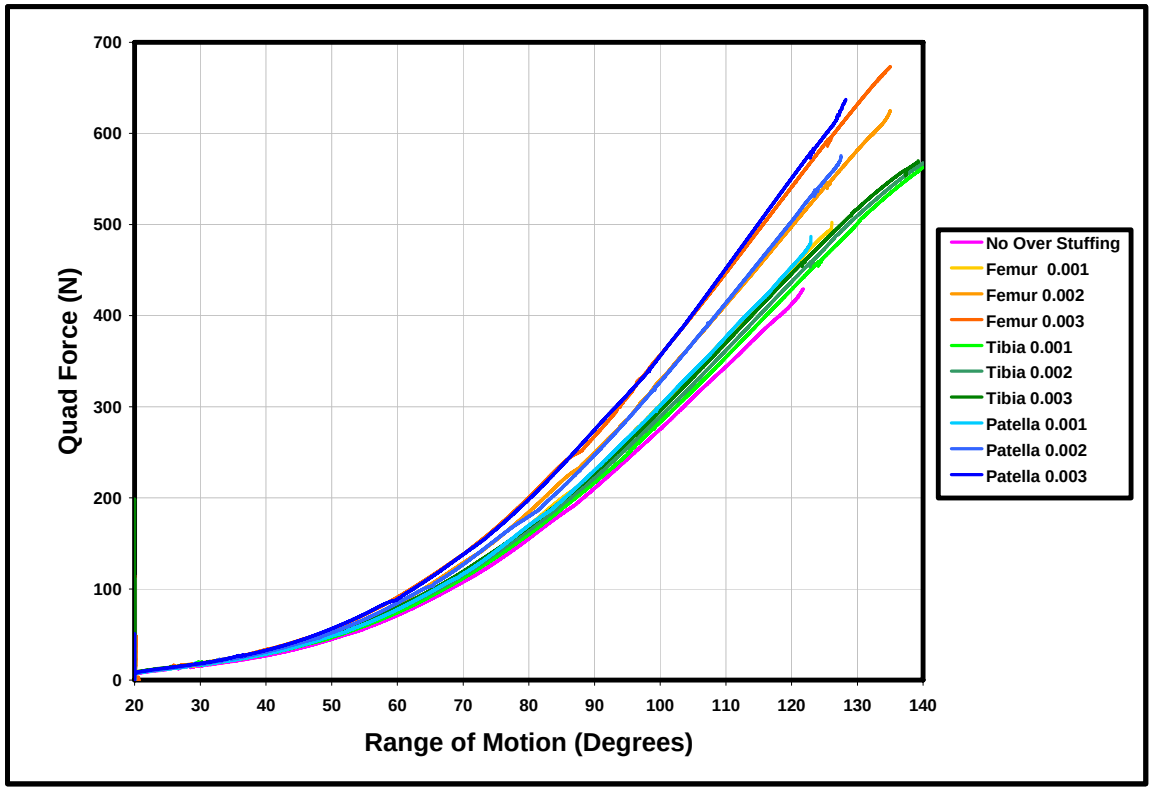


Figure 6: Summed quad force (N) as a function of ROM (degrees), for each surgical variation. The general trend was, as overstuffing increased from 0 to 3 mm, the quad force also increased. One other observation was, overstuffing the tibial component produced much higher ROM with less quad force applied throughout supine ROM.

Forces on Patellar Ligament During Knee Flexion

The patellar ligament, sometimes called the patellar tendon, is located on the anterior (front) part of the tibia. The ligament connects the patella to the tibia bone. During the supine ROM test, the patellar ligament also produces a passive knee extension moment that resists the applied motion. The following is a summary of the forces in the patellar ligament during the simulation.

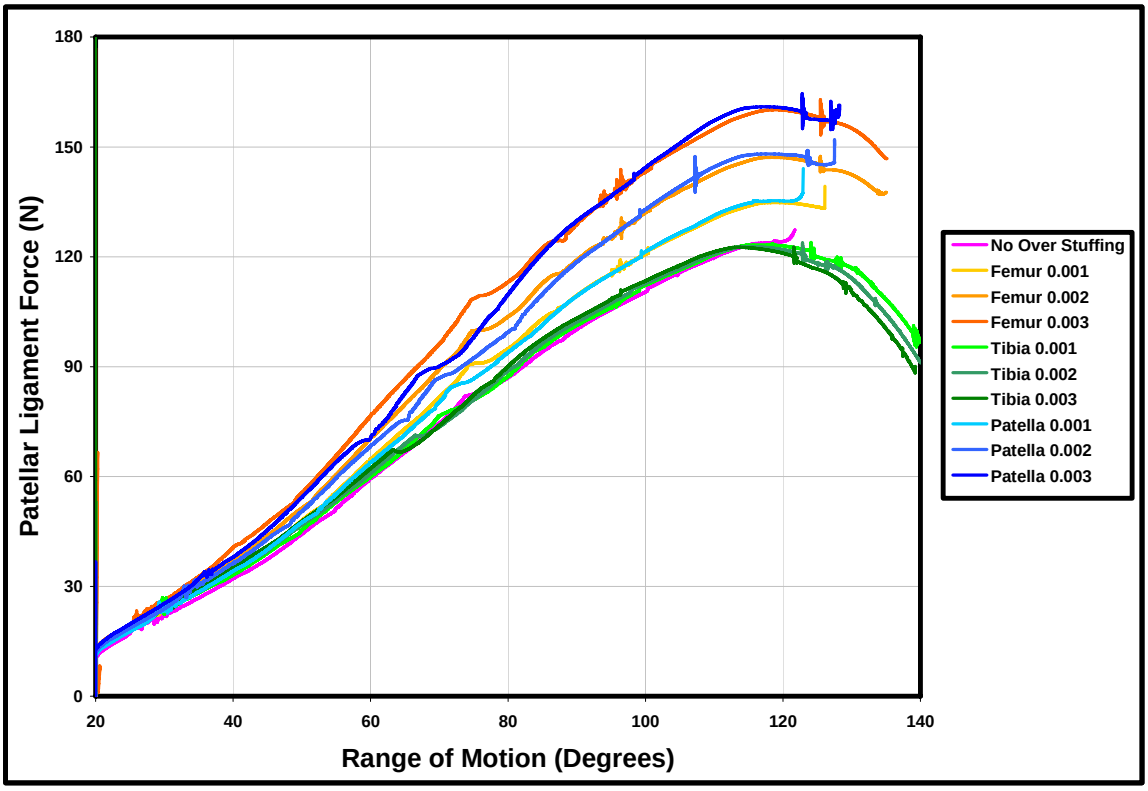


Figure 7: Patellar ligament force (N) as a function of ROM (degrees), for each surgical variation. The general trend present was, as overstuffing in the patella and femur increased from 0 to 3 mm, the force in the patellar ligament also increased. Another observation made, overstuffing the tibial component and no overstuffing produced relatively the same amount of force throughout knee ROM.

Patellofemoral Contact Force

The patellofemoral joint, located on the anterior (front) portion of the knee, plays a crucial role in ROM. As the name suggests, this joint is the contact location between the femur and patella bone (kneecap). Development of high contact forces at this joint may lead to pain and wear of the components following TKR. The following plot is a summary of observations of contact force throughout supine ROM.

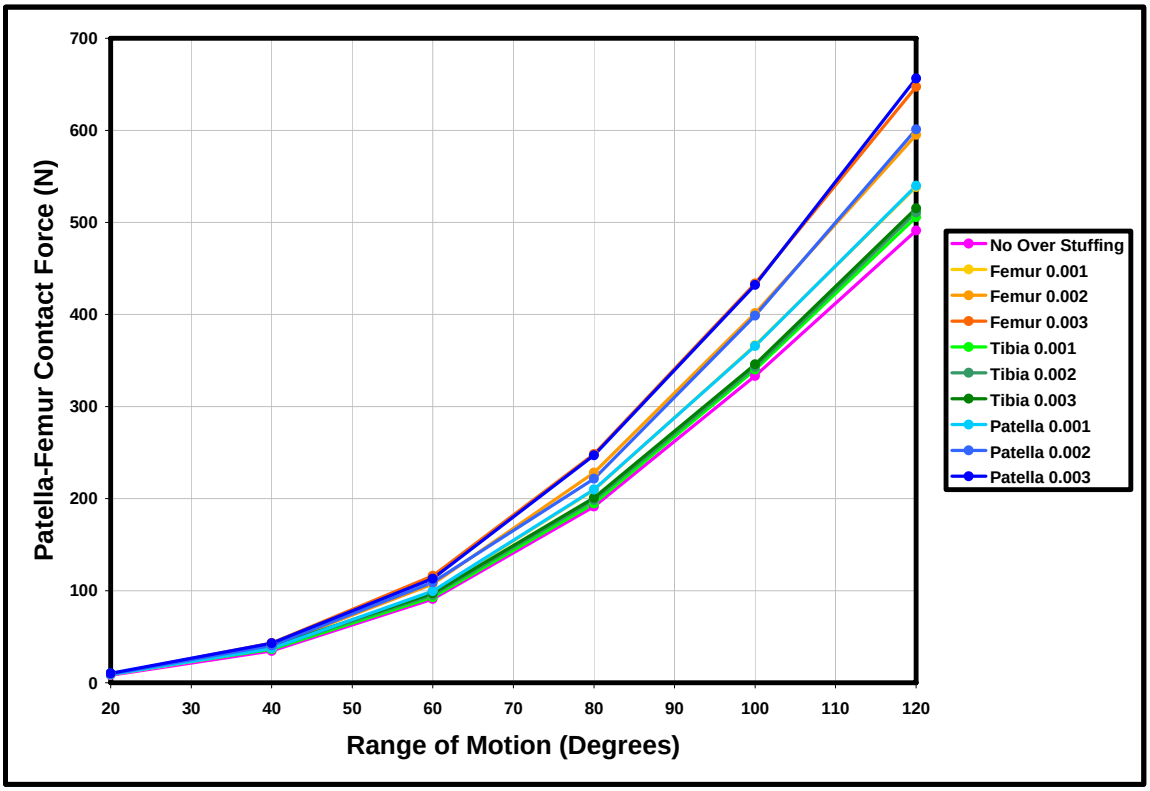


Figure 7: Contact force (N) in the patellofemoral compartment as a function of ROM (degrees), for each surgical variation. Some observations made were: overstuffing the patella or femur produced relatively the same amount of contact force and tibial overstuffing produced less contact force in the patellofemoral compartment.

The supine range of motion test requires a superiorly-directed force applied to the ankle to flex the knee. This force would ordinarily be applied by a surgeon examining a patient at the post-operative stage. In this study the author observed the amount of force required at the ankle to determine if any significant changes have occurred due to TKR overstuffing. The following plot is a summary of the force required to flex the knee with each surgical variation.

External Force Required to Produce Knee Flexion

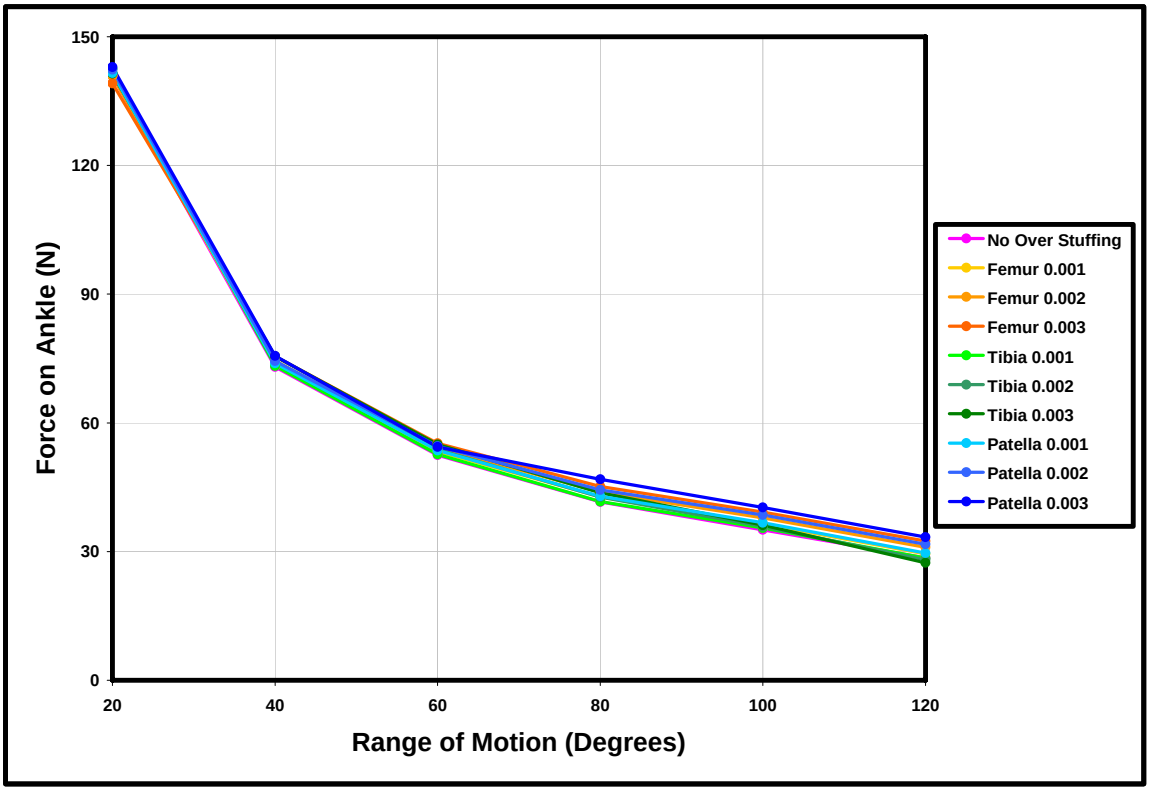


Figure 8: Force applied to the ankle (N) as a function of range of motion (degrees) for each surgical variation. No substantial changes were present from overstuffing each TKR component. However the tibial component required less force to flex the knee when overstuffed.

DISCUSSION

Knee kinematics after total knee replacement influence its long term outcome and quality [1]. Maintaining the anatomical joint line is recognized as one of the most important factors in maximizing knee ROM[1,2,3,4,5,6,7]. The present study investigated variations in joint line geometry also called overstuffing and its effects on knee ROM. Analysis showed that 3mm of tibia overstuffing improved ROM nearly 10 degrees while maintaining suitable anatomical ligament characteristics and contact forces. These outcomes are contrary to those published by Jiang 1993, who found that a 4mm to 10mm increase in the collateral ligaments produced a loss of 0 to 15 degrees in knee ROM [7]. This discrepancy may have resulted from no observations being made exceeding 3mm of overstuffing. Therefore, 3mm might be the threshold before significant variances in ligament lengths and forces are present.

Femur or patella overstuffing were found to improve ROM but resulted in higher contact forces in the patellofemoral joint and higher forces in the quadriceps muscles. Results of patella overstuffing are similar to those described in Jiang 1993 and Stiehl 2001 where increased patellofemoral contact pressure was shown to occur for thicker patella following TKR[6,4].

Some implications that may arise from this study are: tibial overstuffing might improve knee ROM but only when the tolerance is less than 4mm. Also as shown in previous studies, maintaining the patellofemoral joint line is crucial for successful TKR.

Limitations

The author would like to emphasize that these trends may have resulted from improper surgical placement of the components before overstuffing. Another item to acknowledge is that the normal knee motions used to define ligament properties and placement may have been unrealistic. One final point to make is that this study was done on only one type of TKR. Therefore, these results are specific to this design and may not be generalized.

Conclusion

Range of motion (ROM) is a key outcome measure used in the design and evaluation of total knee replacements. An ideal human knee is capable of reaching nearly 165 degrees ROM in full flexion. TKR designers and surgeons are constantly trying to discover better and more innovative ways to achieve higher ROM following TKR. Higher ROM will allow patients the ability to perform more day to day activities without constraints from TKR[11,12]. The overall goal is to design components that are capable of reaching nearly the same range of motion as in the natural human knee. Until this goal is achieved, investigations like the present study provide surgeons and designers with information on how to achieve better ROM with a model currently available on the market.

ACKNOWLEDGMENTS

The author would like to thank Dr. Stephen J. Piazza and Mr. Ryan L. Landon, creators of the forward dynamic simulation used to conduct this study, for all their support and guidance throughout this study. Additionally the author thanks the entire McNair and Penn State Biomechanics team for making this entire experience worthwhile.

REFERENCES

1. Yoshii I, Whiteside LA, White SE, Milliano MT: Influence of Prosthetic Joint Line Position on Knee Kinematics and Patellar Position. The Journal of Arthroplasty 6:169-177, 1991.

2. Reuben JD, McDonald CL, Woodard PL, Hennington LJ: Effect of Patella Thickness on Patella Strain Following Total Knee Arthroplasty. The Journal of Arthroplasty 5:251-258, 1991.

3. Ryu J, Saito S, Yamamoto K, Sano S: Factors influencing the postoperative range of motion in total knee arthroplasty. Hospital for Joint Diseases 53:35-40, 1993.

4. Stiehl JB, Komistek RD, Dennis DA, Keblish PA: Kinematics of the Patellofemoral Joint in Total Knee Arthroplasty. The Journal of Arthroplasty 16:706-714, 2001.

5. Figgie HE, Goldberg VM, Heiple KG, Moller HS: The Influence of Tibial-Patellofemoral Location on Function of the Knee in Patients with the Posterior Stabilized Condylar Knee Prosthesis. The Journal of Bone and Joint Surgery 64A:1035-1040, 1986.

6. Jiang CC, Chen CH, Huang LT, Liu UJ: Effect of Patellar Thickness on Kinematics of the Knee Joint. J Formosan Medical Association 92:373-378, 1993.

7. Jiang CC, Liu CS, Liu YJ, Liu TK: Factors Affecting Knee Motion After Total Knee Arthroplasty: A Cadaveric Study of the Collateral Ligament. J Formos Medical Association 92:249-254, 1993.

8. Piazza S: Dynamic Computer Simulation of Total Knee Replacement. The Pennsylvania State University, 2006.

9. Loan P, Delp S, Smith K, Blaikie K: SIMM 4.0 for Windows User Manual. MusculoGraphics, Inc, 2004.

10. Loan P, Wyles D, Delp S, Blaikie K: Dynamics Pipeline 3.0 for Windows User Guide. MusculoGraphics, Inc, 2003.

11. Kurosaka M, Yoshiya S, Mizuno K, Yamamoto T: Maximizing Flexion After Total Knee Arthoplasty. The Journal of Arthroplasty 17:59-62, 2002.

12. Sultan PG, Most E, Schule S, Li G: Optimizing Flexion After Total Knee Arthroplasty. Clinical Orthopaedics and Related Research 416:167-173, 2003.

An Analysis of the Internet Parasite: A Biological Analog in the Digital World

Mohamed Faacy Farook, McNair Scholar, Penn State University

Faculty Research Advisor
Dr. Patrick McDaniel
Assistant Professor Computer Science and Engineering
College of Engineering
Penn State University

Graduate Assistant
Kevin Butler
Ph.D. Candidate, Computer Science and Engineering
Penn State University

Abstract

The Internet is rife with malware: worms and viruses are rampant. However, a new form of malware, the Internet parasite, could have an even more devastating effect on host systems worldwide. Like their biological counterparts, Internet parasites evolve through mutation and create new attack vectors, propagating silently through their victims. In this study, we attempt to simulate parasitic behavior by extending our "parasim" simulator to more realistically model parasitic propagation across real-world topologies.

Introduction

Computer worms pose a major threat to internet, and it is a general belief that understanding their means of propagation will help to devise efficient control strategies (Leveille 2003). Kevin Butler and Patrick McDaniel (2005) asserted that worm attacks based on mutation and covert propagation are likely to be ultimately more damaging and long lasting, which was supported by parasitic behavior in natural systems. They proposed a new form of computer worm called the "Internet Parasite." Like its biological counterpart, survival of the parasitic worm depends on mutation. While residing in a machine undetected, it dynamically discovers new invasive techniques and covertly propagates across the network. In most cases, the mutations and the attack vectors will fail, but the few successful ones will result in spectacularly successful growth and spread throughout the network. In order to create counter measures for a Parasitic Worm, it is essential to model and understand its behavior. This study extends the previous study by simulating parasitic behavior in real world network topologies at the sub-network level. It is hypothesized that the propagation of the Internet parasite will be slower across real-world network topologies than in a fully connected network but will still exhibit similar behavior as in a fully connected network.

Methodology

The "parasim" simulator was originally written by Kevin Butler in Java programming language. The simulation parameters were the number of hosts in the network, probability of infection Pi, the probability of inoculation Pn, and the probability of mutation Pm and the number of initial hosts infected. These probability distributions are exponential. The "parasim" simulator assumed a fully meshed topology of 500 hosts, where each host is connected to every other host. Also, the hosts in the network topology are assumed to be homogeneous, in the sense that an infected host is equally like to infect any of the other susceptible hosts. Therefore during the simulation of parasitic worm propagation in a fully meshed network, a particular strain of an infected host attempted to infect any other randomly selected host in the network.

A network topology can be thought as a graph. Graphs are composed of a set of nodes (vertices) connected by a set of edges. Vertices connected to a given node (each through a different edge) are called the 'neighbors' of that node. The number of neighbors of a given node is called its 'degree'. In a graph that represents a network topology, each node represents a host in the network and each edge in between two nodes represents the network connection between the hosts. The degree of the node represents the number of network connections to the particular host under consideration. The simplest possible graph is the fully-connected graph: each node is connected to every other node. It has been argued that fully-connected graphs do not offer a realistic account of computer networks (Kephart & White 1991). Users tend to communicate with a subset of users, not with everyone in the network. Therefore, the pattern of connections is not really fully-connected. (Leveille 2003)

In order to simulate parasitic worm propagation in a real world network topology, the "parasim" simulator had to account for the network characteristics such as the actual heterogeneous connections between hosts, connection bandwidth, direction of network data flow, and hierarchical properties of the network. The real world network topology was simplified with the following constrains:

- Hosts and network characteristics are homogeneous
- An infected host is able to infect only a directly connected host
- Network connections are bi-directional (i.e. the edges in the graph are undirected)

The first step was to generate an Internet network topology and to read it into the "parasim" simulator. Boston University Representative Internet Topology Generator, (BRITE) written by Alberto Medina, Anukool Lakhina, Ibrahim Matta, and John Byers, was chosen as it is was able to generate Power law topology in which our study is interested. Furthermore it is available in java source code format which is the language in which the "parasim" simulator is written.

BRITE supports generation of two-level hierarchical topologies and Top-down is one such approach. In a Top-down hierarchical topology, BRITE generates first an Autonomous Systems (AS)-level topology and then for each node in the Autonomous Systems (AS)-level topology BRITE generates a router-level topology. (Medina et al 2001)

Figure 1 shows the generated topology. A two level top-down hierarchical topology was generated using the Waxman model with default parameters. The topology generated contains 20 Autonomous Systems (AS) level nodes each with 25 router level nodes connected. Thus the network consists of a total of 500 hosts in total. A Java program was written to convert the BRITE output file format (.brite) to an edge file format (.edg) which can be inputted into the "parasim" simulator.

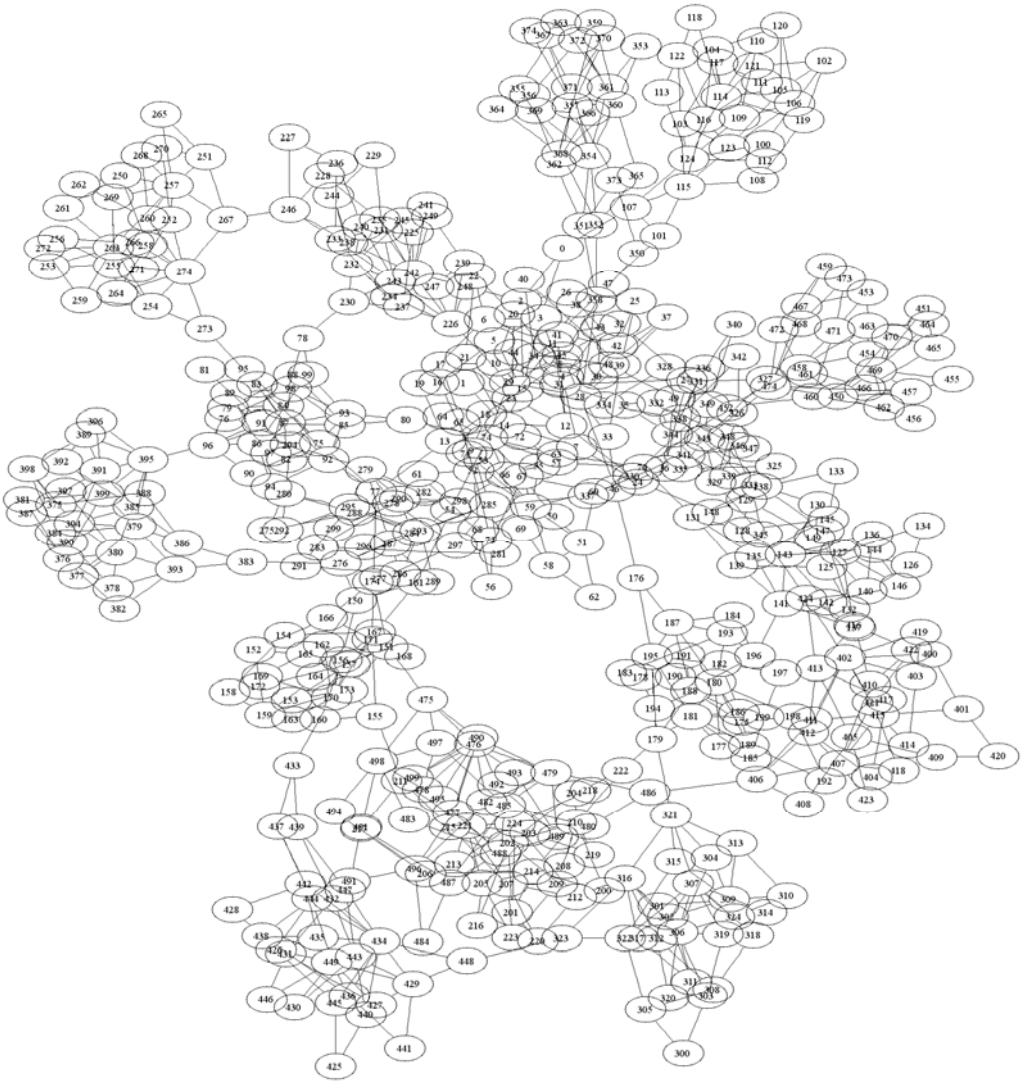


Figure 1: The graph of the Internet topology generated by BRITE simulator with 20 Autonomous Systems (AS) level nodes each with 25 router level nodes connected to give a total of 500 hosts in the network.

The "parasim" simulator was modified to read in a network topology in an edge (.edg) file format where each host in the network is given a unique identifier and the connections between hosts are output as a pair of unique host identifiers. The host connections are assumed to be undirected, so that any connected host can send and

receive data across the network and hence it is equally susceptible for infection by an Internet parasite. The topology was read into the "parasim" simulator and was stored as an internal data structure consisting of an array of an adjacency lists. Then the simulator was modified to attempt infection on a randomly selected directly connected host.

Also, a further modification to the simulator was the selection of the hosts for initial infections. In the original "parasim" simulator which models a fully meshed network the first 'a0' (simulation input parameter for number of initially infected hosts) hosts were selected. In a fully meshed network topology any host can be selected as initially infected because the network connections are identical respect to any other host. But in a hierarchical topology the network connections may differ for each host. Therefore the selection of the hosts can influence the spread of the parasite depending on the number of network connections of that particular host. A more realistic approximation to the initial infections was to model clustered infections. First, a host was chosen at random and then infected. Then all the directly connected hosts of the infected hosts were infected. The process is repeated for the newly infected hosts until the total number of infected hosts in the network reaches 'a0'. Then the time counter was started and the simulation was run.

There were additional constraints that needed to be added to the simulator to run with the available memory in the system. The following constraints were added to the simulator:

- the maximum number of parasite mutation strains in the network
- the maximum number of infection attempts for a given time period, and
- the total number of time periods simulated

It was noted that the constraint for the maximum number of infection attempts for a given time period was not a hard limit, i.e. the infections could go above the limit until the current host has completed the infection attempts with all the parasites it was infected with. Addition of these new constraints were necessary for the simulator to run to completion but it also created side effects with the realistic nature of the simulation. For example, when the maximum number of infection attempts for a given time period was reached, the simulator continues infection attempts with the current host until it completes and then goes to the next time period, by-passing the infection attempts of any remaining hosts attempting infection. This may cause a bias by not allowing newly infected hosts to propagate infections properly. To overcome this issue, newly infected hosts in the current time period were given preference to attempt infections in the next time period because they were added to the beginning of the list of hosts to attempt infection for the next time period. Also, the newly infected hosts in the current time period could attempt infections only at beginning of the next time period.

Our study focused on the propagation dynamics at the beginning of the Internet parasite infection for a given network topology. Therefore, code was added to stop the simulation when all the hosts in the network were compromised by the parasite. At this point the output values were copied till the end of the simulation time periods. The consequence of doing this is that the simulator does not simulate the dynamics of the network after the network has been completely compromised. But during the test runs it was observed that the number of infected hosts oscillates because of the infections and inoculations of the hosts.

Results

The simulation was run on both a fully meshed network (FM) and a top down hierarchical network (TP) for a range of infection probabilities, namely 0.035, 0.040, 0.045, 0.050, and 0.055 while all other simulation parameters were held constant. The simulation parameters for the "parasim" simulator were

- number of hosts in the network - 500
- coefficient of infection - 0.035, 0.040, 0.045, 0.050 or 0.055
- coefficient of mutation - 0.05
- coefficient of inoculation - 0.04
- number of hosts initially infected - 25
- type of initial infection - clustered
- maximum number of time periods - 1000
- maximum number of mutation strains in the system - 1,00,000
- maximum infection attempts per round - 2,00,000

Data was collected from 100 trials with 1000 rounds in each trial. The average number of infected hosts were calculated and plotted for comparison. Figure 2 shows the results. For clarity of the figures only 600 time periods are shown. Figures 3, 4, 5, 6 & 7 are drawn for easier comparison of the "parasim" simulation results for a fully meshed network (FM) and a top-down hierarchical network (TP) generated by BRITE simulator for coefficients of infection of 0.035, 0.040, 0.045, 0.050 and 0.055 respectively. Figure 8 shows the percentage of trials in which the parasite was able to compromise the whole network for the range of infection probabilities. Figure 9 tabulates the important results such as the maximum average number of infections, time period for which the maximum values are reached and the percentage of trials where the parasite is able to compromise the whole network.

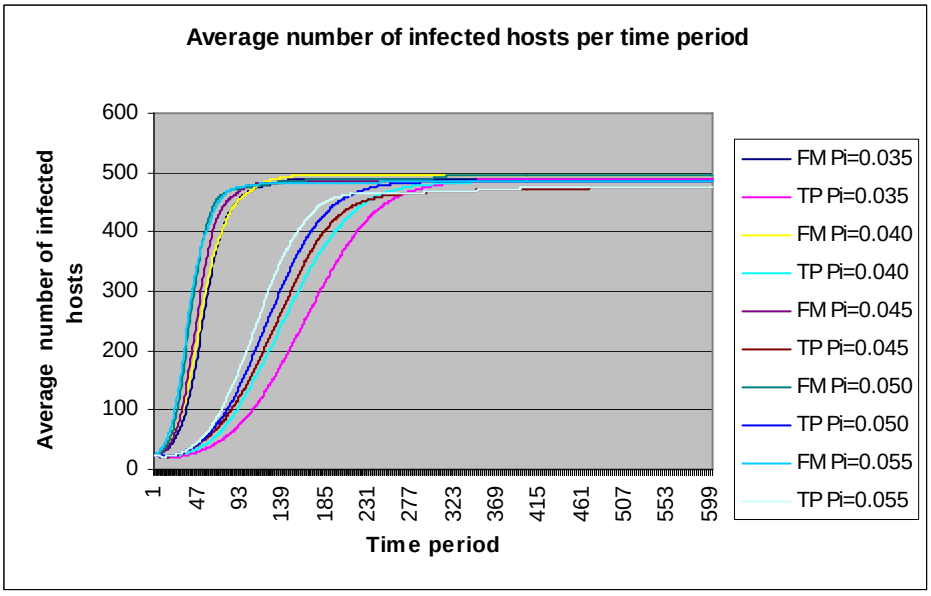


Figure 2: The average number of infected hosts from 100 trials for coefficients of infection 0.035, 0.040, 0.045, 0.50, and 0.055 in fully connected network (FM) and a top down hierarchical network (TP)

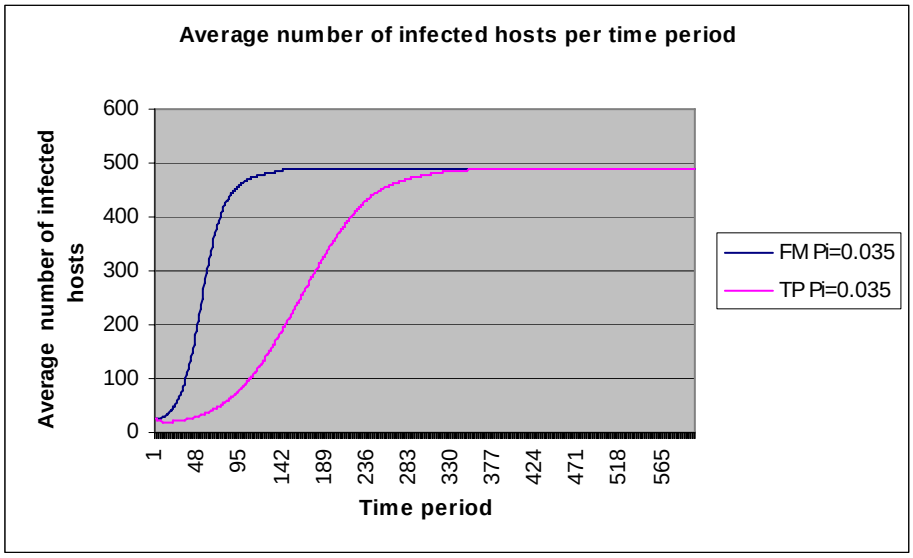


Figure 3: The average number of infected hosts from 100 trials for a coefficient of infection 0.035 in a fully meshed network (FM) and a top-down hierarchical network (TP)

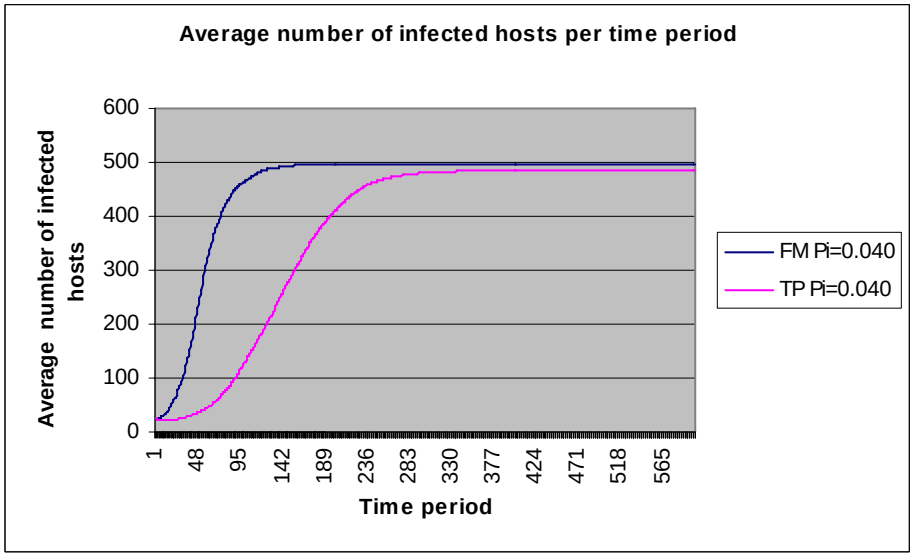
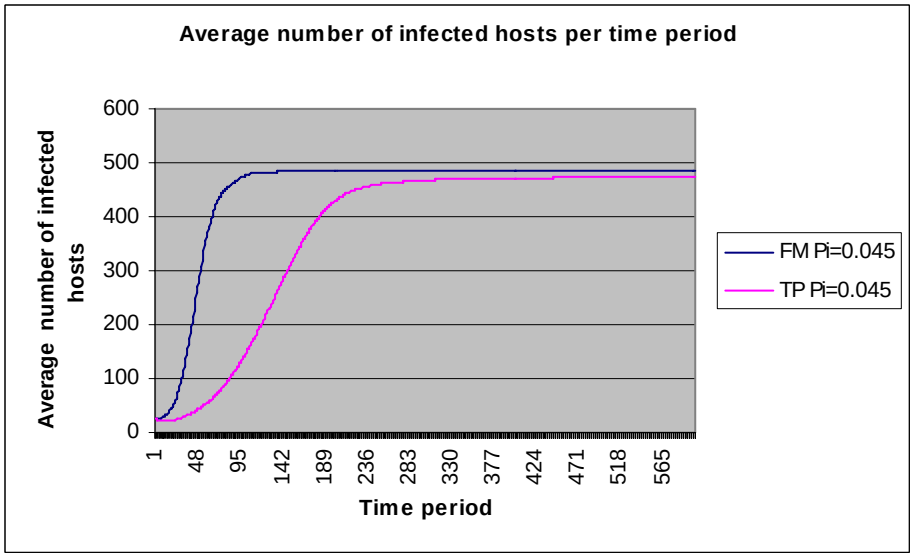
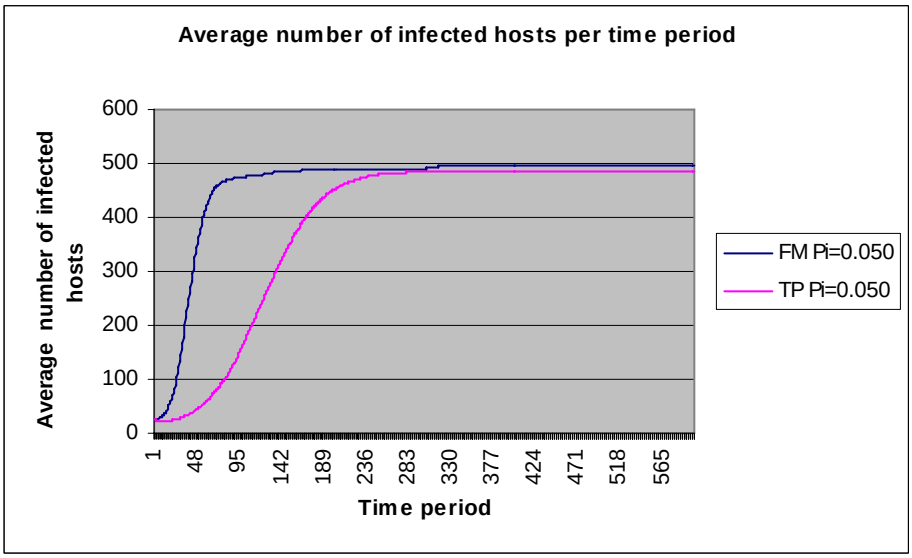
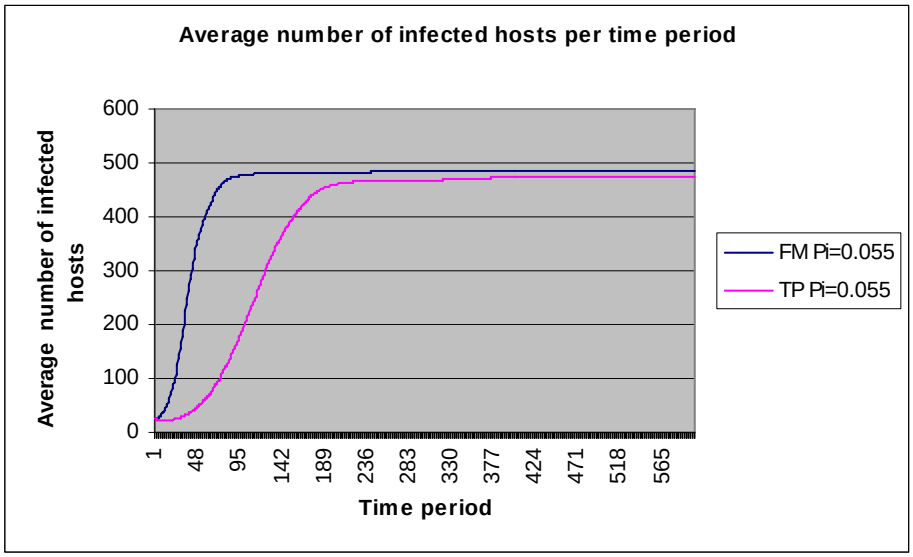


Figure 4: The average number of infected hosts from 100 trials for a coefficient of infection 0.040 in a fully meshed network (FM) and a top down hierarchical network (TP)







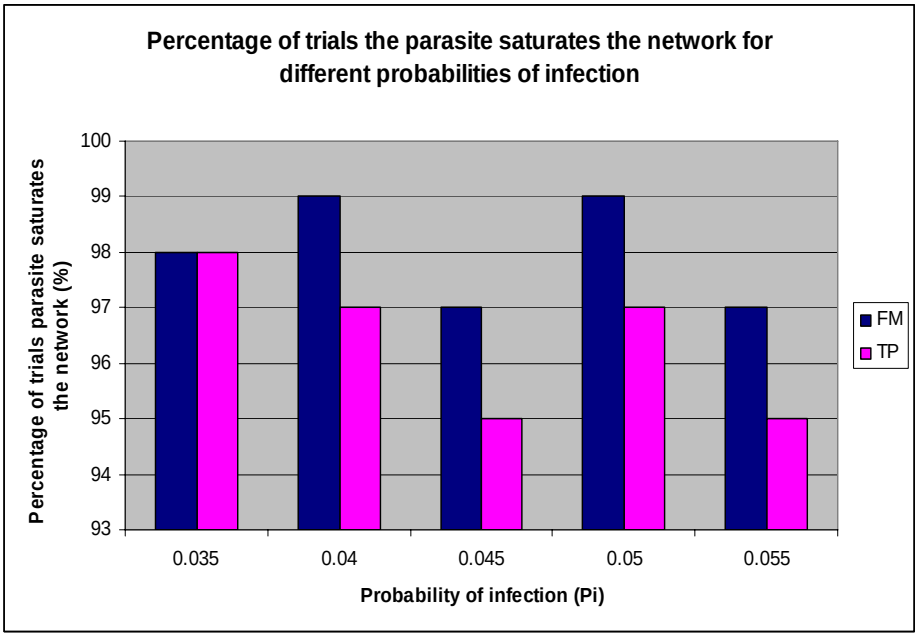


Figure 8: The percentage of trials in which the parasite is able to compromise the whole network for a range of coefficients of infection in a fully meshed network (FM) and a top down hierarchical network (TP)

Important Results					
Coefficient of infection (Pi)	**0.035**	**0.040**	**0.045**	**0.050**	**0.055**
	Time period at which the maximum average number of infections occurs first				
Fully Meshed (FM)	189	172	158	326	261
Top-down (TP)	423	399	533	337	445
	Maximum average number of infected hosts in the network				
Fully Meshed (FM)	490	495	485.02	495	485.01
Top-down (TP)	490	485	475	485	474.74
	Percentage of trials in which the parasite saturates the network				
Fully Meshed (FM)	98	99	97	99	97
Top-down (TP)	98	97	95	97	95

Figure 9: The maximum average number of infections in a given network topology and the time period of first occurrence with the percentage of trials converging to saturation from data collected through 100 trials of the "parasim" simulator for a range of infection probabilities.

We observe (Figure 9) that in each case, the maximum average number of infections for Internet topology (TP) is less or equal to a fully connected topology (FM) and it takes a longer time to reach the maximum number of infections in the Internet topology (TP) than in a fully connected topology (FM). Furthermore, the percentage of trials the parasite is able to compromise the whole network is less for the Internet topology (TP) than in a fully connected topology (FM).

Conclusions and Recommendations

The simulation results show that in majority of cases the network became completely infected with the parasite and in a few others the number of infected hosts converged to zero. The extinction of the parasite is explained intuitively by the fact that a statistical fluctuation might wipe out the parasites before it propagates to sufficient hosts to become established (Kephart & White 1991).

The graphs of average number of infections per time period shows that rate of propagation of a parasite (as given by the gradient/slope of respective graphs) is slower in the simplified Internet topology (TP) as hypothesized. This observation can be explained by the fact that the degree of each node in the TP network is less than that of a FM network. Therefore as the number of hosts connected to a particular host decreases, the number of ways a particular host can be infected by others will be less. Another explanation is that when a particular host at a parent node of a tree is inoculated against a particular parasite strain, then it prevents the parasite from propagating to the child nodes

and beyond. It is also observed that the average rate of propagation for the top down hierarchical topology increases and comes closer to that of the fully meshed topology when the coefficient of infection is increased. However, the Internet parasite is able to ultimately infect more hosts on average in a fully connected network. The latter observation is intuitive because, given the vast number of rapidly infected hosts in a fully-meshed topology and the high number of connected hosts (N-1 connections per host where N is the total number of hosts in the network); the uninfected hosts will be found faster and infected in many ways. These observations support the conjecture that the results obtained for a fully connected network topology by Butler et al (2005), provide an upper bound to the behavior of an Internet parasite.

Further study is necessary to optimize the simulator for efficient memory usage. Also it is necessary to rerun simulations on a variety of different network topologies including network topologies represented as directed graphs, incorporating network characteristics such as link bandwidth, and possibly mathematical analysis.

Acknowledgements

I would like to thank my Faculty Research Adviser, Dr. Patrick McDaniel, and my Research Mentor Kevin Butler for providing the opportunity to work with their research in the Systems and Internet Infrastructure Security (SIIS) laboratory in the Computer Science and Engineering Department at The Pennsylvania State University. Also, I would like to extend my gratitude to The Ronald E. McNair Scholars Program at Penn State.

Appendix – Related Work

Internet Parasite

Kevin Butler and Patrick McDaniel (2005) asserted that worm attacks based on mutation and covert propagation are likely to be ultimately more damaging and long lasting, which was supported by parasitic behavior in natural systems. They proposed a new form of computer worms called the "Internet parasites." Like its biological counterpart, survival of the parasitic worm depended on mutation. While residing in a machine undetected, it dynamically discovered new invasive techniques and secretly propagated across the network. They provided empirical results based on their "parasim" simulator that modeled real propagation of the Internet parasite. The "parasim" simulator modeled a fully meshed network of 500 nodes and the simulation parameters were the probability of infection P_i, the probability of inoculation P_n, and the probability of mutation P_m. They assumed that the probabilities of infection, mutation and inoculation were exponentially distributed and examined literature in epidemiology and parasitology to determine a numerical basis for the values of P_i (=1/0.0056), P_n (=1/0.04) and P_m (=a value randomly selected from the distributions). They found that small changes in the rates of infection, mutation, and inoculation can have dramatic changes on whether a parasite will die out or eventually fully propagate to every host in the network. Their key observation was that in

most cases, the mutations failed, but the few successful ones resulted in spectacularly successful growth and spread throughout the network. They pointed out that for a sufficiently high rate of mutation, even a well-defended network will eventually succumb. They stated further that the effectiveness of a parasite's infection vector and its resistance to host inoculation were major factors in determining whether the network would collapse. They concluded that Internet parasites have the potential to mimic their biological counterparts and spread throughout the virtual world to form an unwelcome relationship with machines and their users. They recommended further detailed analysis and simulation of Internet parasite in real-world network topologies for future work.

Computer Worms – Definitions, Analysis, & Defenses

Weaver, et al, (2003) defined a computer worm as "a program that self-propagates across a network exploiting security or policy flaws in widely-used services." They noted that, the line between worms and viruses was not all that sharp. However, they distinguished between worms and viruses by the fact that viruses cannot self-propagate and require some sort of user action. They described a preliminary classification of computer worms based on worm's target discovery and selection strategies, carrier mechanisms, activation, possible payloads and attackers who would employ a worm. They concluded that the carrier, activation, and payload are independent of each other, and describes the worm itself. They recommended developing more robust defenses by focusing on preventing worms that use one or more of the techniques described by them. They also pointed out the importance of understanding not only the technology used but also the motivations of those that launch the attacks because "worms are ultimately written by humans, and sometimes the easiest way to defend against a worm is to remove the motivation for writing a worm in the first place."

Seely (1998) provided a chronology for the outbreak of the Morris Worm and presented a detailed description of the internals of the worm, based on a C version produced by decompiling. The self-replicating program was released in the Internet in November 2, 1988 which spread across the U.S. in just a few hours, invading VAX and Sun-3 computers running versions of Berkeley UNIX, and used their resources to attack more computers like a chain reaction. He pointed out the importance of analyzing computer worms by stating that "The worm story was on the front page of the New York Times and other newspapers for days. … judging by the response, it has scared us. … but I will say that I think these issues have been ignored for much longer than was safe, and I feel that a better understanding of the crisis just past will help us cope better with the next one. Let's hope we're as lucky next time as we were this time." (Seeley 1988)

According to Staniford et al. (2002), computer worms can be exploited by attackers to rapidly gain control of vast numbers of Internet hosts to pose an immense risk to the overall security of the Internet. They derived the "Random Constant Spread" (RCS) model from empirical data of the spread of Code Red I in July, 2001. Then they discussed, developed and evaluated some possibly strong techniques: hit-list scanning to create a Warhol worm, permutation scanning to enable self-coordinated scanning, and the use of Internet-sized hit-lists to create a flash worm. They proposed the possible threat of a new class of surreptitious worms that spread more slowly but in a much harder to detect

contagion fashion. They also considered robust mechanisms by which attackers can control and update deployed worms, namely direct worm-to-worm communication and programmable updates. They concluded that given the magnitude of Internet-scale threats, it was critical for nations, concerned with cyber-warfare in particular, to attempt to mitigate the immense risk. They recommended creating a "Cyber-Center for Disease Control" (CDC) and identified six key roles of a CDC: identifying outbreaks, rapidly analyzing pathogens, fighting infections, anticipating new vectors, proactively devising detectors for new vectors, and resisting future threats.

Zou et al. (2002) identified two major factors that affect an Internet worm propagation based on the Code Red worm incident. According to them human countermeasures against worm spreading, like cleaning, patching, filtering or even disconnecting computers and networks would remove both susceptible hosts and infectious hosts from circulation and slowing down of worm infection rate due to worm's impact on Internet traffic and infrastructure. Accounting for these factors they presented the Two-factor worm model. They showed that Code Red did not infect almost all susceptible online computers at 19:00 UTC as concluded in by Staniford et al. from the RCS model. Instead, Two-factor worm model showed that Code Red infected roughly 60% of all susceptible online computers at that time. They acknowledged that "However, Internet worm models have their limitations. For example, the two-factor worm model as well as other worm models is only suitable for modeling a continuously spreading worm, or the continuously spreading period of a worm. They can't predict those arbitrary stopping or restarting events of a worm … we can only find such events through manual code analysis."

Zou et al (2003) looked at implementing automatic worm mitigation techniques such as dynamic quarantine on computer networks. Motivated by the methods used in epidemic disease control in real world, they presented a dynamic quarantine method based on the principle "assume guilty before proven innocent." In this method, a host is quarantined whenever its behavior looks suspicious by blocking traffic on its anomaly port and released from the quarantine after a short time, even if the host has not been inspected by security staff. They presented mathematical analysis of three worm propagation models under the dynamic quarantine method which showed that the dynamic quarantine reduced a worm's propagation speed and raised the worm's epidemic threshold which in turn reduced the chance for a worm to spread. Their simulation results verified the analysis and demonstrated the effectiveness of the dynamic quarantine defense.

Zhang et al (2004) presented a worm propagation model that effectively reduced a worm's propagation speed. It was based on the classical epidemic Kermack-Kermack model, and adopted dynamic quarantine strategy, dynamic infection rate and removal rate. Through simulation they verified the effectiveness of their model.

In order to understand how worms propagate and how different scanning strategies affect the dynamics of worm propagation, Zou et al (2006) systematically modeled and analyzed worm propagation under various scanning strategies, such as uniform scan, routing scan, hit-list scan, cooperative scan, local preference scan, sequential scan, divide-and-conquer scan, and target scan. They showed the underlying similarity and relationship between different worm scanning strategies. They provided an analytical

model for the Witty worm's destructive behavior and based on the simulation and analysis of Blaster worm propagation, they provided a guideline for building a better worm monitoring infrastructure.

Cheetancheri (1998) provided and discussed a simple worm model and the aspects involved in defending the Internet against a worm. He developed a life cycle model of worm defense, including prevention, prediction, detection and mitigation. . The models that were developed for each of these techniques were able to automatically respond to a worm outbreak. The "friends' model" and the "hierarchical model" were two mitigating models and "TrendCenter model" was a predicting model. He concluded that worms are dangerous to the Internet but there are ways to mitigate their impact. (Cheetancheri 1988)

Costa et al (2004) proposed, Vigilante, a new host centric approach for automatic worm containment that addressed the limitations of a network centric approach. According to them, worm control must be automatic because worms can spread faster than humans can respond. A network centric approach to automate worm control by analyzing network traffic to derive a packet classifier that blocks (or rate-limits) worm propagation, has the fundamental limitation that the analysis has no information about the application vulnerabilities exploited by worms. But Vigilante relied on collaborative worm detection at end hosts in the Internet and does not require mutual trust between hosts. The hosts detected worms by analyzing attempts to infect applications and broadcasted self-certifying alerts (SCAs) which were automatically generated machine-verifiable proofs of vulnerability. SCAs are independently and inexpensively verified by any host. Then the hosts used SCAs to generate filters or patches that prevented infection. Their preliminary results showed that Vigilante controlled fast spreading worms that exploited unknown vulnerabilities.

Tang & Chen (2005) attempted to answer two questions, namely, "can a localized defense system detect new worms that were not seen before and capture the attack packets?" and "how to identify polymorphic worms from the normal background traffic?" They presented the design of a double-honey pot system, which was able to automatically detect new worms and isolate the attack traffic. They also introduced a position-aware distribution signature (PADS), which was capable of handling certain polymorphic worms, and proposed two algorithms based on Expectation-Maximization (EM) and Gibbs Sampling for efficient computation. Their experiments showed that the algorithms accurately separate new variants of the MS Blaster worm from the normal background traffic. (Tang & Chen 2005)

Ellis (2003) presented a general framework for reasoning about network worms and potency of worms within a specific network. A life cycle of a worm based on a survey of contemporary worms was discussed to build a relational model that associates worm parameters, environmental attributes, and the subsequent potency of the worm. The worm analytic framework captured the generalized mechanical process and the states a worm goes through while moving through a specific environment. According to the author, the Worm Coverage Transitive Closure (WCTC) which was a computation of a worm's final infection set given its parameters and operating environment was sufficient to describe a worm's potency with respect to a particular environment because based on current

defensive technology there are no defensive countermeasures that respond within the time scale of most worm conflicts. It was concluded that the framework can be used to evaluate worm potency and develop and validate defensive countermeasures and postures in both static and dynamic worm conflict. (Ellis 2003)

Epidemiological Studies & Network Topologies

Kephart & White (1998) studied the interaction between topology and computer epidemics by placing the susceptible-infected-susceptible (SIS) epidemiological model on a directed graph. The heterogeneous communication pattern between computer systems was represented by a directed graph. Directed edges from a particular node represented the set of systems that can be infected by a particular node. A rate of infection was associated with each edge and a rate of inoculation was associated with each node. They investigated the behavior of SIS model on the random graph, weak link, hierarchical and spatial models. They discovered that topology influences the ability of viruses to spread.

Zhou et al (2006) with the goal of understanding how the topological structures of networks affect the dynamics upon them, reviewed studies of epidemic dynamics on complex networks, including the description of classical epidemic models, the epidemic spread on small-world and scale-free networks, and network immunization. According to their findings many systems can be described as complex networks and Internet is one such example. Their study of topological structures of the networks used to model the interconnection systems has gone through three stages. The first stage used regular structure such as Euclidean lattices and hypercube networks, while the second stage (late 1950s) used random graphs. The regular networks have great clustering coefficient and long average distance, while the random networks have small clustering coefficient and short average distance. With the advancement of technology, it was later found that most real-life networks were neither completely regular nor completely random. The results of many empirical studies and statistical analysis indicated that the networks in various fields have some common characteristics such as the small-world effect and scale-free property. A small-world network has a small average distance and great clustering coefficient. Networks with power-law degree distribution are referred to as scale-free networks. Some definitions provided by them are quoted below for clarity:

- "In a network, the distance between two nodes is defined as the number of edges along the shortest path connecting them. The average distance L, then, is defined as the mean distance between two nodes, averaged over all pairs of nodes. The number of the edges incident from a node x is called the degree of x, denoted by k(x). Obviously, through the k(x) edges, there are k(x) nodes that are correlated with x; these are called the neighbor-set of x, and denoted by A(x). The clustering coefficient C(x) of node x is the ratio between the number of edges among A(x) and the total possible number, the clustering coefficient C of the whole network is the average of C(x) over all x."
- "Another important characteristic in real-life networks is the power-law degree distribution, that is $p(k) \sim k^{-\alpha}$, where k is the degree and p(k) is the probability density function for the degree distribution. α is called the power-law exponent, and usually between 2 and 3 in real-life networks. This power-law distribution

> falls off much more gradually than an exponential one, allowing for a few nodes of very large degree to exist."

Finally, they listed a few interesting problems for further investigation such as considering the role of network topology because "classical theory of infectious diseases does not care about the network topology," whether network structure affects the spreading velocity and ways to reduce it because "the spreading velocity is a very important measure especially in the outbreaks," and whether network characteristics such as community structures and the hierarchical properties affects the epidemic behaviors. (Zhou et al 2006).

Zou et al (2006) presented an Internet worm monitoring system. Their "trend detection" methodology to detect a worm at its early propagation stage by using Kalman filter estimation was based on the idea of "detecting the trend, not the burst" of monitored illegitimate traffic. They predicted overall vulnerable population size and estimated how many computers were really infected in the global Internet based on the biased monitored data for uniform-scan worms such as Code Red. They also showed that for monitoring a non-uniform scan worm, especially a sequential-scan worm such as Blaster, it is critical for the address space covered by the worm monitoring system to be distributed as possible. They recommended investigation of more detailed models to reflect a future worm's dynamics such as worm spread through a topology, or multiple vulnerability exploits, or meta-servers which may not follow the propagation models presented by them. (Zou et al 2006)

Leveille (2003) proposed Progressive Susceptible-Infected-Detected-Removed (PSIDR) epidemiological model for computer worm epidemics which incorporated aspects related to the availability of antivirus signatures, existence of direct immunization, and presence of a curing phase. Current response strategies as well as the effect of virus throttling was investigated and it was shown that slowing the progress of worms could significantly reduce costs especially in scale-free networks.

Bu and Towsley (2002) investigated the effectiveness of several power law topology generators for generating representative Internet topologies at the Autonomous System (AS) level. The Internet consists of a large collection of hosts interconnected by networks of links and routers. It is divided into thousands of administrative domains, each of which possesses one or several autonomous systems (ASs) and can be considered as either a graph of interconnected routers or a graph of interconnected ASs. They studied the AS-level Internet topology where nodes represented ASs and links represented the relationship of exchanging traffic between them. Even though the real AS-level Internet topology is unknown, it can be inferred from Border Gateway Protocol (BGP) routing tables because BGP is an inter-AS path-vector protocol. According to them, topology generators modeling Internet, fall into one of three classes, random graph generators, structural generators, and degree power law generators. The topology produced by power law topology generators resembles the AS-level Internet topology better than those produced by random graph generators or structural generators.
Their study made several key contributions which included: use of clustering coefficient and characteristic path length to distinguish power law topology generators from one another; a generalized linear preference model coupled with the incremental algorithm

generated topologies that more closely models the Internet; observed that the Internet exhibits the small world properties, and pointed out the advantage of working with the empirical complementary distribution rather than the node degree histogram for studying the node degree power law.

Epidemiological Studies with Analytical Solutions

Kyrychko & Blyuss (2005) derived and studied a time-delayed SIR model with a general incidence rate. The time delay represented temporary immunity period, i.e. time from recovery to becoming susceptible again. Both trivial and endemic equilibria were found, and their stability was investigated. Numerical simulations supported their analytical conclusions of the model.

Oli et al (2006) presented a framework for modeling the dynamics of infectious diseases in discrete time based on the well-founded theory of matrix population models. The modeling framework presented can be used to model any infectious disease of humans or wildlife with discrete disease states, irrespective of their numbers.

Stollenwerk & Jansen (2003) formulated and analyzed a model for infectious diseases transmitted by asymptomatic carriers (Neisseria meningitidis in case of meningococcal disease) by extending the classic epidemic model of susceptible-infected-recovered system (SIR) for the harmless infective agent, acting as a background to a mutant strain Y which occasionally creates severely affected hosts X. The full system of SIRYX was described in the master equation framework. With limiting assumptions of a reduced YX-system with the SIR-system in stationary, they analytically showed convergence to power law scaling typical for critical states and the divergence of the variance of outbreaks near criticality. (Stollenwerk & Jansen 2003)

Gomes & Medley (2002) provided an overview of different models describing the dynamics of “n” distinct strains of infectious agents co-infecting a host population and compared them by using the same system of coordinates with a uniform notation. They organized the coupling structure of multiple strain system into an nxn matrix, termed as the “Cross-immunity matrix”. They pointed out that the general form of the Cross immunity matrix makes the thorough mathematical analysis very difficult and the generality of the result would make it practically inapplicable. They emphasized carefully by imposing symmetry constrains to deal with this issue. The models investigated included Anderson, Lin and Levin (ALL) model; Gupta, Ferguson and Anderson (GFA) model; May and Nowak (MN) model.

References

Kevin Butler, Patrick McDaniel: Understanding Mutable Internet Pathogens, or How I Learned to Stop Worrying and Love Parasitic Behavior. In: Proceedings of 1st International Conference on Information Systems Security (ICISS), Dec. 2005, Kolkata, India.

Kevin Butler. Parasim. A simulator that models Internet parasite propagation. Systems and Internet Infrastructure Security Laboratory (SIIS), The Pennsylvania State University, May 2005.

Alberto Medina, Anukool Lakhina, Ibrahim Matta, and John Byers: BRITE. A universal topology generator. QoS Networking Laboratory (QNL), Boston University, 2002.

Alberto Medina, Anukool Lakhina, Ibrahim Matta, and John Byers: BRITE: Universal Topology Generation from a User's Perspective. (User Manual) BU-CS-TR-2001-003. April 05, 2001.

Jasmine Leveille. Epidemic Spreading in Technological Networks. Information Infrastructure Laboratory HP Laboratories Bristol HPL-2002-287. Oct. 2003.

Jeffrey O. Kephart and Steve White. Directed graph epidemiological models of computer viruses. In Proceedings IEEE Symposium on Security and Privacy, 1991.

Nicholas Weaver, Vern Paxson, Stuart Staniford, Robert Cunningham: A Taxonomy of Computer Worms. In: WORM'03 - Proceedings of the 2003 ACM Workshop on Rapid Malcode, Washington, DC, USA (2003) 11-18.

Stuart Staniford, Vern Paxson, Nicholas Weaver: How to Own the Internet in Your Spare Time. In: Proceedings of the 11th USENIX Security Symposium, San Francisco, CA, USA (2002) 149 – 167

Cliff C Zou, Weibo Gong, Don Towsley. Code red worm propagation modeling and analysis. Proceedings of the 9th ACM conference on Computer and Communications Security, Washington, DC, USA (2002) 138 – 147.

Donn Seeley. A Tour of the Worm. Department of Computer Science,University of Utah. securitydigest.org (1988)

Senthilkumar G Cheetancheri. Modelling a Computer Worm Defense System. Master's thesis for B.E. Computer Science & Engineering. Coimbatore Institute of Technology, Coimbatore, India. (1998)

Tao Zhou, Zhongqian Fu, and Binghong Wang. Epidemic dynamics on complex networks. Progress in Natural Science, 16(5): 452-457 (2006)

Zou, C. C., Gong, W., Towsley, D., and Gao, L. The monitoring and early detection of internet worms. *IEEE/ACM Trans. Netw.* 13, 5 (Oct. 2005), 961-974.

Manuel Costa, Jon Crowcroft, Miguel Castro and Antony Rowstron. Can we contain Internet worms? Proceedings of the 3rd Workshop on Hot Topics in Networks 2004.

Tian Bu and Don Towsley. On Distinguishing between Internet Power Law Topology Generators. Twenty-First Annual Joint Conference of the IEEE Computer and Communications Societies. Proceedings IEEE. INFOCOM 2002.

Yong Tang, and Shigang Chen. Defending Against Internet Worms: A Signature-Based Approach. 24th Annual Joint Conference of the IEEE Computer and Communications Societies. Proceedings IEEE. INFOCOM 2005.

Yun-Kai Zhang, Fang-Wei Wang, Yu-Qing Zhang, and Jian-Feng Ma. Worm propagation modeling and analysis based on quarantine. In Proceedings of the 3rd international Conference on information Security (Shanghai, China, November 14 - 16, 2004). InfoSecu '04, vol. 85. ACM Press, New York, NY, 69-75.

Cliff C. Zou, Don Towsley, Weibo Gong. On the performance of Internet worm scanning strategies. Performance Evaluation 63 (2006) 700–723

Zou, C. C., Gong, W., and Towsley, D. Worm propagation modeling and analysis under dynamic quarantine defense. In Proceedings of the 2003 ACM Workshop on Rapid Malcode (Washington, DC, USA, October 27 - 27, 2003). WORM '03. ACM Press, New York, NY, 51-60. 2003.

Ellis, D. 2003. Worm anatomy and model. In *Proceedings of the 2003 ACM Workshop on Rapid Malcode* (Washington, DC, USA, October 27 - 27, 2003). WORM '03. ACM Press, New York, NY, 42-50.

Yuliya N. Kyrychko, Konstantin B. Blyuss. Global properties of a delayed SIR model with temporary immunity and nonlinear incidence rate. Nonlinear Analysis: RealWorld Applications 6 (2005) 495 – 507

Madan K. Oli, Meenakshi Venkataramana, Paul A. Kleinb, Lori D. Wendland, Mary B. Brown. Population dynamics of infectious diseases: A discrete time model. Ecological Modelling Article in press. (2006)

Nico Stollenwerk, Vincent A.A. Jansen. Meningitis, pathogenicity near criticality: the epidemiology of meningococcal disease as a model for accidental pathogens.
Journal of Theoretical Biology 222 (2003) 347–359

M. Gabriela M. Gomes, Graham F. Medley. Dynamics of multiple strains of infectious agents coupled by cross-immunity: A comparison of models. IMA Volumes in Mathematics and Its Applications. 2002. Vol. 126, 171-192.

Perceptions of African American and Caucasian Partners in two-person work groups: Does Race Matter?

Tamara K. Fleming, McNair Scholar, Penn State University
Susan Mohammed, Ph.D
Associate Professor
Psychology Department
Penn State University

As racism remains a persistent problem in society, this study examined affective and behavioral expectations of minorities and non-minorities in hypothetical two-person work groups. It was hypothesized that participants rating African American partners would be less likely to report positive affective and behavioral expectations regarding the work relationship. The sample consisted of 185 undergraduate students who imagined being paired with another student for a class project. Race and gender were manipulated via the partner's name. Results indicated that participants' attitudes towards racism and diversity in teams had a greater influence on affective expectations than the partner's race or gender.

INTRODUCTION

Over the years, the United States workforce has become increasingly diverse. However, there is a lack of racial and ethnic minorities in higher-level positions. According to the U.S. Bureau of Labor and Statistics, African Americans made up approximately 8 percent of the management and business professional workforce in 2005. African Americans do not earn as much as Caucasian Americans (Black, Haviland, Sanders, & Taylor, 2006). Why is there a disparity among pay between the two groups? Why is there a lack of African-Americans in higher-level and higher paying positions? One explanation may well be negative stereotypes held by those who regulate the goings-on in most organizations. Typically, these regulators are Caucasian Americans.

The purpose of this study was to examine perceptions toward African American as compared to Caucasian American work partners, in terms of potential contribution towards a group's overall effort. In addition to focusing on the initial expectations of African Americans' performance, this study also examined reactions to African Americans after a performance record has been established.

This research paper will be organized in the following way. First, I will briefly go over what previous literature has revealed regarding the stereotyping of African Americans by Caucasian Americans and the impact of racially diverse groups. Second, I will discuss the proposed hypotheses and the rationale behind them. This will be followed by the methodology, the results, and a discussion of this study's findings.

Literature Review

Previous literature asserts that stereotyping is, in a sense, an almost natural reaction to things to which people have been newly introduced (Macrae & Bodenhausen, 2000; Timmerman, 2000). People tend to put others (as well as themselves) into categories in an

attempt to prevent an overwhelming amount of information from being repeatedly accessed and processed (Martins, Milliken, Wiesenfield, & Salgado, 2003). If this categorization did not occur, people would not be able to function to their greatest potential (Monteith, Sherman, & Devine, 1998). Categorizing oneself as well as others is a precursor to stereotyping (Elsass & Graves, 1997; Timmerman, 2000).

Research on diversity in groups has indicated that there are both advantages and disadvantages of formulating diverse teams in organizations (Hobman, Bordia, & Gallois, 2004). Diversity may enhance group performance, as each member's personal experiences, ideas, and opinions would generate various, yet different ideas (Timmerman, 2000). This may be especially prominent in situations where diversity is highly regarded (Timmerman, 2000) Disadvantages include having members who are similar to each other focus too much attention on the individual(s) who may be different (Timmerman, 2000). According to the social categorization theory, the performance of individuals in a racially diverse group would be hindered by the lack of homogeneity (Timmerman, 2000). Individuals in diverse groups may focus little on the task at hand and may be distracted by the racial differences between themselves and their group members. Even before members of a racially diverse group interact, simply knowing that their partners are different from themselves could influence the initial expectations of those different members (Elsass & Graves, 1997).

Research has also found that diversity can disrupt the effective exchange of ideas between members belonging to different racial groups (Hobman, et al., 2004). Relations and communication in racially diverse groups may be influenced by the current organizational practices that are in place. Organizational practices are largely influenced by the decisions, ideals, and standards set forth by Caucasian men who run these organizations (Elsass & Graves, 1997; Pettigrew & Martin, 1987). This is likely to create conflict in groups were members are not of the same race.

In the present study, there were a number of variables that were looked at in connection with individuals' expectations of African Americans as compared to Caucasian Americans. These variables included racial attitudes such as modern racism, openness to diversity, and racial centrality. Also included was Protestant ethic, which is not a racial attitude per se, but has been correlated with racial attitudes (Katz & Hass, 1988). A description of these racial attitudes is provided in the following paragraphs.

Modern Racism. Racism and the publicizing of negative attitudes towards African Americans have significantly declined over the years (Katz & Hass, 1998; McConohay, Hardee, & Batts, 1988). However, there are still some individuals who harbor ill sentiments towards African Americans and do not openly express them. Modern racists do not subscribe to the types of overt racism previously prevalent, such as forcing African Americans to sit at the back of the bus or enter establishments from the rear. Modern racists reject these blatantly discriminatory practices. In fact, they believe that racism is no longer a problem in America, and therefore think that African Americans are no longer the targets of mistreatment and discrimination (McConohay, et al., 1988). Modern racism allows individuals to discriminate against African Americans with non-racist and non-prejudiced reasons to do so (Brief, Dietz, Cohen, Pugh, & Vaslow, 2000). It is the conflict between one's belief that African Americans should be treated equally to Caucasian Americans and the negative sentiments one has regarding African Americans. These negative sentiments are not vocalized and are dealt with internally (Nail, Harton, & Decker, 2003).

Protestant Ethic. Protestant ethic is a reflection of an individual's dedication to hard work and amount of effort put into hard work (Jones, 1997; Katz & Hass, 1988). It was derived from Protestants who believed that working hard in their daily jobs would discourage their participating in secular and immoral activities (Jones, 1997). These Protestants believed that dedication to one's work would lead to a decrease in idleness, which they highly looked down upon (Jones, 1997). Research on Protestant ethic reveals that there is a correlation between theses ethics and negative attitudes regarding African Americans (Katz & Hass, 1988). Katz and Hass (1988) looked at the conflicting, simultaneous viewpoints held by Caucasian Americans. These conflicting viewpoints entailed Caucasians feeling sympathetic towards African Americans because of their troublesome history, while also blaming them for their own lack of success. Katz and Hass (1988) found that there was a relationship between Protestant ethic and how Caucasian Americans view African Americans. It was found that Caucasian Americans who scored higher on the Protestant Ethic scale were more likely to hold disapproving opinions about African Americans.

Racial Centrality. Sellers, Smith, Shelton, Rowley, and Chavous (1998) developed the Multidimensional Model of Racial Identity (MMRI) to assess African Americans' concept of self, how important it is for them to be African American, and what it means to be African American. The MMRI examines how African Americans' define themselves by looking at four elements: salience, centrality, regard and ideology. Sellers et al. (1998) defines racial salience as how relevant one's race is to oneself in a given time or under a certain circumstance. Racial centrality refers to the importance one places on oneself in terms of is or her race. It is based on the individual's life experiences and is constant across time (Sellers et al., 1998).

According to Sellers, et al., 1998, racial regard is the extent to which African Americans feel positively about their race. Racial regard is broken down into private regard and public regard. Private regard is concerned with how positively African Americans feel about themselves as well as other African Americans. Public regard is concerned with how positively African Americans believe other people view African Americans. Racial ideology entails African Americans' views regarding how other African Americans should behave (Sellers, et al., 1998). Racial ideology is broken down into four parts: nationalist oppressed minority, assimilation, and humanist. The nationalist ideology focuses on the significance of being Black and promotes the idea that what African Americans have historically been through is incomparable to that of other groups. The oppressed minority ideology focuses on the similarities in subjugation experienced by African Americans and other groups. The assimilation ideology is concerned with the effort of African Americans to become further integrated into American society. Lastly, the humanist ideology asserts that there are no differences among races, and that the only race is the human race.

For the purpose of this study, the racial centrality scale was extracted from the Sellers et al. (1998) MMRI, and was tailored to assess the importance of race to all individuals, not just African Americans. For example, scale statements such as "In general, being Black is an important part of my self-image" was changed to "In general, my race/ethnicity is an important part of my self-image."

Openness to Diversity. Openness to diversity is defined as the extent to which group members regard, are respectful of, and are productive in their dealings with fellow group members who are

dissimilar from themselves (Hobman, et al. 2004). According to Hobman et al. (2004), individuals open to diversity favor heterogeneous work groups and are more likely to have better communication with their partners who are different from themselves. Through interactions with people who are dissimilar from themselves, these individuals should be able to gain a better understanding of the differences that do and do not exist between the groups and should be less likely to stereotype. Hobman et al. (2004) looked at the effect of how different one person perceives him- or herself to be in relation to others. This study looked at three types of differences: those that can be seen (e.g., gender and ethnicity), work-related (e.g., work habits and principles), and informational (e.g., personal history and past experiences). Results suggested that openness to diversity moderated the relationship between diversity and group member participation, such that individuals who believed that their fellow group members were open to diversity were more likely to participate in their groups.

Development of Hypotheses

Due to the long history of racial inequality, mistreatment of African Americans, and the prejudices held against African Americans in the United States, it was predicted that African Americans would be expected to contribute less to a group's overall effort than would Caucasian Americans. Perceptions of African Americans as compared to Caucasian Americans were measured along two different dimensions: affective expectations and behavioral expectations. Affective expectations measured participants' feelings towards working with their partners, including whether they anticipated feeling comfortable with their partner and thought that they would get along well together. In contrast, behavioral expectations measured partners' anticipated actions that would relate directly to the effectiveness or ineffectiveness of the group. Specifically, participants were asked whether they thought that their partner would contribute high quality ideas, volunteer to complete tasks, submit work on time, and so forth.

<u>Hypotheses Regarding Affective Expectations</u>

Hypothesis 1_a: Participants will be more likely to report negative affective expectations toward African American partners as compared to Caucasian partners.

Hypothesis 1_b: Participants responding higher on the modern racism scale will be more likely to report negative affective expectation towards African American partners as compared to Caucasian partners.

Hypothesis 1_c: Participants responding higher on the protestant ethic scale will be more likely to report negative affective expectations towards African American partners as compared to Caucasian partners.

Hypothesis 1_d: Caucasian participants responding higher on the racial centrality scale will be more likely to report negative affective expectations African American partners as compared to Caucasian partners.

Hypothesis 1_e: Participants who respond lower on the openness to diversity in teams scale will be more likely to report negative affective expectations towards African American partners as compared to Caucasian partners.

Hypotheses Regarding Behavioral Expectations

Hypothesis 2_a: Participants will be more likely to report negative behavioral expectations regarding the work relationship with African American partners as compared to Caucasian partners.

Hypothesis 2_b: Participants responding higher on the modern racism scale will be more likely to report negative behavioral expectations towards African American partners as compared to Caucasian partners

Hypothesis 2_c: Participants responding higher on the protestant ethic scale will be more likely to report negative behavioral expectations towards working with African American partners as compared to Caucasian partners.

Hypothesis 2_d: Caucasian participants responding higher on the racial centrality scale will be more likely to report negative behavioral expectations towards African American partners as compared to Caucasian partners.

Hypothesis 2_e: Participants who respond lower on the openness to diversity in teams scale will be more likely to report negative affective behavioral expectations towards African American partners as compared to Caucasian partners.

Hypotheses Regarding Surprise in Reaction to Confirmed Performance

Literature on individuals' assessments of the actual performance of African Americans in relation to their initial expectations is not extensive. However, based on the stereotyping literature, it was predicted that there would be a disparity in the level of surprise regarding the performance of African Americans versus Caucasian Americans. Because two measures were used for surprise, hypotheses are divided into low and high surprise.

Low Surprise Hypotheses

Hypothesis 3_a: Participants will be more likely to report lower levels of surprise when African American partners perform poorly as compared to Caucasian partners.

Hypothesis 3_b: Participants responding higher on the modern racism scale will be more likely to report lower levels of surprise when African American partners perform poorly as compared to Caucasian partners.

Hypothesis 3_c: Participants responding higher on Protestant ethic scale will be more likely to report lower levels of surprise when African American partners perform poorly as compared to Caucasian partners.

Hypothesis 3_d: Participants responding higher on racial centrality scale will be more likely to report lower levels of surprise when African American partners perform poorly as compared to Caucasian partners.

Hypothesis 3_e: Participants who respond lower on the openness to diversity in teams scale will be more likely to report lower levels of surprise when African American partners perform poorly as compared to Caucasian partners.

High Surprise Hypotheses

Hypothesis 4_a: Participants will be more likely to report higher levels of surprise when African American partners perform well as compared to Caucasian partners.

Hypothesis 4_b: Participants responding higher on the modern racism scale will be more likely to report higher levels of surprise when African American partners perform well as compared to Caucasian partners.

Hypothesis 4_c: Participants responding higher on Protestant ethic scale will be more likely to report higher levels of surprise when African American partners perform well as compared to Caucasian partners.

Hypothesis 4_d: Participants responding higher on racial centrality scale will be more likely to report higher levels of surprise when African American partners perform well as compared to Caucasian partners.

Hypothesis 4_e: Participants who respond lower on the openness to diversity in teams scale will be more likely to report higher levels of surprise when African American partners perform well as compared to Caucasian partners.

METHODOLOGY

Participants. The participants were 185 undergraduate students from a large university in the northeast region of the United States. All students were enrolled in undergraduate level psychology courses at the university. Of the 185 participants, 163 received credit for their participation and the other 22 participants volunteered without any credit. Of the 185 participants, 84 % of the participants were Caucasian, 7% were Asian/Pacific Islanders, 5 % were African Americans, 2% were Hispanics/Latinos, 1 % were Native Americans, and 1 % were of various racial and ethnic backgrounds. Sixty-five percent of the participants were female. The mean age of participants was 21 years of age.

Procedure. The data collection instrument used in this study was a survey. In the three undergraduate psychology courses sampled, the primary investigator stood before the class and read a brief script describing the purpose of the study and then passed out the survey to all of the students and asked those who were not interested in participating to leave their blank surveys on a desk at the back of the room. Attached to the front of the surveys were two blank consent

forms, one marked for the student to hand in with his or her survey, and the other marked for him or her to keep for his or her own record. In the first class, participants completed the surveys in class. In the second and third classes, participants took the surveys home to complete.

Hypothetical Scenario. There were two parts to the hypothetical scenario presented to students. First, participants were asked to imagine that they were enrolled in a health class with a final project assignment involving research, an oral presentation, and a written paper. Students were randomly assigned to work with one other person, and during the second week of the class, they were given a few minutes to meet their partner. Non-performance related information was provided to participants about their partner (e.g., partner's first name, major, extra-curricular activities, place of birth, level at Penn State (e.g., junior). Second, participants were asked to imagine that six weeks had passed into the semester and that the professor was requiring evaluations of partner performance. Partners either performed well by emerging as the project leader or performed poorly and did not contribute greatly to the group's overall effort. Given this information, participants were asked to rate how surprised they were at their partner's performance.

Race & Gender Manipulation. The person described in the scenario was either male or female and either African American or Caucasian American. Race and gender were manipulated via the partner's name. In an attempt to prevent the participants from knowing the study had to deal with race issues, there was no explicit statement of the imaginary partner's race and the partners were given stereotypically Caucasian American or African American names. Stereotypically Caucasian American names included "Brad" and "Allie," whereas stereotypically African American names included "Jamal" and "Laquana."

Performance Manipulation. The second part of the survey included information regarding the partners' performance. Partners either exhibited high performance or low performance. High performance was indicated accordingly:

> Out of five meetings, (partner name):
> 1. Attended all five meetings.
> 2. Arrived on time to all meetings.
> 3. Contributed quality ideas in the discussions.
> 4. Always came prepared with his (or her) portion of the assignment.
> 5. Volunteered to complete various tasks.

Similarly, low performance was indicated in the following way:

> Out of five meetings, (partner name):
> 1. Missed 2 out of 5 meetings without notification.
> 2. Arrived late to 1 meeting.
> 3. Did not contribute quality ideas in the discussions he (or she) did attend.
> 4. Forgot to bring his (or her) part of the assignment on 2 occasions.
> 5. Did not step up and volunteer to complete any tasks.

Measures. The affective expectations scale assessed initial feelings toward the assigned partner. Items included, "I think that we will get along well" and "I think I would feel comfortable working with (name of partner)." Items were rated on a scale of 1 to 5, with 1

signifying "strongly disagree," 3 signifying "neutral," and 5 signifying "strongly agree." There were four items in this scale.

The behavioral/performance expectations scale was used to determine how well or poorly participants expected their partners to perform on the group task. Participants were asked whether they thought their partners would "Contribute high quality ideas?", "Submit work on time?," and "Be a competent partner?" The questions were rated on a 1 to 5 scale with 1 signifying "Not likely at all, 3 signifying "Equally likely and unlikely," and 5 signifying "highly likely." There were nine items in this scale.

The Surprise Regarding Confirmed Low Performance scale consisted of 5 items and included items asking participants how surprised were they that their partner "Contributed low quality ideas" and "Slacked off." Similarly, the Surprise Regarding Confirmed High Performance scale consisted of 5 items and included items asking participants how surprised were they that their partner "Contributed high quality ideas" and "Helped to carry the workload" Items were measured on a scale of 1-5, with 1 signifying "not surprised," 3 signifying "neither surprised nor unsurprised," and 5 signifying "very surprised."

A number of previously validated scales were also used. These scales include the *Protestant Ethic Scale* (Katz & Hass, 1988), *Racial Centrality Scale* (Sellers et al., 1998), *Openness to Diversity Scale* (Hobman et al., 2004), and the *Modern Racism Scale* (McConohay et al., 1988). The Protestant Ethic Scale contained 11 items, the Racial Centrality Scale contained 8 items, the Openness to Diversity Scale contained 6 items, and the Modern Racism Scale contained 7 items. The wording of items from the Openness to Diversity Scale was changed from a specific team referent ("in my team") to a general team referent ("in teams"). Each scale was measures on a 1-5 scale, with 1 signifying "Strongly disagree," 2 signifying "Disagree," 3 signifying "Neutral," 4 signifying "Agree," and 5 signifying "Strongly agree."

RESULTS

Preliminary Results

Manipulation check. A manipulation check was performed to determine the effectiveness of the partner names (Jamal, Laquana, Allie, Brad) in indicating the intended race. When participants were asked to indicate the race of their partner, 30 out of 185 individuals incorrectly guessed their partner's race or did not guess at all (See Table 1). Specifically, 22 individuals incorrectly guessed their partner's race and 8 individuals left the item blank. Subsequently, the data from these 30 participants were deleted from further analysis.

Table 1: Manipulation Check Results for Partner Race

	Asian	**Black**	**Hispanic**	**White**	**Missing**
Allie	0	3	0	**39**	6
Brad	3	3	0	**41**	1
Jamal	0	**40**	2	4	0
Laquana	0	**35**	5	2	1

*Note: The partner's intended race (correct responses) are indicated in **bold**.

Descriptive Statistics. Means, standard deviations, and minimum/maximum responses are reported in Table 2. As shown, respondents generally utilized the full scale range for survey items. However, for the modern racism scale, descriptive statistics revealed a restriction of range, as most participants only selected response items 1 through 3 on a 5-point scale.

Table 2: Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
Affective Expectations Scale	155	2.50	2.50	5.00	4.1323	.60053
Behavioral Expectations Scale	155	2.67	2.33	5.00	3.8208	.52474
Surprise Regarding Confirmed Low Performance Scale	69	4.00	1.00	5.00	3.5531	.99979
Surprise Regarding Confirmed High Performance Scale	86	3.83	1.00	4.83	1.8337	.97432
Protestant Ethic Scale	155	2.64	1.82	4.45	3.1459	.46499
Racial Centrality Scale	155	3.75	1.00	4.75	2.8763	.72663
Openness to Diversity Scale	155	2.83	2.17	5.00	3.7151	.67473
Modern Racism Scale	155	2.57	1.00	3.57	1.9567	.52813

Scale Reliabilities. As shown in Table 3, with the exception of the Protestant Ethic Scale (alpha = .68), all of the scales used in data collection had reliabilities of .7 or greater, indicating adequate internal consistency.

Table 3: Scale Reliabilities

Scale	Affective Expectations Scale	Behavioral Expectations Scale	Surprise Regarding Confirmed Low Performance Scale	Surprise Regarding Confirmed High Performance Scale	Protestant Ethic Scale	Racial Centrality Scale	Openness to Diversity Scale	Modern Racism Scale
Cronbach's Alpha	.872	.815	.902	.926	.682	.809	.851	.725

Correlations. Table 4 depicts the correlations between all study variables. The results indicated a significant relationship between modern racism and the participant's gender, such that males were more likely to score higher on the modern racism scale (i.e., reported more racist attitudes towards African Americans; $r = -.31$, $p < .01$). Participants who reported more positive affective expectations towards their partners were more likely to report more positive behavioral expectations ($r = .44$, $p<.01$). In addition, results showed that there was a significant relationship between affective expectations and surprise regarding confirmed performance, such that participants who reported higher affective expectations of their partners were more likely to report higher levels of surprise when their partners performed poorly ($r =.40$, $p < .01$) and lower levels of surprise when they performed well ($r = -.23$, $p<.05$). Participants who reported higher affective expectations of their partners were more likely to report more openness towards diversity in teams ($r = .37$, $p < .01$). There was also a significant relationship between affective expectations and modern racism, indicating that participants who reported lower affective expectations of their partners were more likely to report racist attitudes towards African Americans ($r = -.28$, $p < .01$).

Results showed a significant relationship between behavioral expectations and surprise regarding performance. Participants who reported higher behavioral expectations of their partners were more likely to report higher levels of surprise when their partners performed poorly ($r = -.65$, $p<.01$) and lower levels of surprise when their partners performed well ($r = -.35$, $p<.01$). The correlation matrix also revealed a relationship between surprise regarding confirmed low performance and racial centrality, such that participants who reported higher levels of surprise when their partners performed poorly were less likely to report that their race is a significant aspect of who they are ($r= -.26$, $p < .05$).

Results also indicated a significant relationship between Protestant ethic and modern racism ($r = .26$, $p < .01$). Participants who reported having a stronger work ethic were more likely to report racist attitudes towards African Americans. There was also a relationship found between openness to diversity and modern racism ($r = -.38$, $p < .01$), such that individuals who reported being less open to working in diverse groups were more likely to report racist attitudes towards African Americans.

Table 4: Correlation matrix

	1	2	3	4	5	6	7	8	9	10
1. Partner Race	__									
2. Partner Gender	-0.02									
3. Participant Gender	-0.02	0.05								
4. Affective Expectations Scale	0.03	-0.00	0.16							
5. Behavioral Expectations Scale	-0.07	0.07	-0.02	0.44**						
6. Surprise Regarding Confirmed Low Performance Scale	-0.07	-0.09	0.09	0.40**	-0.65**					
7. Surprise Regarding Confirmed High Performance Scale	-0.12	-0.11	0.01	-0.23*	-0.35**	.(a)				
8. Protestant Ethic Scale	-0.08	-0.13	-0.04	0.07	0.06	0.05	0.13			
9. Racial Centrality Scale	0.05	-0.11	0.13	-0.03	0.02	-0.26*	0.00	0.12		
10. Openness to Diversity Scale	-0.07	-0.09	0.08	0.37**	0.14	0.16	0.02	0.13	0.09	
11. Modern Racism Scale	0.07	-0.06	-0.31**	-0.28**	-0.06	0.02	0.10	0.26**	0.05	-0.38**

* = Correlation is significant at the 0.05 level (2-tailed).

** = Correlation is significant at the 0.01 level (2-tailed).

a = Cannot be computed because at least one of the variables is constant.

Note: For Partner Race, 1= Caucasian, 2= African American; For Partner Gender, 1=Male, 2=Female; For Participant Gender, 1=Male, 2=Female.

Test of Hypotheses.

Analyses. Hypotheses were tested using analysis of variance (ANOVA) and regression analyses. For ANOVAs, the key independent variables were partner race and partner gender. However, in order to assess whether the demographics of the respondent affected responses, respondent gender was also considered. Because the overwhelming majority of the respondents were Caucasian (n = 151) with only a low number of African American respondents (n = 10), respondent race could not be entered into the ANOVA. Therefore, a 2 (Black/White *Partner*) X 2 (Male/Female *Partner*) X 2 (Male/Female *Respondent*) ANOVA was performed on each of the key dependent variables (affective expectations, behavioral expectations, surprise regarding confirmed low performance, surprise regarding confirmed high performance). Ninety-eight of the participants were in the African American partner condition, 89 of the participants were in the Caucasian American partner condition, 81 of the participants were in the male condition, and 99 of the participants were female. Because racial attitudes (Protestant Ethic Scale, Racial Centrality Scale, Modern Racism Scale) and team attitudes (Openness to Diversity Scale) were measured continuously, hierarchical regression analyses were performed for hypotheses involving these scales.

Hypotheses Regarding Affective Expectations. Hypothesis 1_a predicted that participants would be more likely to report negative affective expectations toward African American partners as compared to Caucasian partners. As shown in Table 5, there was no significant main effect for

partner race (F (1, 147) = 1.04, p > .05). However, there was a significant interaction between partner race and participant gender (F (1, 147) = 1.96, p < .05). As shown in Figure 1, males were more likely to report more positive affective expectations for African American partners than Caucasian partners. In contrast, females were more likely to report positive affective expectations for Caucasian partners than African American partners. Therefore, Hypothesis 1_a was supported for female respondents, but not male respondents. This finding should be interpreted with caution, as there were almost twice as many female participants (N=99) as male participants (N=56). Hypothesis 1_a was partially supported.

Table 5: ANOVA Results for Affective Expectations as the Dependent Variable

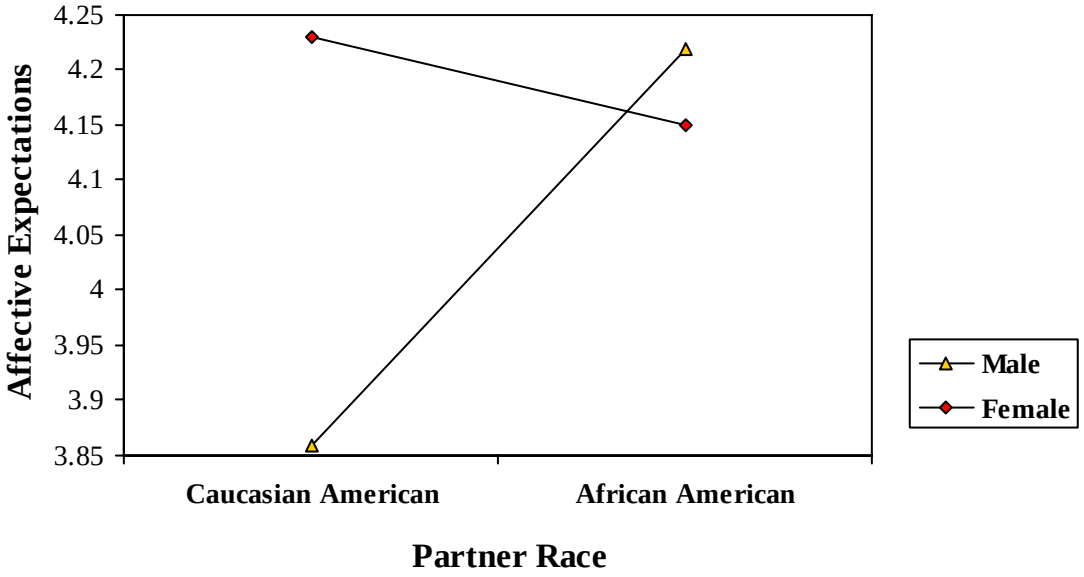
Tests of Between-Subjects Effects

Dependent Variable: Affective Expectations

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	4.775(a)	7	.682	1.976	.062	.086
Intercept	2391.851	1	2391.851	6926.300	.000	.979
Partner Race	.358	1	.358	1.036	.310	.007
Partner Gender	.020	1	.020	.058	.811	.000
Participant Gender	1.221	1	1.221	3.537	.062	.023
Partner Race * Partner Gender	.327	1	.327	.948	.332	.006
Partner Race * Participant Gender	1.957	1	1.957	5.668	.019	.037
Partner Gender * Participant gender	.586	1	.586	1.697	.195	.011
Partner Race * Partner Gender * Participant Gender	.222	1	.222	.644	.424	.004
Error	50.763	147	.345			
Total	2702.250	155				
Corrected Total	55.539	154				

a R Squared = .086 (Adjusted R Squared = .042)

Figure 1: Interaction between participant gender and partner race.



Hypothesis 1_b predicted that modern racism would moderate the relationship between partner race and affective expectations such that participants scoring higher on modern racism would be more likely to report negative affective expectations towards African American partners as compared to Caucasian partners. As shown in Table 6, a hierarchical regression analysis was conducted in which independent variables (partner race, partner gender, and participant gender) were entered in Step 1, race-related and team-related scales were entered in Step 2, and interactions were entered in Step 3. A significant main effect resulted for modern racism (beta = -.26, $p < .05$), indicating that students scoring higher on modern racism were more likely to report lower affective expectations of partners, regardless of race or gender. The interaction between modern racism and partner race was not significant (beta = .51, $p>.05$). Therefore, Hypothesis 1b was not supported.

Table 6: Hierarchical regression analyses for testing moderating effects of racial attitudes on partner race and affective expectations.

Independent Variables	Model		
	1	2	3
Controls			
Partner Race	0.03	0.08	0.44
Partner Gender	-0.01	0.02	0.01
Participant Gender	0.16	0.10	0.10
Racial Attitudes			
Racial Centrality Scale		-0.08	-0.04
Protestant Ethic Scale		0.10	0.21^{+}
Openness to Diversity Scale		0.31**	0.31**
Modern Racism Scale		-0.15^{+}	-0.26*
Interactions			
Protestant Ethic x Partner Race			-0.84
Racial Centrality x Partner Race			-0.28
Openness to Diversity x Partner Race			-0.18
Modern Racism x Partner Race			0.51
R^2	0.03	0.18	0.23
F	1.30	4.75**	3.47**
$R^{2\ increment}$	0.03	0.16**	0.04

** p<0.01; *p<0.05; +p<0.10

Hypothesis 1_c predicted that Protestant ethic would moderate the relationship between partner race and affective expectations such that participants scoring higher on the Protestant ethic scale would be more likely to report negative affective expectations of African American partners as compared to Caucasian partners. As shown in Table 6, the main effect for Protestant ethic was marginally significant (beta = .21, $p < .10$), suggesting that students scoring higher on Protestant work ethic were more likely to higher affective expectations of partners, regardless of race or gender. The interaction between Protestant ethic and partner race was not significant (beta = -.84, p>.05). Therefore, Hypothesis 1c was not supported.

Hypothesis 1_d predicted that racial centrality would moderate the relationship between partner race and affective expectations such that participants scoring higher on racial centrality would be more likely to report negative affective expectations towards African American partners as compared to Caucasian partners. As shown in Table 6, the interaction between racial centrality and partner race was not significant (beta = -.28, p>.05). Therefore, Hypothesis 1d was not supported.

Hypothesis 1_e predicted that openness to diversity in teams would moderate the relationship between partner race and affective expectations such that participants scoring less positively on openness to diversity in teams would be more likely to report negative affective expectations of African American partners as compared to Caucasian partners. As shown in Table 6, the main effect for openness to diversity in teams was significant (beta = .31, $p < .05$), suggesting that students who had more positive attitudes towards team diversity were more likely to have higher affective expectations of partners, regardless of race or gender. The interaction between openness to diversity in teams and partner race was not significant (beta = .40, p>.05). Therefore, Hypothesis 1e was not supported.

Hypotheses Regarding Behavioral Expectations. Hypothesis 2_a predicted that participants would be more likely to report negative behavioral expectations regarding the work relationship with African American partners as compared to Caucasian partners. As shown in Table 7, there was no significant main effect for partner race ($F (1, 147) = .193$, $p > .05$). Therefore, Hypothesis 2_a was not supported.

Table 7: ANOVA Results for Behavioral Expectations as the Dependent Variable

Tests of Between-Subjects Effects

Dependent Variable: Behavioral Expectations Scale

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	.871(a)	7	.124	.440	.875	.021
Intercept	2069.118	1	2069.118	7323.210	.000	.980
Partner Race	.075	1	.075	.265	.608	.002
Partner Gender	.148	1	.148	.523	.471	.004
Participant Gender	.021	1	.021	.073	.787	.000
Partner Race * Partner Gender	.030	1	.030	.105	.746	.001
Partner Race * Participant Gender	.347	1	.347	1.230	.269	.008
Partner Gender * Participant Gender	.018	1	.018	.064	.800	.000
Partner Race * Partner Gender * Participant Gender	.046	1	.046	.164	.686	.001
Error	41.534	147	.283			
Total	2305.160	155				
Corrected Total	42.405	154				

a R Squared = .021 (Adjusted R Squared = -.026)

Hypothesis 2_b predicted that modern racism would moderate the relationship between partner race and behavioral expectations such that participants scoring higher on modern racism would be more likely to report negative behavioral expectations of African American partners as compared to Caucasian partners. As shown in Table 8, a hierarchical regression analysis was conducted in which independent variables (partner race, partner gender, and respondent gender) were entered in Step 1, race-related and team-related scales were entered in Step 2, and interactions were entered in Step 3. The interaction between modern racism and partner race was not significant (beta = -.08, $p > .05$). Therefore, Hypothesis 2b was not supported.

Hypothesis 2_c predicted that Protestant ethic would moderate the relationship between partner race and behavioral expectations such that participants scoring higher on Protestant ethic would be more likely to report negative behavioral expectations towards African American partners as compared to Caucasian partners. As shown in Table 8, the interaction between Protestant ethic and partner race was not significant (beta = .41, $p > .05$). Therefore, Hypothesis 2_c was not supported.

Hypothesis 2_d predicted that racial centrality would moderate the relationship between partner race and behavioral expectations such that participants scoring higher on racial centrality would be more likely to report negative behavioral expectations towards African American partners as compared to Caucasian partners. As shown in Table 8, the interaction between racial centrality and partner race was not significant (beta = -.23, p>.05). Therefore, Hypothesis 2_d was not supported.

Hypothesis 2_e predicted that openness to diversity in teams would moderate the relationship between partner race and behavioral expectations such that participants scoring less positively on openness toward team diversity would be more likely to report negative behavioral expectations towards African American partners as compared to Caucasian partners. As shown in Table 8, the interaction between openness to diversity and partner race was not significant (beta = .65, p>.05). Therefore, Hypothesis 2_e was not supported.

Table 8: Hierarchical regression analyses for testing moderating effects of racial attitudes on partner race and behavioral expectations

Independent Variable	Model		
	1	2	3
Controls			
Partner Race	-0.07	-0.06	-1.21
Partner Gender	0.07	0.09	0.08
Participant Gender	-0.02	-0.42	-0.03
Racial Attitudes			
Racial Centrality Scale		0.02	0.05
Protestant Ethic Scale		0.05	-0.03
Openness to Diversity Scale		0.13	0.05
Modern Racism Scale		-0.03	-0.11
Interactions			
Protestant Ethic x Partner Race			0.41
Racial Centrality x Partner Race			-0.23
Openness to Diversity x Partner Race			0.65
Modern Racism x Partner Race			-0.08
R^2	0.01	0.04	0.06
F	0.56	0.77	0.72
$R^{2\ increment}$	0.01	0.02	0.02

** p<0.01; *p<0.05; +p<0.10

Hypotheses Regarding Surprise About Confirmed Low Performance. Hypothesis 3_a predicted that participants would be more likely to report lower levels of surprise when African American partners perform poorly as compared to Caucasian partners. As shown in Table 9, there was no significant main effect for partner race (F (1, 61) = .025, p >.05). Therefore, Hypothesis 3_a was not supported.

Hypothesis 3_b predicted that modern racism would moderate the relationship between partner race and surprise regarding confirmed low performance, such that participants scoring higher on modern racism would be more likely to report less surprise regarding the confirmed

low performance of African American partners as compared to Caucasian partners. As shown in Table 10, a hierarchical regression analysis was conducted in which independent variables (partner race, partner gender, and respondent gender) were entered in Step 1, race-related and team-related scales were entered in Step 2, and interactions were entered in Step 3. The interaction between modern racism and partner race was not significant (beta = -0.69, p>.05). Therefore, Hypothesis 3_b was not supported.

Hypothesis 3_c predicted that Protestant ethic would moderate the relationship between partner race and surprise regarding confirmed low performance, such that participants scoring higher on Protestant ethic would be more likely to report lower levels of surprise regarding confirmed low performance of African American partners as compared to Caucasian partners. As shown in Table 10, the interaction between Protestant ethic and partner race was not significant (beta = .42, p>.05). Therefore, Hypothesis 3_c was not supported.

Table 9: ANOVA Results for Surprise Regarding Confirmed Low Performance as the Dependent Variable

Tests of Between-Subjects Effects

Dependent Variable: Surprise Regarding Low Performance Scale

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	5.353(a)	7	.765	.745	.635	.079
Intercept	774.945	1	774.945	754.916	.000	.925
Partner Race	.026	1	.026	.025	.875	.000
Partner Gender	.459	1	.459	.447	.506	.007
Participant Gender	.451	1	.451	.440	.510	.007
Partner Race * Partner Gender	1.506	1	1.506	1.468	.230	.023
Partner Race * Participant Gender	.655	1	.655	.638	.428	.010
Partner Gender * Participant Gender	.638	1	.638	.621	.434	.010
Partner Race * Partner Gender * Participant Gender	1.960	1	1.960	1.910	.172	.030
Error	62.618	61	1.027			
Total	939.083	69				
Corrected Total	67.972	68				

a R Squared = .079 (Adjusted R Squared = -.027)

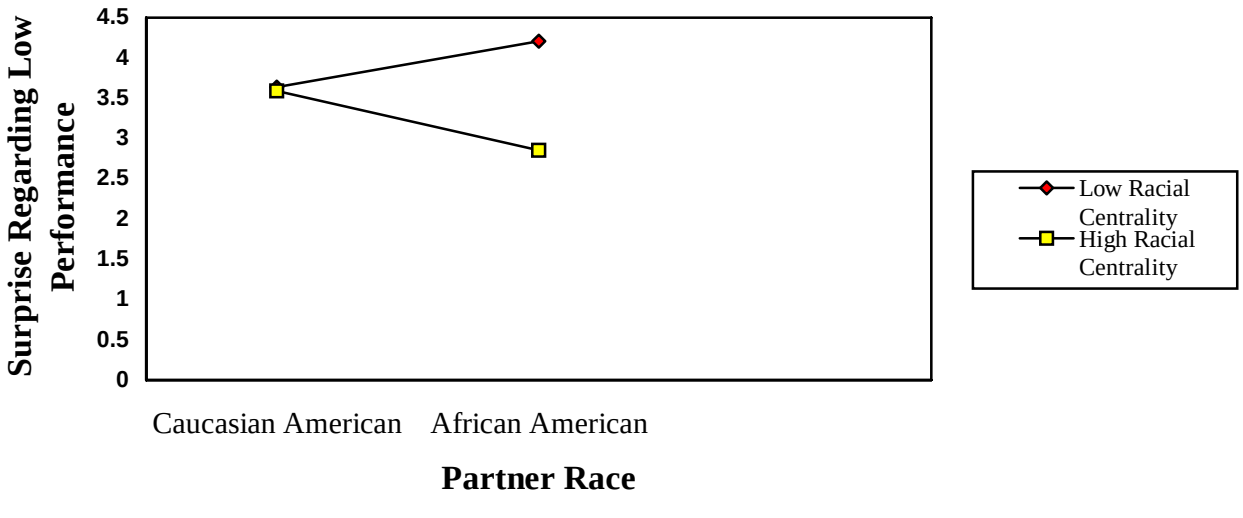
Table 10: Hierarchical regression analyses for testing moderating effects of racial attitudes on partner race and surprise regarding confirmed low performance.

Independent Variable	Model		
	1	2	3
Controls			
Partner Race	-0.06	0.01	1.61
Partner Gender	-0.10	-0.11	-0.18
Participant Gender	0.09	0.18	0.14
Racial Attitudes			
Racial Centrality Scale		-0.30*	0.02
Protestant Ethic Scale		0.01	-0.02
Openness to Diversity Scale		0.23^{+}	0.32*
Modern Racism Scale		0.14	0.25
Interactions			
Protestant Ethic x Partner Race			0.42
Racial Centrality x Partner Race			-1.95**
Openness to Diversity x Partner Race			-0.26
Modern Racism x Partner Race			-0.69
R^2	0.02	0.14	0.36
F	4.56	1.43	2.60**
$R^{2\ increment}$	0.02	0.12^{+}	0.22**

** p< 0.01; * p < 0.05; $^{+}$ p< 0.10.

Hypothesis 3_d predicted that racial centrality would moderate the relationship between partner race and surprise regarding confirmed low performance such that participants scoring higher on racial centrality would be more likely to report lower levels of surprise if an African American partner performed poorly. As shown in Table 10, there was a main effect for racial centrality (beta = -0.30, p<.05), indicating that participants who reported that their race is a significant aspect of their identity were less likely to report lower levels of surprise regarding the confirmed low performance of partners, regardless of race or gender. Results also showed an interaction between racial centrality and partner race (beta = -1.95, p<.01). Figure 2 indicates that individuals whose race was an important aspect of their identity were more likely to report lower surprise when African American partners performed poorly than individuals whose race was a less important aspect of their identity. Therefore, Hypothesis 3_d was supported.

Figure 2: Interaction between partner race and racial centrality on surprise.



Hypothesis 3_e predicted that openness to diversity in teams would moderate the relationship between partner race and surprise regarding confirmed low performance, such that participants scoring less positively on openness toward team diversity would be more likely to report less surprise when African Americans performed poorly as compared to Caucasian Americans. As shown in Table 7, the interaction between openness to diversity and partner race was not significant (beta = -.26, p>.05). Therefore, Hypothesis 3_e was not supported.

Hypotheses Regarding Surprise Regarding Confirmed High Performance. Hypothesis 4_a predicted that participants would be more likely to report higher levels of surprise when African American partners perform well as compared to Caucasian partners. As shown in Table 11 there was no significant main effect for partner race (F (1, 78) = .920, p >.05). Therefore, Hypothesis 4_a was not supported.

Table 11: ANOVA Results for Surprise Regarding Confirmed High Performance as the Dependent Variable

Tests of Between-Subjects Effects

Dependent Variable: Surprise Regarding High Performance Scale

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3.134(a)	7	.448	.450	.867	.039
Intercept	256.244	1	256.244	257.712	.000	.768
Partner Race	.914	1	.914	.920	.341	.012
Partner Gender	1.531	1	1.531	1.540	.218	.019
Participant Gender	.018	1	.018	.018	.895	.000
Partner Race * Partner Gender	.001	1	.001	.001	.979	.000
Partner Race * Participant Gender	.075	1	.075	.075	.785	.001
Partner Gender * Participant Gender	.814	1	.814	.819	.368	.010
Partner Race * Partner Gender * Participant Gender	.007	1	.007	.007	.932	.000
Error	77.556	78	.994			
Total	369.868	86				
Corrected Total	80.690	85				

a R Squared = .039 (Adjusted R Squared = -.047)

Hypothesis 4_b predicted that modern racism would moderate the relationship between partner race and surprise regarding confirmed high performance, such that participants scoring higher on modern racism would be more likely to report higher levels of surprise regarding the confirmed high performance of African American partners as compared to Caucasian partners. As shown in Table 12, a hierarchical regression analysis was conducted in which independent variables (partner race, partner gender, and participant gender) were entered in Step 1, race-related and team-related scales were entered in Step 2, and interactions were entered in Step 3. The interaction between modern racism and partner race was not significant (beta = -0.26, p>.05). Therefore, Hypothesis 4_b was not supported.

Hypothesis 4_c predicted that Protestant ethic would moderate the relationship between partner race and surprise regarding confirmed high performance, such that participants scoring higher on Protestant ethic would be more likely to report lower levels of surprise regarding confirmed high performance of African American partners as compared to Caucasian partners. As shown in Table 12, the interaction between Protestant ethic and partner race was not significant (beta = .42, p>.05). Therefore, Hypothesis 4_c was not supported.

Hypothesis 4_d predicted that racial centrality would moderate the relationship between partner race and surprise regarding confirmed high performance such that participants scoring higher on racial centrality would be more likely to higher levels of surprise when African American partners performed well. As shown in Table 12, the interaction between racial centrality and partner race was not significant (beta = -0.53, p> .05). Therefore, Hypothesis 4_d was not supported.

Table 12: Hierarchical regression analyses for testing moderating effects of racial attitudes on partner race and surprise regarding confirmed high performance

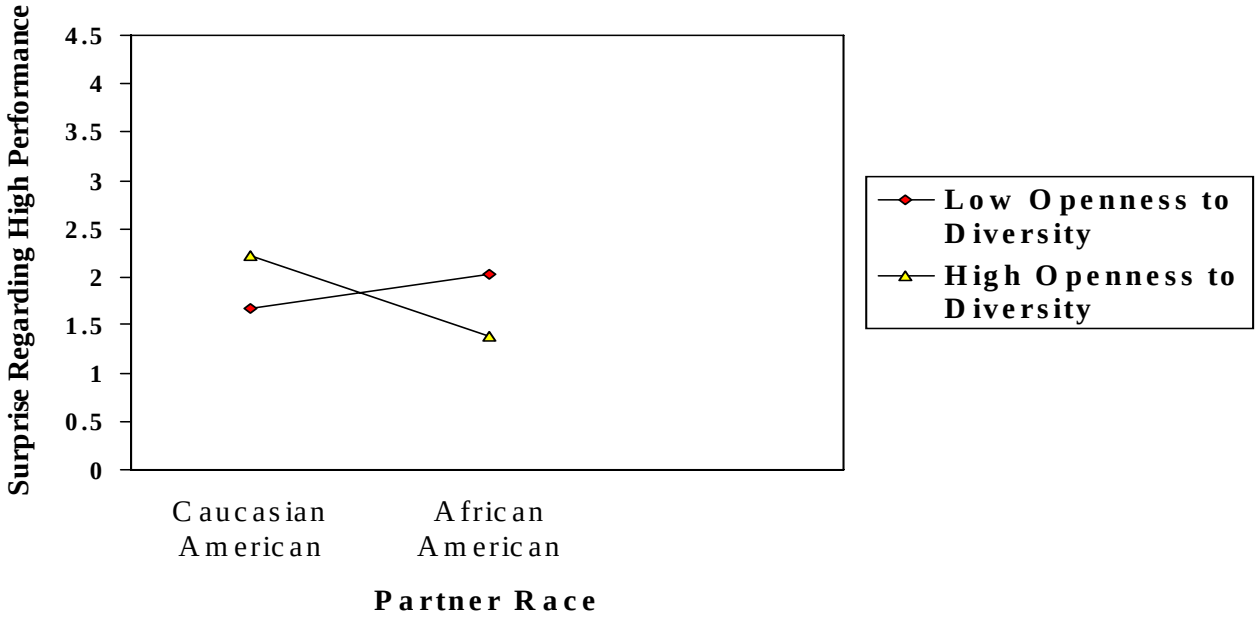
Independent Variable	Model		
	1	2	3
Controls			
Partner Race	-0.13	-0.15	1.92^{+}
Partner Gender	-0.11	-0.09	-0.07
Participant Gender	0.01	0.07	0.09
Racial Attitudes			
Racial Centrality Scale		-0.06	0.05
Protestant Ethic Scale		0.08	0.04
Openness to Diversity Scale		0.03	0.27
Modern Racism Scale		0.14	0.17
Interactions			
Protestant Ethic x Partner Race			0.42
Racial Centrality x Partner Race			-0.53
Openness to Diversity x Partner Race			-1.94*
Modern Racism x Partner Race			-0.26
R^2	0.03	0.05	0.15
F	0.78	0.63	1.07
$R^{2\ increment}$	0.03	0.03	0.10

**p<0.01; *p<0.05; +p<0.10.

Hypothesis 4_e predicted that openness to diversity in teams would moderate the relationship between partner race and surprise regarding confirmed high performance, such that participants scoring higher on openness toward team diversity would be more likely to report lower surprise when African Americans performed well, as compared to participants scoring lower on openness toward team diversity. As shown in Table 12, the interaction between openness to diversity and partner race was significant (beta = -1.94, p<.05). Figure 3 shows that participants with high openness to diversity in teams were less surprised when African American

partners performed well than participants with low openness to diversity in teams. Therefore, Hypothesis 4_e was supported.

Figure 3: Interaction between partner race and openness to diversity in teams on surprise regarding high performance



DISCUSSION

The purpose of this study was to examine initial affective and behavioral expectations toward African American partners as compared to Caucasian partners in the context of a team project. It was hypothesized that expectations toward African Americans would be lower than expectations toward Caucasians, both regarding initial feelings toward working with partners as well as expectations of their contribution toward the group's overall effort. However, results were not simplistic regarding race. Just because participants had an African American partner did not mean that they would rate them lower on affective or behavioral expectations or report higher levels of surprise for high performance or lower levels of surprise for low performance. Instead, expectations were dependent upon other factors such as attitudes toward race. In fact, attitudes toward race had a greater influence on the dependent variables measured than partner's race or gender. Partner race matters, but results were complex, involving interactions with respondents' gender, racial centrality, and openness to team diversity.

Significant findings emerged for initial affective expectations, but not for behavioral expectations. In terms of affective expectations, there was a significant interaction between partner race and participant gender. Hypothesis 1_a was supported for females, but not males. Specifically, male participants were more likely to report more positive affective expectations for

African American partners than Caucasian partners and female participants were more likely to report more positive affective expectations for Caucasian partners than African American partners. Hypothesis 3_d was supported, as racial centrality moderated the relationship between partner race and surprise regarding confirmed low performance. Specifically, this interaction indicated that individuals who reported that their race was an important aspect of their identity were more likely to report lower surprise when African American partners performed poorly than individuals who reported that their race was a less important aspect of their identity. Hypothesis 4_e was also supported, as openness to diversity in teams moderated the relationship between partner race and surprise regarding confirmed high performance. The interaction revealed that participants with high openness to diversity in teams were less surprised when African American partners performed well than participants with low openness to diversity in teams. No other relationships were significant.

Limitations of the study and future research. It is possible that few relationships were significant because of social desirability and students not being truthful about their beliefs and expectations. This was exemplified through the restriction of range in responses on the modern racism scale (see *Table 2*). Items may not have been sensitive enough to measure subtle forms of racism. Future research should address and try to control for social desirability, as it was possible that individuals may have been cautious in reporting their true feelings regarding race and related matters. Creating a safe forum would allow people to relay their true feelings regarding racial issues honestly, openly, and without the fear of being labeled as "racist." Racism remains a thorn in society's side that some people would rather not acknowledge.

The hypothetical nature of the study was also a limitation. Clearly, asking students to imagine being assigned a partner of a certain race and gender was not as desirable as allowing participants to actually interact with partners. It is possible that few moderated relationships were found because interactions are difficult to find with a low sample size. Although the overall sample was rather larger (N=185), when dividing the sample into 4 conditions crossing gender and race, the cell sample sizes may have been too small to detect an interaction. Future research should be done with a larger sample size from a non-student population, preferably one that is comprised of employees within the workforce. Given the homogeneous racial composition of the college campus from which the sample was obtained, analyses examining whether expectations of African American and Caucasian partners' performance across racial groups could not be performed. It is possible that results may have varied had the sample been larger, more racially diverse, and not comprised of college students.

REFERENCES

Black, D., Haviland, A., Sanders, S., & Taylor, L. (2006). Why do minority men earn less? A study of wage differentials among the highly educated. *The Review of Economics and Statistics. 88*(1), 300-313.

Brief, A.P., Dietz, J., Cohen, R.R., Pugh, S.D., & Vaslow, J.B. (2000). Just doing business: Modern racism and obedience to authority as explanations for employment discrimination. *Organizational Behavior and Human Decision Processes, 81*(1), 72-97.

Elsass, P.M., & Graves, L.M. (1997). Demographic diversity in decision-making groups: The experiences of women and people of color. *Academy of Management Review, 22*(4), 946-973.

Hobman, E.V., Bordia, P., & Gallois, C. (2004). Perceived dissimilarity and work group involvement. *Group & Organizational Management, 29*(5), 560-587.

Jones, Jr., H.B. (1997). The Protestant ethic: Weber's model and the empirical literature. *Human Relations, 50*(7), 757-778.

Katz, I., & Hass, R.G. (1988). Racial ambivalence and American value conflict: correlational and priming studies of dual cognitive structures. *Journal of Personality and Social Psychology, 55*(6), 893-905.

Macrae, C., & Bodenhausen, G.V. (2000). Social cognition: Thinking categorically about others. *Annual Review of Psychology, 51*, 93-120.

Martins, L.L., Milliken, F.J., Wiesenfeld, B.M., and Salgado, S.R. Racioethnic diversity and group members' experiences: The role of the racioethnic diversity of the organizational context. *Group & Organization Management, 28*(1) 75-106.

McConahay, J.B., Hardee, B.B., & Batts, V. (1981). Has racism declined in America? It depends on who is asking and what is asked. *Journal of Conflict Resolution, 25*(3), 563-579.

Monteith, M.J., Sherman, J.W., & Devine, P.G. (1998). Suppression as a stereotype control strategy. *Personality and Social Psychology Review, 2*(1), 63-82.

Nail, P.R., Harton, H.C., & Decker, B.P. (2003). Political orientation and modern versus aversive racism: Tests of Dovidio and Gaertner's (1998) integrated model. *Journal of Personality and Social Psychology, 84*(4), 754-770.

Pettigrew, T.F., & Martin, J. (1987). Shaping the organizational context for Black American inclusion. *Journal of Social Issues, 43*, 41-78.

Sellers, R., Smith, M.A., Shelton, J.N., Rowley, S.A.J., & Chavous, T.M. (1998). Multidimensional model of racial identity: A reconceptualization of African American racial identity. *Personality and Social Psychology Review, 2*(1), 18-39.

Timmerman, T.A. (2000). Racial diversity, age diversity, interdependence, and team performance. S*mall Group Research, 31*(5), 592-606.

U.S. Dept. Labor. Retrieved July 20, 2006, from ftp://ftp.bls.gov/pub/special.requests/lf/aat11.txt

The Effect of Ligand-Activated PPARβ on Breast and Liver Cancer Cell Proliferation

Renee L. Killins, McNair Scholar, Penn State University

Jeffrey M. Peters, Ph.D
Associate Professor or Environmental Toxicology
Veterinary Science Department
Penn State University

Abstract

There is considerable controversy regarding the effects of ligand activation of peroxisome proliferator-activated receptor-β (PPARβ) on cell growth. Some studies show that ligand activation of PPARβ leads to a decrease in cell proliferation and promotes differentiation. However, other work shows that ligand activation of PPARβ increases proliferation of breast and colon cancer cells. The purpose of this study was to determine the effects of a PPARβ-specific ligand, GW0742, on the proliferation of breast and liver cancer cell lines, and to examine possible pathways through which ligand-activated PPARβ causes the observed effects. In contrast to some previous reports, results from these studies show that ligand activation of PPARβ caused inhibition of cell growth in both breast and liver cancer cell lines. We examined if changes in extracellular signal-regulated kinase (ERK) phosphorylation contributed to the decrease in cell proliferation, as ERK can be a central regulator of all growth. However, no change in ERK phosphorylation was observed in response to GW0742. Combined results from the studies show that ligand activation of PPARβ inhibits, but does not potentiate, cell growth of breast and liver cancer cells. Thus, PPARβ may be a target that could be used to inhibit liver cancer.

Introduction

The history of peroxisome proliferator-activated receptors began in 1990 when scientists cloned PPARα from rodent liver [1]. Shortly thereafter, the other two members of the PPAR family, PPARγ and PPARβ/δ, were identified [2]. PPARs are ligand-activated transcription factors belonging to the nuclear-hormone-receptor-receptor family (NHR) [3]. While the three receptors have similar structures, the expression and function of the three PPAR isoforms can vary greatly.

PPARα is found in liver, heart and skeletal muscle [4]. This receptor was found to function in lipid homeostasis, inflammation, and liver carcinogenesis in rodents. PPARγ is mainly found in adipose tissue. It functions in adipocyte differentiation, fatty acid storage and inflammation [4]. PPARβ/δ (from here on referred to as PPARβ) is ubiquitous with a high expression found in skin. Less is known about this isoform than what is known about PPARα and PPARγ. This is due, in part, to the fact that PPARα and PPARγ are targets of dyslipidemia and type 2 diabetes drugs [4]. Scientists have shown conclusively that PPARβ functions in keratinocyte

differentiation, apoptosis and cell proliferation [5]. However, the role of PPARβ in the differentiation, apoptosis and cell proliferation of other cell types remains controversial.

Xenografts from PPARβ-null colon cancer cells formed fewer tumors than the xenografts for wild-type colon cancer cells [6]. This suggests that PPARβ promotes cell growth of colon cancer cells. The pro-proliferative role of PPARβ has also been reported in response to ligand activation of this receptor in breast, prostate, and liver cancer cell lines ([7], [8]). In contrast, more evidence exists supporting an anti-proliferative role for PPARβ. In the first experiment to demonstrate the in vivo effects of PPARβ on epidermal cell proliferation, results showed that PPARβ-null mice had a greater hyperplastic response to TPA than wild-type mice [9]. Also, results indicated that null mice treated with TPA had more inflammation than the controls, suggesting that not only does PPARβ have anti-proliferative properties, but also anti-inflammatory properties [9]. A similar study done in 2005 supported these findings when mice treated with TPA had a greater hyperplastic response in the epidermis than controls; scientists found that these effects were mediated by changes to the MAP kinase pathway caused by PPARβ [10]. Further studies on the effect of PPARβ activation on keratinocytes showed that treatment with GW0742 resulted in keratinocyte terminal differentiation as well as inhibition of keratinocyte proliferation [11]. Also, topical treatment of mice with PPARβ-specific ligand, GW501516, resulted in keratinocyte differentiation as well as anti-inflammatory effects [12]. Another study also showed that PPARβ increased human keratinocyte differentiation [13]. Scientists have also studied the effects of PPARβ in colon carcinogenesis. Recently, it was found that PPARβ is involved in the negative growth control of lung cancer cells [14]. A recent study showed that PPARβ is involved in the differentiation of colon cancer cells [15]. Ligand activation of PPARβ has also been found to inhibit colon carcinogenesis in mice [16].

There is good evidence that PPARβ ligands may be useful for treating type 2 diabetes [17]. A study done in 2000 demonstrated the therapeutic value of PPARβ when the activation of PPARβ in insulin resistant db/db mice resulted in an increase of total plasma cholesterol concentrations which were associated with an increase in high density lipoproteins (HDL), the good cholesterol [18]. This experiment was repeated in insulin-resistant middle-aged obese rhesus monkeys and resulted in an increase in HDL levels as well [20]. In a more recent study, scientists treated macrophages with a PPARβ-specific ligand. This treatment resulted in an increase in the catabolism of fatty acids [19], thus further confirming the possibility of PPARβ ligands being used therapeutically. Furthermore, treatment of mice and rats with PPARβ-specific ligand, GW501516 was found to promote fatty acid oxidation in skeletal muscles as well as decrease plasma glucose and blood insulin levels in ob/ob mice [20]. Another similar study found that PPARβ is involved in the regulation of *ucp-2* gene expression, a gene involved in the regulation of ATP synthesis as well as the regulation of fatty acid oxidation [21]. However, before this receptor can be used as a pharmacological agent, it is important that the toxicological effects of its activation are fully known. The purpose of the present study was to determine the effects of ligand activation of PPARβ on cell proliferation of breast cancer (MCF7) and liver cancer (HEPG2) cell lines. The dose-dependent response of cell proliferation was studied using a PPARβ-specific ligand, GW0742. It was hypothesized that ligand activation of PPARβ would result in a dose-dependent decrease in cell proliferation in both cell lines.

Materials and Methods

Materials. DMEM was obtained from Sigma-Aldrich. MEM was obtained from Gibco. Sodium bicarbonate was purchased from Sigma-Aldrich. Fetal bovine serum (FBS) was obtained from Gemini Bio Products.

Cell culture and proliferation. The MCF-7 cell line was purchased from the American Type Culture Collection (ATCC) and grown in Dulbecco's modified Eagle's medium (DMEM) with 10% FBS, penicillin (100 U/mL) and streptomycin sulfate (100 µg/mL). Both cell lines were grown in an incubator at 37° C with 5% CO2 and 95%O2. The HepG2 cell line was purchased from the American Type Culture Collection (ATCC) and grown in modified Eagle's medium (MEM) with 10% FBS, penicillin (100 U/mL) and streptomycin sulfate (100 µg/mL). Both cell lines were plated at 100,000 cells/well on 6-well plates. For the 14 day experiments, MCF-7 cells were treated with 2 µL of DMSO, and 100 nM 100 nM—5 µM GW0742 three days after being plated. Cells were counted on days 0, 7 and 14 using a Coulter counter. For the 7 day experiments, HepG2 cells were treated with 2 µL of DMSO, and 100 nM—5 µM GW0742 three days after being plated. Cells were counted daily using a Coulter Counter.

Protein Analysis. Nuclear extracts from HepG2 cells were collected from cells grown to 80% confluency using cell lysis buffer. Protein was quantified using a BCA assay. Following separation via SDS-PAGE and proteins were electrophoretically transferred to a polyvinylidene fluoride (PVDF) membrane by electroblotting in standard Tris-glycine buffer. Immunodetection was performed using primary antibodies: αLDH, phosphorylated extracellular signal-regulated kinase (ERK/MAPK) and ERK/MAPK. Membranes were incubated in the primary antibodies at 4° C over night. Membranes were then incubated in biotinylated 2° antibodies: anti-goat for α LDH and anti-rabbit for phosphorylated ERK/MAPK and ERK/MAPK for one hour at room temperature and then washed in TBST. Membranes were then incubated in ^{125}I-strepavidin for 40 minutes and washed. Radiolabeled membranes were exposed to phosphorimager plates and the hybridization signal was quantified after normalization to LDH using a Cyclone Phosphorimager and Image Quant software.

Quantitative Real Time PCR. Cells were grown to 80% confluency and then treated in triplicate with 10 µL of either 0.1%DMSO or 500 nM GW0742. Cells were then harvested from cells using 750 µL of Trizol per dish. RNA was then purified using 0.25 mL of cold chloroform per tube and then centrifuged at 12,000 rpm for 15 minutes. Next, RNA was precipitated using isopropanol. Samples were centrifuged at 12,000 rpm in a refrigerated (4°) Eppendorf centrifuge for 15 minutes. The supernatant was removed, and samples were air-dried to remove any excess supernatant. RNA was then resuspended in 0.4 mL of DEPC water and vortexed. Then 0.4 mL of cold phenol was added and samples were again centrifuged at 12,000 rpm for 15 minutes. Finally, the upper phase was removed and placed in a fresh autoclaved tube and then spun down again. The supernatant was removed and the pellet was resuspended in DEPC water. The quantity of the RNA was then measured in a spectrophotometer at 260/280 nm. cDNA was generated using 2.5 µg total RNA with MultiScribe Reverse Transcriptase kit (Applied Biosystems). The GenBank accession numbers for the forward and reverse primers used to

quantify mRNAs were hADRP (NM_007408): forward, 5-CTGCTCTTCGCCTTTCGCT-3', and reverse, 5'-ACCACCCGAGTCACCACACT-3'. All mRNAs examined were normalized to the gene encoding glyceraldehyde-3-phosphate dehydrogenase (hGAPDH; BC013310) using the following primers: forward, 5'-TGCACCACCACCTGCTTAGC-3', and reverse, 5'-GGCATGGACTGTGGTCATGAG-3'. Real-time PCR reactions were carried out using SYBR green PCR master mix (Finnzymes, Espoo, Finland) in the PTC-200 DNA Engine Cycler and detected using the CFD-3200 Opticon Detector (MJ Research, Waltham, MA). The reactions were run at 95°C for 15 seconds, 94°C for 10 seconds, 60°C for 30 seconds, and 72°C for 30 seconds. This was repeated for 45 cycles. The PCR had a no-template control reaction in order to control for contamination. Relative expression levels of mRNA were normalized to GAPDH and analyzed for statistical significance using one-way ANOVA (Prism 4.0).

Results

Effect of GW0742 in the MCF-7 cell line. To investigate the effects of activated PPARβ on breast cancer cells, MCF-7 cells were treated with 0.1% DMSO, 100 nM or 500 nM GW0742 over the course of 14 days and counted every seven days. These results showed no significant differences between the treated groups and the control group (figure 1A).

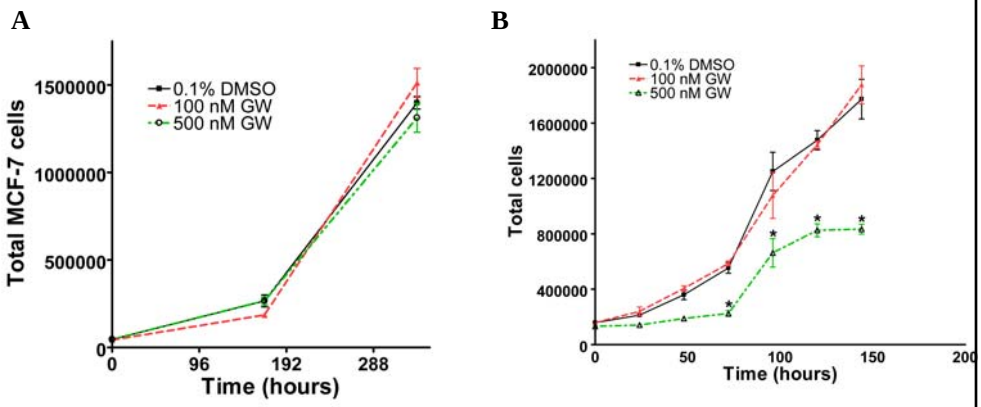


Figure 1. **Effect of GW0742 on cell proliferation.** Both cell lines were treated with 0.1% DMSO and 500 nM GW0742 for fourteen days. **A.** Results showed no significant difference between the treated MCF-7 cells and control cells. Data points are means ± S.E, averaged from 3 separate wells counted in triplicate. **B.** There was a significant decrease in HepG2 cell proliferation on days 3, 4, 5 and 6. Data points are means ± S.E, averaged from 3 separate wells counted in triplicate. *, values are significantly different from the control 0.1% DMSO

Effect of GW0742 in the HepG2 cell line. Liver cancer cells, HepG2, were treated with 0.1% DMSO, 100 nM or 500nM GW0742 over the course of 6 days and counted every day. Results showed that at 100 nM GW0742, there was no significant effect on cell growth, while at 500 nM, there was a significant decrease in cell proliferation (Figure 1B).

Activation of PPARβ via GW0742. In order to confirm that PPARβ was activated by the ligand treatments, a real time polymerase chain reaction (rtPCR) was performed to quantify the levels of adipose differentiation regulated protein (ADRP), a gene known to be up-regulated by PPARβ. Results showed that ADRP levels found in the treated MCF7 cells were not statistically different from those found in the control MCF7 cells (figure 2A). This finding may explain why there was no

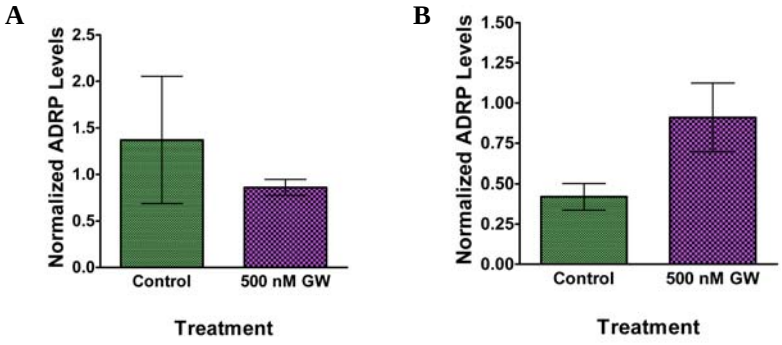


Figure 2. **Effect of GW0742 on ADRP gene expression**. Both cell lines were treated with 0.1% DMSO and 500 nM GW0742 and harvested at 6 hours. A real time PCR was performed to quantify the levels of ADRP, a gene known to be up-regulated by PPARβ. **A.** Results showed that PPARβ was not activated in MCF-7 cells by ligand treatment **B.** Results showed a clear increase in ADRP expression with GW0742 treatment in HepG2 cells.

significant change in the proliferation of MCF-7 cells when treated with GW0742. However, there was a clear increase in ADRP levels was found in the ligand-treated HepG2 cells, demonstrating that PPARβ was activated (Figure 2B).

Effect of GW0742 on HepG2 ERK and phospho-ERK levels. To determine the means by which ligand-activated PPARβ causes the observed effect of decreasing cellular proliferation, HepG2 cells were grown in 10 cm dishes and grown to 80% confluency. Once the cells reached the desired confluency, they were treated in triplicate with either 10 µL of 0.1% DMSO or 500 nM GW0742. Cells were harvested at 12 hour and 24 hour time points and a western blot was performed to determine the protein levels of ERK and phoshporylated ERK. Results indicated that treatment of cells with GW0742 does not significantly change the levels of ERK (Figure 3). There appeared to be no measurable levels of phosphorylated ERK in neither the control nor the treated cells (Figure 3).

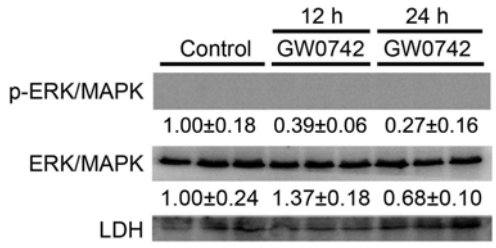


Figure 3. **Western Blot of HepG2 cells.** There was no significant change in the levels of ERK in treated cells. There was no appreciable amount of phosphorylated ERK in the HepG2 cell line

Conclusion

Results from this study, show that ligand-activated PPARβ has no significant effect on MCF-7 cell growth (a breast cancer cell line). These findings conflict with previous research showing that ligand activated PPARβ increased MCF-7 cell proliferation [7]. This could be due to differences in the methods of the experiments. For example, in the previous experiment, researchers used the PPARβ-specific ligand, compound F rather than the ligand, GW0742, which was used in our research. Findings from that study showed that under hormonal deprivation, PPARβ activation stimulated cell proliferation in MCF-7 cells. This was done by stripping the serum, however, in our study, the serum was not stripped. Furthermore, the previous study used MCF-7 Tet-On cells to ensure that there was enough PPARβ in the cells to be activated. The difference in the findings could be due to the fact that there was not enough PPARβ expressed in our MCF-7 cells to cause an effect on cell proliferation or it could be because the cells were not grown under hormonal deprivation. Further research should be done to determine the levels of PPARβ expressed in the control as well as the ligand treated MCF-7 cells.

From this research, it was determined that GW0742 ligand activation of PPARβ significantly decreases cell proliferation in HepG2 cells (a liver cancer cell line). These findings are consistent with many of the previous studies suggesting an anti-proliferative role of PPARβ and thus the possibility for a therapeutic use of PPARβ-specific ligands in treatments such as Type II diabetes or liver cancer treatment [11, 17, 18]. We believe that these effects are caused by PPARβ dependent changes in a cell cycle pathway. From these results, it can be concluded that this decrease in cell proliferation is not caused by PPARβ dependent changes in the ERK pathway. Further research should be done to determine the specific pathway, such as the p70S6K1 or the Jak-STAT pathways that PPARβ uses to cause the observed effects.

Collectively, results from these studies are inconsistent with previous work by others suggesting that PPARβ potentiates cell growth and are more consistent with the greater body of evidence suggesting that PPARβ inhibits cell growth. Results from this study suggest that the PPARβ-specific ligand, GW0742 could be a safe and useful pharmaceutical. Further research should be done to determine the in vivo effects of ligand-activated PPARβ on other cell types and to determine the specific mechanisms underlying these effects. Also, it is imperative to confirm that the effects found are not due to cytotoxicity to the cell line.

Works Cited

1. Issemann, I. and S. Green, *Activation of a member of the steroid hormone receptor superfamily by peroxisome proliferators.* Nature, 1990. **347**(6294): p. 645-50.
2. Burk, P.G., et al., *Xeroderma pigmentosum and D. N. A. repair.* Lancet, 1971. **1**(7699): p. 601.
3. Michalik, L., B. Desvergne, and W. Wahli, *Peroxisome-proliferator-activated receptors and cancers: complex stories.* Nat Rev Cancer, 2004. **4**(1): p. 61-70.
4. Staels, B. and J.C. Fruchart, *Therapeutic roles of peroxisome proliferator-activated receptor agonists.* Diabetes, 2005. **54**(8): p. 2460-70.
5. Burdick, A.D., et al., *The role of peroxisome proliferator-activated receptor-beta/delta in epithelial cell growth and differentiation.* Cell Signal, 2006. **18**(1): p. 9-20.
6. Park, B.H., B. Vogelstein, and K.W. Kinzler, *Genetic disruption of PPARδ decreases the tumorigenicity of human colon cancer cells.* Proc Natl Acad Sci U S A, 2001. **98**(5): p. 2598-2603.
7. Stephen, R.L., et al., *Activation of peroxisome proliferator-activated receptor delta stimulates the proliferation of human breast and prostate cancer cell lines.* Cancer Res, 2004. **64**(9): p. 3162-70.
8. Glinghammar, B., et al., *PPARdelta activation induces COX-2 gene expression and cell proliferation in human hepatocellular carcinoma cells.* Biochem Biophys Res Commun, 2003. **308**(2): p. 361-8.
9. Peters, J.M., et al., *Growth, adipose, brain and skin alterations resulting from targeted disruption of the mouse peroxisome proliferator-activated receptor β(δ).* Molecular and Cellular Biology, 2000. **20**: p. 5119-5128.
10. Kim, D.J., et al., *PPARbeta/delta selectively induces differentiation and inhibits cell proliferation.* Cell Death Differ, 2006. **13**(1): p. 53-60.
11. Kim, D.J., et al., *Peroxisome proliferator-activated receptor-beta/delta inhibits epidermal cell proliferation by down-regulation of kinase activity.* J Biol Chem, 2005. **280**(10): p. 9519-27.
12. Schmuth, M., et al., *Peroxisome proliferator-activated receptor (PPAR)-beta/delta stimulates differentiation and lipid accumulation in keratinocytes.* J Invest Dermatol, 2004. **122**(4): p. 971-83.
13. Westergaard, M., et al., *Modulation of keratinocyte gene expression and differentiation by PPAR-selective ligands and tetradecylthioacetic acid.* J Invest Dermatol, 2001. **116**(5): p. 702-12.
14. Fukumoto, K., et al., *Peroxisome proliferator-activated receptor delta as a molecular target to regulate lung cancer cell growth.* FEBS Lett, 2005. **579**(17): p. 3829-36.
15. Aung, C.S., et al., *Isoform specific changes in PPAR alpha and beta in colon and breast cancer with differentiation.* Biochem Biophys Res Commun, 2006. **340**(2): p. 656-60.
16. Marin, H.E., et al., *Ligand activation of peroxisome proliferator-activated receptor beta inhibits colon carcinogenesis.* Cancer Res, 2006. **66**(8): p. 4394-401.
17. Luquet, S., et al., *Roles of PPAR delta in lipid absorption and metabolism: a new target for the treatment of type 2 diabetes.* Biochim Biophys Acta, 2005. **1740**(2): p. 313-7.
18. Leibowitz, M.D., et al., *Activation of PPARdelta alters lipid metabolism in db/db mice.* FEBS Lett, 2000. **473**(3): p. 333-6.

19. Lee, C.H., et al., *Peroxisome proliferator-activated receptor delta promotes very low-density lipoprotein-derived fatty acid catabolism in the macrophage.* Proc Natl Acad Sci U S A, 2006. **103**(7): p. 2434-9.
20. Tanaka, T., et al., *Activation of peroxisome proliferator-activated receptor delta induces fatty acid beta-oxidation in skeletal muscle and attenuates metabolic syndrome.* Proc Natl Acad Sci U S A, 2003. **100**(26): p. 15924-9.
21. Chevillotte, E., et al., *The regulation of uncoupling protein-2 gene expression by omega-6 polyunsaturated fatty acids in human skeletal muscle cells involves multiple pathways, including the nuclear receptor peroxisome proliferator-activated receptor beta.* J Biol Chem, 2001. **276**(14): p. 10853-60.

The Effects of Video Games on Perceptions of Legitimacy for Aggressive Sport Behavior

Robert Ksiazkiewicz, McNair Scholar, Penn State University

David Conroy PhD
Associate Professor of Kinesiology
College of Health and Human Development
Penn State University

Abstract

Recent studies have investigated links between media and violence. Whereas most research has focused on the cumulative (i.e., long term) effects of media on aggression, few have examined the acute (i.e., short term) effects of media on aggression. This study investigated whether interactive video games that reward violence increase perceptions that aggressive sport behavior is acceptable. Male participants were randomly assigned to play one of three video games: a non-contact game (World Championship Poker™), a contact sport game that punishes participants for aggressive acts (Madden 2006™), or a contact sport game that rewards participants for aggressive acts (Blitz: The League™). Hierarchical multiple regression analyses revealed that none of these games led to changes in perceptions of legitimacy.

The Effects of Video Games on Perceptions of For Aggressive Sport Behavior

A week after the school shootings in Littleton, Colorado, Senator Sam Brownback, presented a speech to his fellow Senate members. In this speech, he discussed the need for U.S. Senate to convene special committee hearings on the effects of video games on children. He stated, "The video game industry has received far less attention than television or movies, but is among the fastest-growing entertainment media (Brownback, 1999)." This call for attention was followed a week later by a hearing in the Senate Committee on Commerce, which examined the marketing of violent video games to children. In recent years, there have been other hearings to examine video games, and their effect on children. One recurring topic is the effects of aggressive video games on children and young adults. The short-term effects of video games have been of particular because of their potential for serious long-term consequences.

The need for special hearings of the United States Senate points to the much larger social problem. Media greatly influences our everyday lives. Ninety-eight percent of homes in the United States own a Television (Nielson Media Research, 1998). The wide-spread availability of television allows everyone in the United States access to some media exposure. The average child is exposed to over 40 hours of media content a week included in that time children and adolescent play video games for almost 7 hours a week (Kaiser Family Foundation, 2005). Americans became concerned about the effects of video games in the late 1990s. The public outcry was in association with a rash of school shooting by avid video game players (Anderson, 2004). Both the public and the government wanted to know how video games influence children's thoughts and behavior.

Psychologists have recently started to examine media in much greater depth. Many competing views have been proposed on the effects of video games on aggression. These studies have focused on both long-term and short-term effects. The study of media exposure on short-term thoughts and behavior is divided into two distinct groups: passive and active exposure (Anderson *et al.*, 2003). *Passive media* constitutes the first type media exposure (e.g., television, film, and music). The person acts as an observer. They have no control in the actions presented on screen. They can only absorb these actions (Felson, 1996). In contrast, with *active media* (e.g., internet and video games), the person not only absorbs the violence, but also actively participates in the acts. The participant has the ability to control acts of aggression and rarely faces consequences for their aggressive actions. In some games, rewards will follow these aggressive acts (Funk, & Buchman, 1996). These rewards entice the participant to commit increasing acts of violence.

The best example of *active media* enticing players to act aggressively is the Grand Theft Auto™ franchise. In the game, the player has the ability to act as violently as they choose. The character is free to explore a fictitious city environment. This city provides the player with the ability to interact with almost thing in it. The person can talk to other characters, driver cars, and explore buildings. There is a dark side to this interaction. The player encounters many other characters, against whom the player can choose to commit random acts of violence. These random killings have no effect on the player's ability to win or lose the game. These acts of violence aid the player's ability to collect money and to buy better weapons (Frasca, 2003).

Video Games and Aggression

Many studies have focused on video games and aggression see Anderson *et al.* (2003) or Kirsch (2003). These studies examine both aggressive thoughts and behaviors. Violent video games have shown to effect subjects' aggressive behavior. After exposure to aggressive video games, participants behaved more aggressively than those participants who played non-aggressive video games (Anderson & Dill 2000; Irwin & Gross, 1995). Participants who were introduced to aggressive games were more likely to show higher levels of approval for aggressive actions (Calvert & Tan, 1994; Uhlmann & Swanson, 2003).

The mechanisms that cause violent video games to increase aggressive behavior are still not completely understood. There are theories, which provide a solid base for research. Social learning theory proposes observational learning of aggressive values and goals (Bandura, 1965; Bandura, Ross, & Ross, 1963). Bandura, Ross, and Ross (1963) found that children who were exposed to adults committing aggressive acts against a doll were more like to commit aggressive acts against the doll. The children were also more likely to mirror the type acts done by the adult. In a follow up study children were shown videos of the adult being punished or rewarded (Bandura, 1965). If the adult was rewarded, the child was more likely to act aggressively toward the doll.

More recent models propose that these mechanisms are not solely observationally learned but maybe automatic and nonconscious. Exposure to violent stimuli may trigger short-term aggressive motives (Bargh & Chartrand, 1999). This exposure does not only include real life interaction. Violent media may also lead to the priming of these aggressive thoughts and goals (Berkowitz, 1990). These aggressive thoughts and goals could lead to aggressive tendencies in certain individuals (Anderson, Benjamin & Bartholow 1998; Todorov & Bargh, 2002; Ferguson, & Bargh, 2003). Recent experimental studies have focused on the priming of automatic aggressive thoughts and behaviors. In the lab setting, participants have shown higher levels of aggressive behavior after being introduced to an aggressive video game than those who played non-aggressive games. This aggressive behavior maybe attributed to short-term priming effects from the games (Anderson, & Dill, 2000; Carnagey & Anderson 2005).

The present study has two primary purposes. First, the effect of exposure to aggressive-sport video games on perceptions of legitimacy of aggressive sport acts was examined. Participants who were exposed to the aggressive video game were expected to increase their perceptions of legitimacy for the aggressive actions. Second, different effects from games that rewards vs. punishment of aggressive acts were tested Participants punished for aggressive actions were not expected to show no significant change in their perceptions of legitimacy whereas participants rewarded for their aggressive actions were expected to increase their perceptions of legitimacy for the aggressive actions.

Methods

Participants

Participants were male college students ($N = 50$) from a large eastern university. Participants were randomly assigned to one of three conditions in which they played a video game that featured either: no opportunities for aggression (Poker; $n = 16$), was punished for aggressive behavior (Madden; $n = 17$), or rewarded for aggressive behavior (Blitz; $n = 17$). Participants ranged from 18 to 24 years ($M = 20.48$ $SD = 2.04$). White/Caucasians comprised 66% of the sample. African American/Blacks comprised 14% of the sample. Asian-Americans comprised 8% of the sample. Hispanics comprised 4% of the sample. Other responses included other (6%), and missing data (2%). Participants included seniors (48%), freshman (32%), juniors (10%), sophomores (6%), and graduate students (4%).

Instruments

Participants completed a pre-game questionnaire which included demographic questions, the Aggression Questionnaire (Buss & Perry, 1992) and three scenarios from the Sports Behavior Inventory (SBI; Conroy *et al.,* 2001). A post-game questionnaire was also completed which included three additional scenarios from the Sports Behavior Inventory. The Aggression Questionnaire is a 29-item questionnaire. It has four scales: verbal aggression, physical aggression, anger, and hostility. All of these scales have proved to have acceptable psychometric properties. The participants responded on a five-point likert type scale ranging from 1 (*extremely uncharacteristic of me*) to 5 (*extremely characteristic of me*). Due to an administrative oversight item 16 from the Aggression Questionnaire was not included.

The SBI provides a measure of perceptions of legitimacy of aggressive sport behavior. Both the pre-game and post-game questionnaire included one scenario from a basketball, football, and soccer situation. These scenarios portray aggressive, rule-violating behavior. The participants could respond on an eight-point scale ranging from 1 (*Never OK*) to 8 (*Always OK*). Conroy *et al.* (2001) found that the SBI may provide a sound structural validity in measuring participants' perceptions of legitimacy of aggressive sport behavior. Conroy *et al.* also found perceived legitimacy scores as measured by the SBI were related to physical aggression scores as measured by the Aggression Questionnaire. See Table 1 for internal consistency of the SBI and physical aggression scale.

Procedures

Each participant completed a pre-game questionnaire. Participants were randomly-assigned to a video game condition and provided with a brief introduction to the game the participant before play began. Participants times were recorded by the researcher: World Championship Poker™ (M = 25.00 SD = 0.00), Madden 2006™ (M = 24.12 SD = 2.45), Blitz: The League ™ (M = 22.48 SD = 2.15). After playing the game, participants completed the post-game questionnaire. Upon completion of questionnaires, the researcher conducted a debriefing to gauge the participant's awareness of the purpose of the study. Participants received a gift certificate for one ice cream cone upon completion of the study.

Equipment

The console used in this experiment was a Sony Playstation II game system. Participants were exposed to one of three possible conditions. Blitz: The League ™ is a video game, which allows the participant to commit aggressive acts. The game does not enforce penalties and the participant does not experience an adverse consequence for committing an unsportsmanlike act. This game passively rewards the participants for committing unsportsmanlike conduct. Participants were asked to watch a quick instructional video on how to use the "dirty hit" control. The dirty hit button allows the participant to damage the health or injure the opposing team's players. The participant will also receive "clash icon" for each dirty hit. Once a certain amount are obtained the player becomes almost invincible, and the likelihood of inflicting an injury to their opponent rises dramatically. They then played an entire game of four two-minute quarters.

Madden 2006™ is a football game that simulates the National Football League. The game enforces penalties and these penalties create consequences for unsportsmanlike actions (i.e., breaking rules hinders the participant chances of winning). The participant watched a short video on a new passing feature in Madden 2006™ and then played two five-minute quarters.

World Championship Poker™ simulates tournament style Texas Hold'em. Participants did not watch an introductory video. Participants participated in the tournament for twenty-five minutes.

Results

Descriptive Statistics

Table one presents descriptive statistics for SBI and Aggression Questionnaire scores. Participants reported having little experience with World Championship Poker™ (M = 0.40 months, SD = 2.01) and only slightly more experience with other poker games (M = 0.68 months, SD = 2.07). Participants reported having played Madden 2006™ an average of 3 months (SD = 4.34). Participants reported having played Blitz: the League™ considerably less then Madden 2006™ (M = 0.44 months, SD =1.86). Other football games were played in varying amounts (M = 26.77 months, SD = 50.24). Participants reported having played video games in a drastically varying amounts (M = 84.96 months, SD = 74.58). Collision sports included lacrosse, ice hockey, and football (M = 4.27 season, SD = 5.06). Contact sports included basketball and soccer (M = 6.56 seasons, SD = 7.78). Non-contact sports included tennis, volleyball, golf, track, and bowling (M = 4.38 seasons, SD = 4.18).

The pre-game SBI scores were parceled and averaged for each of the three scenarios (Conroy *et al*., 2001). The internal consistency of each of the SBI responses was then determined. Responses to the pre-game and post-game questionnaires had high internal consistency (α = .94 and .93) respectively. The internal consistency coefficient (Cronbach alpha) for physical aggression was .76.

Data Analysis

A hierarchical multiple regression tested whether changes in SBI scores could be predicted by either (a) football vs. poker, or (b) engagement in a football game that rewards vs. punishes aggression. Pre-game SBI scores were entered into the first step of the regression to predict post-game SBI scores; experimental condition contrasts were then entered in a second step. Results indicated that Perceived Legitimacy (pre-game) significantly predicted post-game scores (β = .3.47 p < .01); however, none of the planned contrasts between video game conditions were statically significant predictions (p > .05).

In a post-hoc of analyses collision (β = -.04), non-contact (β = -.60), and non-contact (β = -.18) sport experience failed to predict changes in SBI scores. Prior video games experience also failed to predict changes in SBI scores: Poker Video Games (β= -.00), Madden 2006™ (β= .05), Blitz (β = .03), and all video game experience (β= -.11). Physical aggression cores marginally predicted post-game scores (β= -.15 p = .05).

Discussion

This study examined the effect of video games on perceptions of legitimacy of aggressive sport behavior Although it was hypothesized that participants' perceptions of legitimacy would change as a result of playing one of three video games that varied with respect to aggressiveness, results did not indicate any significant change due to experimental condition. After playing the video games, participants who played the collision sport related games (Blitz: The League™ & Madden 2006™) did not report higher levels of perceived legitimacy than those who played a control video game (World Championship Poker™). It was also hypothesized that participants that played a collision sport game that rewarded aggressive acts (Blitz: The League™) would report higher levels of perceived legitimacy than those who played a sport game that punished aggressive acts (Madden 2006™). Results did not indicate a significant difference between those that played Blitz: The League™ and those that played Madden 2006™.

There were two statistically significant predictors of post-game SBI scores. Pre-game SBI scores predicted post-game SBI scores. This findings indicated that SBI scores were reliable and resistant somewhat to change. Physical aggression scores demonstrated a marginal significance in determining post-game SBI scores. Post-hoc analyses of sport and video game experience did not find any indication of a significant relationship to post-game SBI scores. Participants' sport experience did not predict post-game perceptions of legitimacy. These results differed from previous findings; Conroy *et al.* (2001) found that participants with contact sport experience indicated higher levels of perceived of legitimacy. Results indicated that previous video game experience did not effect perceptions of legitimacy. In other studies, video game experience has exhibited an effect on participants' aggressive cognitions (Anderson & Dill, 2000; Uhlmann & Swanson, 2003).

These results are an anomaly in light of findings from previous research. (Anderson, 2004). Previous research has suggested that there is a relationship between aggressive cognitions and exposure to aggressive video games (Calvert & Tan, 1994; Uhlmann & Swanson, 2003; Anderson, & Dill, 2000; Carnagey & Anderson 2005). For a more complete review of video games and aggression readers are referred to either Anderson *et al.* (2003) or Kirsch (2003).

One reasons for the lack of support for the hypothesis might have stemmed from statistical power limitations of the study that were a result of a limited sample size. Due to time constraints, only 50 participants completed the study. This sample size does not provide adequate power to detect medium-sized effects at the conventional $p = .05$. Only large effects ($d = .80$) would be detectable (Cohen, 1988). The effect size of this study was .22; with n = 50 and a conventional $p = .05$, the power of this study would be .29. The effect size points towards this studying being underpowered. In order to obtain adequate power, a minimum of 78 participants would be needed to find a large effect size (.80).

This study is one of a limited number of studies that examine the effects of video games on aggression. More research on video games effect on perceptions of legitimacy of aggressive behavior is needed. Future studies should examine reward vs. punishment of aggressive acts. To date, only this study and Carnegy and Anderson (2005) have examined reward vs. punishment in video games. Almost all violent video games either directly or indirectly reward aggressive acts. In Blitz: The League™, players receive many direct rewards for these aggressive acts (e.g., clash icons, verbal praise, and possession of the football).

The reward of useful items, verbal praise, and advancement of levels are also common direct rewards found in video games. These direct rewards actively promote the aggressive act. Indirect rewards include intriguing visuals and sound effects. They might not actively promote the action, but they happen simultaneously or immediately after the action. Indirect rewards may also encourage players to act more aggressively. The future research should examine the effects of both direct and indirect rewards on participants' aggressive thoughts and behavior. Even though this study was unable to find significant results; the need for video game research is still pertinent to issues effecting children and adolescents.

References

Anderson, C.A. (2004). An update on the effects of playing violent video games. *Journal of Adolescence*, *27,* 113-122.

Anderson, C.A., Benjamin, A.J., & Bartholow, B.D. (1998). Does the gun pull the trigger? Automatic priming effects of weapon pictures and weapon names. *Psychological Science, 9,* 308-314.

Anderson, C.A., Berkowitz, L., Donnerstein, E., Huesmann, L.R., Johnson, J.D., Linz, D., et al. (2003). The influence of media violence on youth. *Psychological Science in the Public Interest*, *4*, 83-110.

Anderson, C.A., & Bushman, B.J. (2001). Media and the American Public. *American Psychologist, 56*, 477-489.

Anderson, C.A. & Dill, K.E. (2000). Video games and aggressive thoughts, feelings, and behavior in the laboratory and in life. *Journal of Personality and Social Psychology*, *78,* 772-790.

Bandura, A. (1965). Influence of models' reinforcement contingencies on the acquisition of imitative responses. *Journal of Personality and Social Psychology, 6,* 589-595.

Bandura, A., Ross, D., & Ross, S.A. (1963). Imitation of film-mediated aggressive models. *Journal of Abnormal and Social Psychology, 66*, 3-11.

Bargh, J.A., & Chartrand, T.L. (1999). The unbearable automaticity of being. *American Psychologist, 54,* 462-479. *American Psychologist, 45,* 494-503.

Berkowitz, L. (1990). On the formation and regulation of anger and aggression. A cognitive-neoassocationistic analysis. *American Psychologist, 45*, 494-503.

Brownback criticizes violent video games aimed at kids. (1999). Retrieved August 4, 2006 from http://brownback.senate.gov/pressapp/record.cfm?id=175689&

Buss, A.H., & Perry, M. (1992). The Aggression Questionnaire. *Journal of Personality and Social Psychology*, *63,* 452-459.

Calvert, S.L., & Tan, S. (1994). Impact of virtual reality on young adults' physiological arousal and aggressive thoughts: interaction versus observation. *Journal of Applied Developmental Psychology, 15,* 125-139.

Carnagey, N.L., & Anderson, C.A. (2005). The effects of reward and punishment in violent video games on aggressive affect, cognition, and behavior. *Psychological Science, 16,* 882-889.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Hillsdale, New Jersey: Erlbaum.

Conroy, D.E., Silva, J.M., Newcomer R.R., Walker, B.W., & Johnson, M.S. (2001). Personal and participatory socializers of the perceived legitimacy of aggressive behavior in sport. *Aggressive Behavior*, *27*, 405-418.

Felson, R.B. (1996). Mass media effects on violent behavior. *Annual Review of Sociology, 22, 103-128.*

Ferguson, M.J., & Bargh, J.A. (2003). How social perception can automatically influence behavior. *Trends in Cognitive Sciences, 8*, 33-39

Feshbach, S., & Singer, R.D. (1971). *Television and aggression*. San Francisco: Jossey-Bass.

Frasca, G. (2003). Sim sin city: some thoughts about grand theft auto 3. *Game Studies, 3,* Retrieved July 14, 2006, from http://www.gamestudies.org/0302/frasca/

Funk, J.B. & Buchman, D.D. (1996). Playing Violent Video and Computer Games and Adolescent Self-concept. *The Journal of Communication, 46*, 19-32

Huesmann, L.R. (1988). An information processing model for the development of aggression. *Aggressive Behavior, 14*, 13-24.

Huesmann, L.R. (1998). The role of social information processing and cognitive schemas in the acquisition of maintenance of habitual aggressive behavior. In R.G. Green & E. Donnerstein (Eds.), *Human aggression: Theories, research, and implications for social policy* (pp. 73-109). New York: Academic Press.

Irwin, A.R., & Gross, A.M. (1995). Cognitive tempo, violent video games, and aggressive behavior in young boys. *Journal of Family Violence, 10,* 337-350.

Kaiser Family Foundation. (2005). *Generation M: Media in the lives of 8-18 Year-olds*. Menlo Park, Ca: Author.

Kirsch, S.J. (2003). The effects of violent video games on adolescent the overlooked influence of development. *Aggression and Violent Behavior, 8,* 377-389.

Nielsen Media Research. (1998). *Galaxy explorer*. New York: Author.

Todorov, A., & Bargh, J.A. (2002). Automatic sources of aggression. *Aggression and Violent Behavior, 7,* 53-68.

Uhlman, E. & Swanson, J. (2004). Exposure to violent video game increases automatic aggressiveness. *Journal of Adolescence, 27*, 41-52.

Table 1
Descriptive Statistics for Aggression Questionnaire, pre-game, and post-game SBI

Scale	N	*M*	*SD*	α
Aggression Questionnaire				
Physical Aggression	50	2.50	0.76	.76
Hostility	50	2.86	0.76	.74
Verbal Aggression	50	3.18	1.10	.66
Anger	50	2.25	0.58	.60
SBI Scores				
Perceived Legitimacy (pre-game)	50	2.60	1.22	.94
Perceived Legitimacy (post-game)	50	1.97	1.22	.93

Table 2
Summary of hierarchical Regression analysis for Variables Predicating Post-Game levels of Perceived Legitimacy

Variable	B	SE B	β
Step 1			
Pre-Game SBI	3.47	.59	.00**
Step 2			
Physical Aggression	-.14	.14	.07*
Rewards Aggression or No Reward	-.27	.21	.21

** $p < .01$
* $p < .05$

Sex Differences in Depression in Patients with Multiple Sclerosis

Andrae J. Laws, McNair Scholar, Penn State University

Faculty Research Advisor
Dr. Peter A. Arnett, Associate Professor of Psychology
The College of Liberal Arts
Penn State University

Abstract

Multiple Sclerosis (MS) is a demyelinating disorder of the central nervous system. Approximately 50% of MS patients experience clinical depression at some point during their lifetime, a rate that far exceeds what is found in the general population. This study examined sex differences in depression in 80 female and 17 male MS patients. The following four inventories for measuring depression were used: The Beck Depression Inventory-2 (BDI-2), Beck Depression Inventory- Fast Screen (BDI-Fast Screen), Depression Proneness Rating Scale (DPRS), and the Chicago Multiscale Depression Inventory (CMDI). A statistical trend ($p < .10$) was found for male patients to show greater depression proneness than female patients. Males also showed significantly ($p < .05$) greater use of avoidance coping strategies compared with females. Because avoidance coping has been found to be maladaptive in MS patients and associated with depression, greater use of avoidance coping in males may underlie their differential proneness to depression.

Introduction

Many individuals with MS experience a secondary consequence of the disease—depression. Fifty percent of MS patients experience clinical depression at some point during their lifetime, a rate that far exceeds the 10-15% found in the general population (American Psychiatric Association, 1994; Sadovnik et al., 1996). There is an abundance of literature covering cognitive functioning and depression in individuals with MS. However, there is very little literature covering sex differences in patients with MS. The purpose of this study was to investigate whether there are sex differences in depression in MS patients.

In one of the few studies examining sex differences and depression in MS, Hickey and Greene (Hickey & Greene, 1989) found no significant differences between men and women with MS in depression as measured by The Focus of Coping Scale. Men and women with MS were not different on The Hopelessness Scale. However, men and women were found to have a mean depression and hopelessness score above the general population. One limitation of their study, however, is that the sample size of 45 (22 males and 23 females) was somewhat small and thus possibly not large enough to be representative for the MS population or to have adequate statistical power. Another limitation of this study was its lack of a homogeneous sample. Hickey and Greene point

out in their study a large variation of scores obtained for males and females (Hickey & Greene, 1989). This variation could be a result of the diversity of physical symptoms in the patients within their study. Hickey and Greene (Hickey & Greene, 1989) also point out that a patient who has had a longer remission may be less psychologically traumatized than a patient who has had frequent relapses. In fact, Randolph and Arnett (Randolph & Arnett, 2005) found that relapsing-remitting patients with a history of more variability in symptoms were more likely to be depressed than patients with less variability.

In a study examining the prevalence and correlates of depression among veterans with MS, Williams and colleagues (Williams et al., 2005) administered a self-report measure of depression to 451 participants, 86.6% of whom were males. The Patient Health Questionnaire is an abbreviated version of the Primary Care Evaluation of Mental Disorders, which is designed to give diagnoses of high prevalence psychiatric disorders, was one of the measurements used for this study (Williams et al., 2005). Williams and colleagues found that males and females with MS had equivalent rates of depression. Although males and females with MS were shown to have similar rates of depression, when compared to the general population females exceeded males with having higher rates of depression. According to the Diagnostic and Statistical Manual of Mental Disorder-4th Edition (DSM-IV), major depressive disorder is twice as common in adolescent and adult females as in adolescent and adult males (American Psychiatric Association, 1994). The DSM-IV features for major depressive disorder supports the results found in the study by Williams and colleagues (Williams et al., 2005).

Related to depression, some research has examined sex differences on locus of control (Hickey & Greene, 1989). Locus of control reflects the internal or external characteristics of a person's personality or strategy for coping. Using the Multidimensional Health Locus of Control Scale to measure locus of control, Hickey and Greene found that men with MS had statistically significant higher scores (X^2=6.9, $p<.01$) on the powerful health locus of control (PHLC) subscale than women with MS (Hickey & Greene, 1989). This subscale reflects the extent to which patients feel they have control over health-related issues.

Also related to depression is coping, in that adaptive coping in response to stress is associated with low levels of depression whereas maladaptive coping is associated with high levels. Coping and stress theorists have identified two broad forms of coping—problem-focused and emotion-focused. Lazarus (Lazarus, 1993) noted that people who use problem-focused coping strategies attempt to alter the source of their stress, whereas people who use emotion-focused coping strategies attempt to reduce the emotional distress of their situation. Within the literature on coping, depression has been associated as a major factor. In particular, the literature has shown that emotion-focused coping is associated with high levels of depression, whereas problem-focused coping is associated with lower levels of depression (Revenson & Felton, 1989; Thompson, Gil, Abrams, & Phillips, 1992).

Although the problem-focused and emotion-focused conceptualizations of coping have proven to be useful constructs, Carver and colleagues (Carver, Scheier, & Weintrub, 1989) found that these conceptualizations were too broad. In particular, they found that the subscales comprising these broad coping factors were often not correlated or even sometimes inversely correlated with one another. In response to such limitations they

provided a narrower, though more unitary conceptualization of these coping domains to capture a better representation of coping—avoidance and active scales (Carver, Scheier, & Weintraub, 1989). Carver and colleagues (Carver, Scheirer, & Weintraub, 1989) found that the avoidance coping scales were related to less adaptive responses such as anxiety and depression, whereas active coping scales were related to more desirable personality qualities such as self-esteem and optimism. In a study examining depression with MS patients, Arnett and colleagues (Arnett, Higginson, Voss, & Randolph, 2002) used the Chicago Multiscale Depression Inventory (CMDI) Mood and Evaluative scales and found that a greater use of avoidance coping and less use of active coping were associated with high levels of depression. Arnett and colleagues' (Arnett, Higginson, Voss, & Randolph, 2002) study illustrates that the active and avoidance scales may be better indices for measuring coping in MS.

As an aside to the present focus on depression and coping in MS, research in biological psychology has found sex differences in men and women in diseases and health. Research by Kudielka and Kirschbaum (Kudielka & Kirschbaum, 2005) suggests that the hypothalamic-pituitary-adrenal (HPA) axis may be responsible for the variability in diseases in men and women. The HPA axis is located in the CNS and is responsible for regulating hormones in this region—mostly triggered by stress (Kudielka & Kirschbaum, 2005). According to these investigators, major depression is often found to be associated with hyperactivity in the HPA in men and hyporeactivity is associated with MS and often found to be associated with depression in women.

With these considerations in mind, the current study was conducted to further explore possible sex differences in depression in MS. Given the well-established association between coping and depression in MS and other populations, a secondary goal of the study was to examine possible sex differences in coping with the notion that such differences may underlie differences in depression in these patients. The present study improves upon past research by Anne Hickey and Sheila Greene's article *Coping with Multiple Sclerosis* (1989) in which they examined sex differences and coping in MS groups by using a larger overall sample and one in which there is likely to be greater variability in symptom manifestations. Because of the paucity of studies published in this area, the present study was exploratory and as such did not have specific hypotheses.

Methodology

Participants and Procedure

Participants for this study included 80 women and 17 men with MS. The participants were recruited for the PSU-MS1 study which was conducted by The Pennsylvania State University neuropsychology research lab. The Penn State neuropsychology lab recruited participants from an ad placed in a newsletter distributed to individuals with MS in Western Pennsylvania, MS support groups in Central Pennsylvania Region, and flyers distributed in the State College, Pennsylvania community. Those who contacted the study team were administered a telephone screening interview designed to review exclusionary criteria; participants who were not excluded from screening were then scheduled for testing. Participants who had a history of drug or alcohol abuse, neurological disease other than MS, learning disability, or

visual or motor impairment that significantly interfered with questionnaire and test completion were excluded from the study. Participants were administered a variety of measures assessing depression described below. After participating in this study, participants were given 75 dollars and a brief neuropsychological report of their cognitive functioning.

Measures

Chicago Multiscale Depression Inventory

The Chicago Multiscale Depression Inventory (CMDI) is a self-report measurement, which is designed to assess depression in MS groups. The CMDI is a 42-item Likert-style measure, which consists of three subscales: Mood, Evaluative, and Vegetative. The CMDI subscales each consists of 14 items and participants are then asked to rate themselves on a scale 1-5 to which each word or phase describes them during the past week, including today. A rating of "1" indicates "Not at All" and "5" indicates "Extremely". A high CMDI score thus indicated a higher level of depression. For this study the subscale "vegetative" was excluded from analysis because its characteristics closely resemble symptoms of MS, making interpretation of them vis-à-vis depression difficult.

Beck Depression Inventory

The Beck Depression Inventory-2 Edition (BDI-II) is a self-report measure assessing the severity of depression in adolescents and adults. Among psychiatric self-reported depression measures, the BDI-II is the most commonly used (Beck et al., 1996). It consists of 21 groups of statements on which participants rate themselves on a 0-3 scale. Participants are asked to pick the one statement which best describes the way they have been feeling the past two weeks, including today. A high BDI-II score indicated a higher level of depression. All 21 items were used in this study.

Beck Depression Inventory-Fast Screen for Medical Patients

The Beck Depression Inventory-Fast Screen for Medical Patients (BDI-Fast Screen) is a self-report measure assessing the severity of depression in adolescents and adults. The BDI-Fast Screen consists of 7-items extracted from the BDI-II. The BDI-Fast Screen identifies symptoms of depression in patients reporting somatic and behavioral symptoms. It does not include the latter symptoms because of their overlap with a variety of common medical symptoms. A high BDI-Fast Screen score indicated a high level of depression. All 7-items were used in this study.

Depression-Proneness Rating Scales

The Depression-Proneness Rating Scales (DPRS) is a two factor self-report measure assessing depression proneness. The first self-report index of the DPRS has three questions: (1) "Compared to most people you know, how often did you get depressed?" (2) "Compared to most people you know, how long did your depressions last?" and (3) "Compared to most people you know, how deeply depressed did you become?" Each question is followed by the parenthetical phrase "over the past 2 years". The index has a seven-point scale which lists descriptors "much less often" (1), "about

the same" (4), and "much more often" (7). The total score on the first DPRS index is the sum of the three scale scores. The first DPRS index could thus range from 3 (low depression-proneness) to 21 (high depression-proneness). All items were used in this study.

The second self-report index of depression proneness consists of 10 of the most frequently assessed symptoms of depression and also asks examinees to rate on the same scale of 1-7 the extent to which each symptom describes their feelings or attitude over the past few years. The total score on this DPRS index is the sum of the 10 scale scores. The DPRS scores for this index could thus range from 10 (low depression prone) to 70 (high depression prone). For the present study, the two DPRS indices were combined to form a total score, which was analyzed.

COPE

The COPE is a 52-item scale designed to measure coping styles used in response to stressful events. The COPE is divided into 4-item clusters consisting of 13 scales. The COPE can be used to measure situational and dispositional coping tendencies. For the present study, situational tendencies were evaluated by creating a stressful scenario relating to MS that participants were asked to imagine themselves experiencing and then responding to the COPE items with this particular situation in mind. Following an approach suggested by Carver and colleagues (Carver, Scheier, & Weintrub, 1989), the COPE inventory was divided into adaptive (Active Coping) and maladaptive (Avoidance Coping) scales. The Active Coping index included subscales for Active Coping, Planning, and Suppression of Competing Activities. The Avoidance Coping index included the subscales Mental Disengagement, Behavioral Disengagement, and Denial.

Results

The statistical analyses used for this study were performed using SPSS computer software. The first statistical analysis performed evaluated participants' demographic data (table 1) using t-tests to compare the means and standard deviation for males and females.

Table 1

Means and Standard Deviations of Participant Demographics.

Males	Mean	Std. Dev.	**Females**	Mean	Std. Dev.	t-value	p-value
Age	44.82	7.812	Age	47.88	9.131	-1.281	.203
Education	14.53	2.452	Education	14.23	1.922	.564	.574
WAIS-R IQ	101.0000	11.34681	WAIS-R IQ	105.0625	9.30271	-1.572	.119
Symptom Duration	11.4706	7.53424	Symptom Duration	15.5000	8.88178	-1.740	.085
Diagnosis Duration	9.1176	7.99126	Diagnosis Duration	11.2125	7.78459	-1.003	.318

As seen in table 1, males and females had relatively similar means on all demographic variables, an observation supported by the lack of significant differences between sexes on any of the demographic variables.

The second set of statistical analyses performed compared the means for males and females on the depression inventories using t-tests. Table 2 shows the means and standard deviations for males and females on the depression inventories, in addition to the t-tests performed for the inventories, specifically comparing the means of males and females.

Table 2

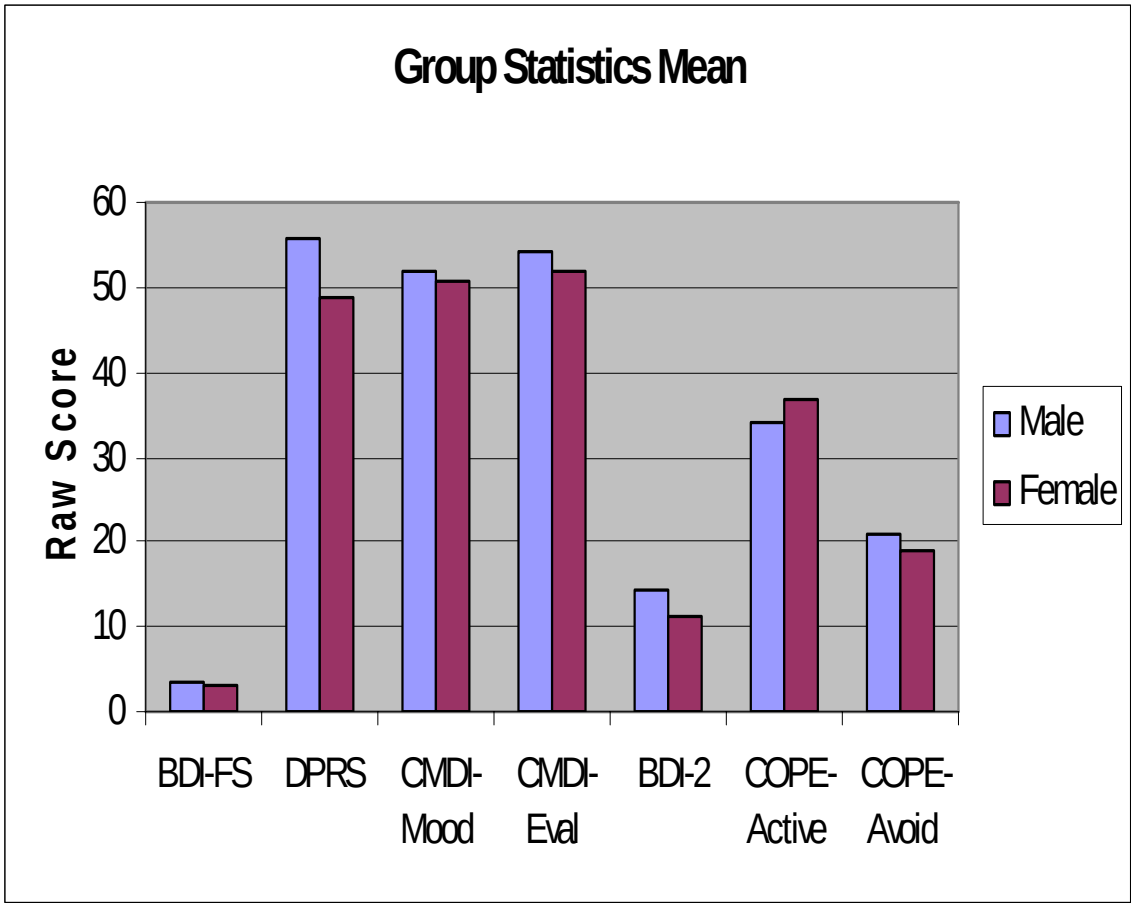
Mean and Standard Deviation of depression inventories.

Males	Mean	Std. Dev.	**Females**	Mean	Std. Dev.	t-value	p-value
BDI- Fast Screen	3.5294	3.20386	BDI-Fast Screen	2.9750	2.59002	.768	.444
DPRS	55.6875	14.00818	DPRS	48.6375	13.61611	1.882	.063
CMDI-Mood	51.7154	11.95262	CMDI-Mood	50.5756	10.09435	.409	.683
CMDI- Evaluative	54.3728	18.22228	CMDI- Evaluative	51.6843	13.58960	.696	.488
BDI-2	14.2941	9.37260	BDI-2	11.3125	6.65914	1.553	.124
COPE- Active Coping Index	34.2353	5.86866	COPE- Active Coping Index	36.7875	5.43009	-1.736	.086
Cope- Avoidance Coping Index	21.0588	5.47118	Cope- Avoidance Coping Index	18.8875	3.71447	2.001	.048

Of the seven inventories analyzed, the BDI-Fast Screen (.444), BDI-2 (.124), CMDI-Mood and CMDI-Evaluative scales, as well as both BDI scales, were statistically non-significant, with p-values > .10. However, there were statistical trends found for the DPRS ($p = .063$) and the COPE-Active ($p = .086$). Furthermore, the COPE-Avoid (.048) was statistically significant ($p < .05$). To have a better understanding of the depression inventory mean comparison for males and females I have provided a figure (bar graph) below which depicts the difference further.

Figure 1

Bar graph of Depression Inventory Means.



In regards to figure 1, it can be seen that on the DPRS, male patients showed a greater depression proneness level than female patients. On the COPE-Avoidance and COPE-Active it can be seen that males also showed a significantly greater use of avoidance coping strategies and the use of fewer active strategies compared with females. Because avoidance coping has been found to be maladaptive in MS patients and associated with depression, greater use of avoidance coping in males may underlie their differential proneness to depression. Furthermore, less use of more adaptive active coping strategies may also increase males' proneness to depression.

Discussion

The purpose of the present study was to investigate whether there are sex differences in depression in MS patients. This study was exploratory and as such did not have specific hypotheses. The results indicate that male MS patients showed a tendency toward greater depression proneness than females based on DPRS scores. Furthermore, males showed greater use of avoidance coping strategies and a trend toward fewer active coping strategies than females on the COPE Active and Avoidance scales. Hickey and Greene (Hickey & Greene, 1989) examined sex differences in MS patients and found no differences between men and women. One explanation for the inconsistent results in Hickey and Greene (Hickey & Greene, 1989) study and my study may stem from the different coping measures used. Hickey and Greene used the problem-focused and emotion-focused coping scales, whereas I used the COPE active and avoidance coping scales. As noted earlier, Carver and colleagues (Carver, Scheier, & Weintrub, 1989) found that problem-focused and emotion-focused scales were too broad and sometimes not psychometrically sound. In particular, they found that the subscales comprising these broad coping factors were often not correlated or even sometimes inversely correlated with one another.

Consistent with Carver and colleagues' (Carver, Scheier, & Weintrub, 1989) findings, males in my study were found to use greater avoidance coping strategies and were found to have a high level of depression. Because avoidance coping has been found to be maladaptive in MS patients and associated with depression, males greater use of avoidance coping may underlie their differential proneness to depression.

Of the seven inventories measured, five depression inventories and two coping inventories, only three were found to be statistically significant or trending toward significance—DPRS ($p<.063$), COPE-Active ($p<.086$) and COPE Avoidance ($p<.048$). Furthermore, of the three inventories found to be statistically significant, only one was a depression inventory—the DPRS. In a future study, I plan to conduct another SPSS t-test on the DPRS and examine its two factor measures separately. I hope to explain why the DPRS was the only significant depression inventory and explore the difference between the DPRS and the other depression measures.

The results for the current study are significant for MS treatment because they may imply that differences between men and women do exist in regards to depression and coping styles. My results are also significant because they could help in improving future treatment of depression in MS, such as creating clinical therapy methods for effectively treating men and women and teaching men and women with MS effective coping strategies.

An important limitation of the current study is the small number of males used. A future study should include an increased sample size with relatively equal number of male and female participants.

To summarize, the results suggest that male MS patients show greater depression proneness than females and that males show a greater use of avoidance coping strategies and fewer active coping strategies than females. The present study may help in our understanding of depression in MS. Again, my findings are significant for MS treatment because they imply a difference between men and women in regards to depression and coping styles, and my results improves upon the literature and treatment of clinical methods for MS patients. The results also suggest a possible mechanism underlying the sex differences in depression proneness, in that the latter may be mediated by relatively poorer coping strategies employed by male MS patients in response to stress. Differentially focusing treatment on helping male MS patients improve their coping strategies may help them to decrease their future likelihood of depression and, ultimately, improve their quality of life while living with what can be a devastating disease.

References

American Psychiatric Association. (1994). *Diagnostic and Statistical Manual of Mental Disorders* (Fourth ed.). Washington, D.C.: American Psychiatric Association.

Arnett, P. A., Higginson, C. I., Voss, W.D. & Randolph, J. J. (2002). Relationship between coping, depression, and cognitive dysfunction in multiple sclerosis. *The Clinical Neuropsychologist,* 16, 341-355.

Beck, A. T., Steer, R. A., & Brown, G. K. (1996). Beck Depression Inventory-2nd *edition manual.* New York: Psychological Corporation.

Carver, C. S., Scheier, M. F., & Weintraub, J. K. (1989). Assessing coping strategies: A theoretically based approach. *The Journal of Personality & Social Psychology,* 56, 267-283.

Hickey A. & Greene S. M. (1989). Coping with multiple sclerosis. *Irish Journal of Psychological Medicine,* 6, 118-124.

Kudielka, B. M., & Kirschbaum, C. (2005). Sex differences in HPA axis responses to stress: a review. *Biological Psychology.* 69. 113-132.

Lazarus, R. S. (1993). Coping theory and research: Past, present, and future. *Psychosomatic Medicine,* 55, 234-247.

Randolph, J. J., & Arnett, P. A. (2005). Depression and fatigue in relapsing-remitting MS: the role of symptomatic variability. *Multiple Sclerosis, 11,* 186-190.

Revenson, T. A., & Felton, B. J. (1989). Disability and coping predictors of psychological adjustment to rheumatoid arthritis. *Journal of Consulting and Clinical Psychology,* 57, 344-348.

Sadovnick, A. D., Remick, R. A., Allen, J., Swartz, E., Yee, I. M. L., Eisen, K., et al. (1996). Depression and multiple sclerosis. *Neurology.* 46, 628-632.

Thompson, R. J., Gil, K. M., Abrams, M. R., & Phillips, G. (1992). Stress, coping and psychological adjustment of adults with sickle cell disease. *Journal of Consulting & Clinical Psychology*, 60, 433-440.

Williams, R. M., Turner, A. P., Hatzakis, M. Jr., Bowen, J. D., Rodriquez, A. A., & Haselkorn, J. K. (2005). Prevalence and correlates of depression among veterans with multiple sclerosis. *Neurology*, 64, 75-80.

Conserved Linkage Groups and Rearrangements in Drosophila

Michael U. Mollenhauer, McNair Scholar, Virginia State University

Stephen W. Schaeffer, Ph.D.
Associate Professor of Biology
Biology Department
Penn State University

Abstract
Drosophila is an excellent model to investigate gene organization and the process of genomic rearrangement because it has a small genome size and genes tend to be conserved in the chromosomal location among species. Gene order differences were inferred in a comparison of the completed genomes of *Drosophila virilis* and *D. mojavensis* using *D. melanogaster* to determine derived rearrangements on the two lineages. The six chromosomes in the two species had 444 conserved gene order breakpoints that resulted from 264 inversions that estimate that each breakpoint was used 1.189 times. These data suggest that genomic rearrangements reuse breakpoints at a low to modest level.

Introduction

Sankaranarayanan (1979) examined the results of 1 million conceptions and examined the health of all these embryos. Fifteen percent of the embryos are spontaneously aborted due to a variety of genetic causes. Alterations in gene order account for 5,250 of the 150,000 spontaneous abortions observed in humans. Comparisons of gene order among different species may provide valuable insights into how genome rearrangements occur and potential mechanisms for their control.

Comparisons of complete genomes are elucidating the mechanisms that rearrange gene order among species (Coghlan *et al.* 2002; Coghlan and Wolfe, 2005; Richards *et al.* 2005). Genes within a genome are organized into units called chromosomes. The organization of genes on chromosomes can vary among species and can also differ in the order of genes. Synteny is defined as two or more genes that are found on the same chromosome in two or more species (Ehrlich *et al.* 1997). Conserved linkage groups have two or more syntenic genes that are in the same order in two or more species (Ehrlich et al 1997). Chromosomal inversions provide a mechanism that can alter the arrangement of genes on a chromosome. Inversions occur when the chromosome is broken at two locations on the chromosome and are rejoined in the opposite orientation, which reverses the order of genes (Figure 1) .

The genomes of *Drosophila* consist of six chromosomal arms that have been conserved over evolutionary time (Figure 2) (Muller, 1940). These genes within these six chromosomal arms are largely syntenic among species, however, gene order has been extensively shuffled (Ranz *et al.* 2001; Richards *et al.* 2005). The complete genomes of 12 species of Drosophila provide a model system for the study of the processes that alter gene order on the six chromosomes of the fly genomes. *Drosophila* is an excellent model to investigate gene organization and the process of genomic rearrangement because it has a small genome size (~200 Megabases) and genes tend to be conserved within chromosomal arms among diverse species. *Drosophila* are easily cultured in the laboratory, they have a short (10-14 day) generation time,

and there are many phenotypic changes that can be observed. Another advantage of using *Drosophila* is that it only has six chromosomes and 90% of the gene rearrangements occur within a chromosomal arm. Also, there are many biochemical and genetic techniques available to manipulate the genome to create changes, i.e. the ability to make transgenic animals.

This study examined the differences in gene order between *Drosophila virilis* and *Drosophila mojavensis* using *Drosophila melanogaster* as an outgroup to understand the mechanism of genome rearrangement, the most abundant being intrachromosomal inversions.

Materials and Methods

Genome Sequences and Assemblies. Agencourt Bioscience Corporation generated the *D. virilis* and *D. mojavensis* genomes with the whole genome shotgun method (Myers *et al.* 2000). A total of 3.6 million sequence reads were generated for *D. virilis* and 3.1 million reads for *D. mojavensis*. The sequence reads for the two species were assembled into sequence scaffolds using the ARACHNE assembler from the Whitehead/MIT Genome Center.

Orthologous Gene Calls. The 13,363 genes of *D.* melanogaster from release 3.0 were assigned a unique gene identifier beginning with the first gene on Muller A and proceeding sequential across the six chromosomes to Muller F (Figure 2). Each *D. melanogaster* gene sequence was used to identify orthologous genes in the assembled scaffolds with BLAST searches either BLASTN, which matches nucleotide sequences between the two genomes or TBLASTX, which matches the translated nucleotide sequences against the translated target species genome (Altshul *et al.* 1997). An E-value of 1×10^{-5} was used as the cutoff for the BLAST screen of the BLASTN and TBLASTX analyses. The best BLAST hit for each gene was concatenated into a Microsoft Excel spreadsheet for each chromosome/element. The sequence scaffolds were then assigned to 1 of the 6 chromosomes or Muller's elements based on majority rule in comparison to the *D.melanogaster* chromosomal assignment. The scaffolds within a chromosomal arm were ordered based on physical and genetic mapping data (*D. virilis* by Bryant McAllister at the University of Iowa; *D. mojavensis* by Luciana Matzkin at the University of Arizona).

Identification of Conserved Linkage Groups. Conserved linkage groups are a set of genes that are in the same order in two or more species. Genes found in only one species were removed from the analysis. These genes were not detected either because the species did not have the gene or the whole shotgun did not provide a sequence for the gene. The residual list of genes was assigned new identification numbers that reflect the gene order in the respective species. This list was used to identify conserved linkage groups and breakpoints. A conserved linkage group was composed of gene identifiers that were sequential. A break in gene identifier number that was greater than 2 units was identified as a conserved linkage breakpoint. A conserved linkage group with just a single gene could be due to a transposition event where a segment of DNA moved to a new location or could be a single gene at the boundary of two inversion events. A gene was considered a transposition if its two adjacent neighbors are each other's closest neighbor. All transposed genes were removed from the analysis of conserved linkage groups.

Linkage Chain Analysis. The *D. virilis* gene order was used as the standard for each chromosome and was compared to the gene order of *D. mojavensis*. Gene order was compared between the two species noting conserved linkage groups, where the gene order was the same between the two species, and conserved linkage breakpoints, where the gene order changed in *D.*

mojavensis relative to *D. virilis*. Each breakpoint was given a unique identifier such as BP_006_007_C, which indicates that the breakpoint is between conserved linkage groups 6 and 7 on Muller element C. The conserved linkage breakpoints can be linked together by following the gene order of genes at the boundaries. For instance, in Figure3B, the next gene in the sequence of BP_006_007 is predicted to be 672. This leads one to BP_005_006, which completes the linkage chain because the boundary genes at both breakpoints are the next genes in the sequence for original breakpoint. When matching breakpoint boundaries, be aware when the same breakpoint halves can occur in the same chain; they cannot be linked to one another (see Figure 3A).

The chain analysis was performed manually using an MS Excel spreadsheet or with the aid of Fortran program (S. W. Schaeffer, Penn State University). Linkage chains were represented by the set of breakpoints that form a complete chain. Each breakpoint showed the first and last gene identifier for the conserved linkage groups before and after the breakpoint. The linkage chain was completed when the gene order from one breakpoint to another comes back to the initial breakpoint in the chain (Figure 4).

The numerical paths of the conserved linkage groups were then checked for possible analysis problems. The gene orders could have been shuffled artificially either because the two or more genes had transcripts that overlapped or because related duplicate genes matched the same region of DNA. In both of these cases, the order of gene identifier numbers could have been artificially rearranged. In these cases, the artificial gene orders were corrected so that gene order was the same in the two species. Some single gene conserved linkage groups resulted from legitimate rearrangement events, but the next gene expected after the boundary was not obvious. In many cases, this was resolved by examining the neighbor for the opposite boundary. Thirdly, gene sections were separated because the grouping criteria was too strict and were rectified by modifying the criteria to the necessary value greater then 5 and finally, genes sections were grouped together because the grouping criteria was not strict enough and were rectified by modifying the criteria to <2.

Inference of Ancestral Breakpoint Arrangements. For each chain, the *D. mojavensis* gene identifiers were replaced with the corresponding gene identifiers of *D. melanogaster*. The ancestral state of the breakpoints was determined by comparing the gene order in *D. melanogaster* to that of *D. virilis* and *D. mojavensis*. Because the original identifiers were designated in *D. melanogaster*, sequential numbers at conserved linkage group boundaries were assumed to represent the ancestral state. If the ancestral states were determined for *n*-1 breakpoints in a linkage chain with n breakpoints, then the ancestral state for all breakpoints was known (Figure 5). If the sequential genes spanned the same breakpoint in the *D. virilis* sequence, then an inversion was assumed to occur in *D. mojavensis*, otherwise the inversion occurred along the *D. virilis*. This information was then used to construct the gene order of the common ancestor and assembled the gene breakpoints according to their identified ancestral connections (Figure 6). In cases where all ancestral states could not be inferred for all breakpoints in the chain, we assumed that (n-1)/2 inversions occurred on each lineage to allow us to estimate the total number of inversions on the two lineages.

Statistical Analysis. The numbers of inversions that occurred on each species lineage were tallied for each Muller element. The distribution of inversion events among the chromosomal arms and species were tested with either a Chi-square test of heterogeneity or goodness-of-fit (Sokal and Rohlf, 1981). The number of conserved linkage groups, numbers of breakpoints (n_{bp}), and numbers of inversions (n_{inv}) were estimated for comparison of the *D.*

virilis and *D. mojavensis* genomes. The reusage of breakpoints can be evaluated by estimating a reusage statistic (r) (Sankoff and Trihn 2005), $r=(2n_{inv})/n_{bp}$. The departure of the observed rearrangement data from random expectations was evaluated by randomly shuffling x genes of a particular chromosome with n_{inv} inversions and estimating the frequency of times the randomly shuffled genes matched the observed data. This would produce a number between 1 and 2. A value of 1 indicates that breakpoints were used an average of 1 time and a value of 2 indicates that breakpoints were used an average of 2 times.

Results

Genome Inversion Distribution. The results of the chain analyses for the six chromosomal arms are found in Appendices A-F. The distribution of inversions among the five major chromosomes is not significantly different between the two species (X^2=0.913, df=4, P>0.05) for the set of breakpoints where ancestral states could be inferred. If we assume that all data continues this trend, then the rate of inversion is 5.28 inversions per million years. This is half the rate observed between *D. pseudoobscura* and *D. melanogaster* (12.34/my) suggesting either an accelerated rate with the *Sophophoran* subgenus or a decelerated rate in the *Drosophila* subgenus. Whether rearrangement rates are accelerated or decelerated will require other pairwise comparisons to make a concrete inference.

Lineage Specific Inversions. Once the chromosomal ancestral states were determined based on the gene order of *D. melanogaster*, the inversion events were placed on either the *D. virilis* or D. mojavensis lineage. *D. virilis* had a total of 79 inversions while *D. mojavensis* had 91 although this difference is not significantly different from the assumption of equal number of inversions on each lineage (Goodness of Fit Test X^2=0.847, df=1, *P*=0.357) (Figure 7). The inversion rate on the different Muller's elements was not the same (Goodness of Fit Test X2=31.823, df=4, P<0.001), however, the rate differences were similar in the two species (Heterogeneity Test X^2=0.913, df=4, *P*=0.923).

Breakpoint Reusage. The breakpoint reusage within the six chromosomes varied between 1.1 and 1.6 times. The statistical analysis of the reusage shows that breakpoints are being reused more than expected given the number of genes and the number of inversions on each chromosome. Some linkage chains include too many breakpoints given a random usage model.

Final Data Result. The six chromosomes in the two species had 444 total conserved gene order breakpoints that resulted from 264 inversions. From this it was estimated that each breakpoint was used 1.189 times. This suggested that genomic rearrangements reuse breakpoint at a low to modest level. This also illustrates that the genetic rearrangements present in the gene order of each species is not random.

Discussion

Rate of chromosomal inversions in *D. mojavensis* and *D. virilis*. The inversion rate was equal on the two species lineages across all chromosomes. This suggests that there is no bias in the process that generates inversions in the two different species. There was a bias in the rate of inversions among the different chromosomes. This bias may emerge either because the nucleotide sequences that are responsible for the rearrangements may differ in their frequency on the different Muller's elements. Alternatively, the genes combinations required for proper protein function and regulation may differ in their sensitivity to chromosomal rearrangements. For instance, Muller's D may be less sensitive to chromosomal rearrangement than Muller's C.

The linkage chain analysis rejects the hypothesis that rearrangements are randomly introduced. The hypothesis of random usage of breakpoints was rejected. This suggests that some breakpoints are used more than expected, while some regions of the chromosomes are not broken by rearrangement breaks. These results may mean that some sequences on chromosomes are more susceptible to double-stranded breaks, while other regions do not have rearrangement breakpoints either because sequences in these regions are not susceptible to double-stranded breaks or breakpoints are introduced, but individuals with these breaks are selected against. One possibility was suggested by Stolc *et al.* (2004) who found that genes with similar expression patterns tend to be clustered in the genome. Breakpoints within these regions may be selected against because these events would break up coordinately expressed genes.

Uses of ancestral origins of genomic inversions. The research indicates that although changes within chromosomes cannot yet be predicted, their origins can be derived from the current arrangement of genes on each chromosomes. Knowing the ancestral state of a chromosome allows researchers to begin tracing each step of a mutation, identifying the sequence of events that gave rise to the current gene arrangement, inferring how each stage affected the species population and distribution, and then approximate the rate of genome rearrangement. The more frequently a conserved linkage group is involved in rearrangement events, the higher the chance of a genetic modification such as a transposition, duplication, or a deletion may cause mutations in the organism. Identifying and understanding the degree, frequency, and effects of chromosomal rearrangement is a valuable tool in the ongoing search for treatments for individuals with genetic conditions. It can also aid in predicting possible evolutionary tracks a specific species may take. Once we understand what causes these gene rearrangements, cures for human genetic disorders may be more easily achieved that will ensure a more promising outlook for future generations.

Breakpoint reusage. It was found that the reusage statistic for Muller Element F was the highest with a reusage of 1.6. This does not take into consideration that it has the least number of genes among the 6 chromosomes and as such any chromosomal inversions on that chromosome would show as significant. It is noteworthy that the rate of reusage does not correlate to the size of the other five chromosomes. Muller Element E, the largest of the chromosomes, has a moderate reusage of 1.208. This is nearly the same as that of Element A, which is the second smallest chromosome (Table 1).

Problems/difficulties encountered. The most difficult issue was making consistent, logical decisions in the assignment of conserved linkage groups. In the chain analysis, it was frequently necessary to reevaluate breakpoints to resolve large gaps between sequential breakpoint neighbors or numerous breaks in a segment of genes that were not necessary. Another challenge was the identification of transpositions. As the research progressed more criteria to

make those distinctions were used and additional transpositions were identified. This required re-evaluation of the linkage chains in some of the chromosomes once new transpositions were removed. Another issue was ensuring that a breakpoint that appeared twice in the same chain was not linked to itself in the ancestral inference. Such a mistake would create a circle between the breakpoint ends that did not connect to the reconstructed assembly.

Additional research. The mechanisms that drive genetic rearrangement within the chromosomes of *Drosophila* are still unclear. This leaves several questions that still need to be investigation. For example, what are the factors that initiate a mutation? Chromosomal inversions are not the only type of mutation that occurs within the genome. In other species there are types of rearrangements such as pericentric inversion and inter-chromosomal translocations that play major roles in diversifying the particular species. It is not clear what type of rearrangement is used more than others? Are the forces that cause inversions the same as those that cause transpositions? Can these rearrangements be manipulated to reverse their effects? Deliberate changes in gene order have been achieved in several cases using techniques such as exposure to ultraviolet radiation to create abnormalities. We have yet to understand what is necessary, if possible, to reverse the effects of such treatments on chromosomes.

Literature Cited

ALTSCHUL, S. F., T. L. MADDEN, A. A. SCHAFFER, J. ZHANG, Z. ZHANG, W. MILLER and D. J. LIPMAN, 1997 Gapped BLAST and PSI-BLAST: a new generation of protein database search programs. Nucleic Acids Res. **25:** 3389-3402.

COGHLAN, A., E. E. EICHLER, S. G. OLIVER, A. H. PATERSON and L. STEIN, 2005 Chromosome evolution in eukaryotes: a multi-kingdom perspective. Trends Genet **21:** 673-682.

COGHLAN, A., and K. H. WOLFE, 2002 Fourfold faster rate of genome rearrangement in nematodes than in Drosophila. Genome Res. **12:** 857-867.

EHRLICH, J., D. SANKOFF and J. H. NADEAU, 1997 Synteny conservation and chromosome rearrangements during mammalian evolution. Genetics **147:** 289-296.

MULLER, H. J., 1940 Bearings of the 'Drosophila' work on systematics., pp. 185-268 in *The New Systematics*, edited by J. HUXLEY. Clarendon Press, Oxford.

MYERS, E. W., G. G. SUTTON, A. L. DELCHER, I. M. DEW, D. P. FASULO, M. J. FLANIGAN, S. A. KRAVITZ, C. M. MOBARRY, K. H. REINERT, K. A. REMINGTON, E. L. ANSON, R. A. BOLANOS, H. H. CHOU, C. M. JORDAN, A. L. HALPERN, S. LONARDI, E. M. BEASLEY, R. C. BRANDON, L. CHEN, P. J. DUNN, Z. LAI, Y. LIANG, D. R. NUSSKERN, M. ZHAN, Q. ZHANG, X. ZHENG, G. M. RUBIN, M. D. ADAMS and J. C. VENTER, 2000 A whole-genome assembly of Drosophila. Science **287:** 2196-2204.

RANZ, J. M., F. CASALS and A. RUIZ, 2001 How malleable is the eukaryotic genome? Extreme rate of chromosomal rearrangement in the genus Drosophila. Genome Res. **11:** 230-239.

RICHARDS, S., Y. LIU, B. R. BETTENCOURT, P. HRADECKY, S. LETOVSKY, R. NIELSEN, K. THORNTON, M. A. TODD, R. CHEN, R. P. MEISEL, O. COURONNE, S. HUA, M. A. SMITH, H. J. BUSSEMAKER, M. F. V. BATENBURG, S. L. HOWELLS, S. E. SCHERER, E. SODERGREN, B. B. MATTHEWS, M. A. CROSBY, A. J. SCHROEDER, D. ORTIZ-BARRIENTOS, C. M. RIVES, M. L. METZKER, D. M. MUZNY, G. SCOTT, D. STEFFEN, D. A. WHEELER, K. C. WORLEY, P. HAVLAK, K. J. DURBIN, A. EAGAN, R. GILL, J. HUME, M. B. MORGAN, Y. HUANG, L. WALDRON, D. VERDUZCO, K. P. BLANKENBURG, H. ROBERTSON, I. DUBCHAK, M. A. F. NOOR, W. W. ANDERSON, K. WHITE, A. G. CLARK, S. W. SCHAEFFER, W. M. GELBART, G. WEINSTOCK and R. A. GIBBS, 2005 Comparative genome sequencing of *Drosophila pseudoobscura*: Chromosomal, gene and *cis*-element evolution. Genome Res. **15:** 1-18.

SANKARANARAYANAN, K., 1979 The role of non-dysjunction in aneuploidy in man: An overview. Mutation Research **61:** 1-28.

SANKOFF, D., and P. TRINH, 2005 Chromosomal breakpoint reuse in genome sequence rearrangement. J Comput Biol **12:** 812-821.

SOKAL, R. R., and F. J. ROHLF, 1981 *Biometry*. W. H. Freeman and Co., New York.

STOLC, V., Z. GAUHAR, C. MASON, G. HALASZ, M. F. VAN BATENBURG, S. A. RIFKIN, S. HUA, T. HERREMAN, W. TONGPRASIT, P. E. BARBANO, H. J. BUSSEMAKER and K. P. WHITE, 2004 A gene expression map for the euchromatic genome of *Drosophila melanogaster*. Science **306:** 655-660.

Table 1. Distribution of Inversions and Breakpoints among the six Muller Elements based on the comparison of gene order in *D. virilis* and *D. mojavensis*. Breakpoint re-usage for each chromosomal element for the comparison is also shown.

Chromosome	Genes	Inversions	Breakpoints (95% CI)	*r* (95% CI)
Muller A	1,909	48	80 (91- 97)	1.20 (1.00-1.06)
Muller B	2,170	36	62 (69- 73)	1.16 (1.00-1.05)
Muller C	2,455	45	73 (87- 91)	1.23 (1.00-1.05)
Muller D	2,616	73	128 (139-146)	1.14 (1.01-1.06)
Muller E	3,155	58	96 (112-117)	1.21 (1.00-1.05)
Muller F	68	4	5 (7- 9)	1.60 (1.00-1.33)
Total	12,373	264	444 (not done)	1.19 (not done)

r, breakpoint re-usage statistic. 95% CI, 95% confidence interval of the simulations with the given number of inversions and genes on the chromosomal arm.

Figure Legends

Figure 1. Mechanism of chromosomal inversion showing the introduction of two breakpoints and the reversal of gene order.

Figure 2. Phylogeny of five *Drosophila* species. The Drosophila genome is divided into six chromosomal arms or Muller's elements that are conserved among different species. The organization of the chromosomes, however, changes through the fission and fusion of these arms. The gene identifiers of *D. melanogaster* are indicated on its Muller elements.

Figure 3 . Chain analyses A. Incorrect linkage. B. Correct linkage

Figure 4 . Example of a complete linkage chain. Linkage chain analysis moves from breakpoint to breakpoint (red arrows) identifying the nearest neighbor of the gene at the breakpoint (colored boxes) until the breakpoints form an unbroken chain.

Figure 5. Ancestral state inference for conserved linkage breakpoints. The colored boxes indicate the inferred adjacent neighbors in the common ancestor of *D. virilis* and *D. mojavensis*.

Figure 6. Inference of lineage specific inversions. A. If the gene order at the breakpoint is conserved between *D. melanogaster* and *D. mojavensis* (colored boxes), then an inversion occurred on the *D. virilis* lineage (red arrow). B. If the gene order at the breakpoint is conserved between *D. melanogaster* and *D. virilis* (colored boxes), then an inversion occurred on the *D. mojavensis* lineage (red arrow).

Figure 7. Distribution of chromosomal inversions on the *D. virilis* and D. mojavensis lineages where the ancestral states could be unambiguously determined for linkage chains.

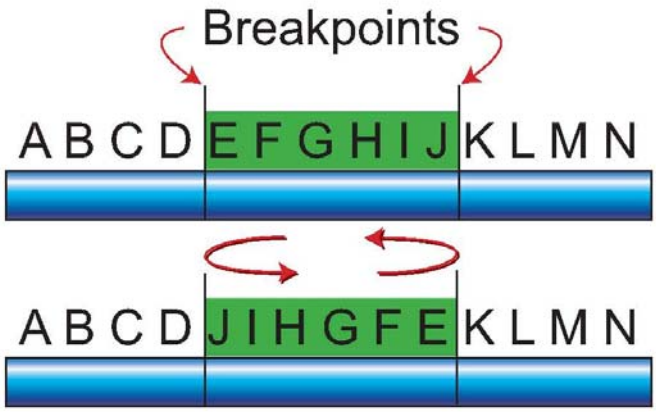


Figure 1

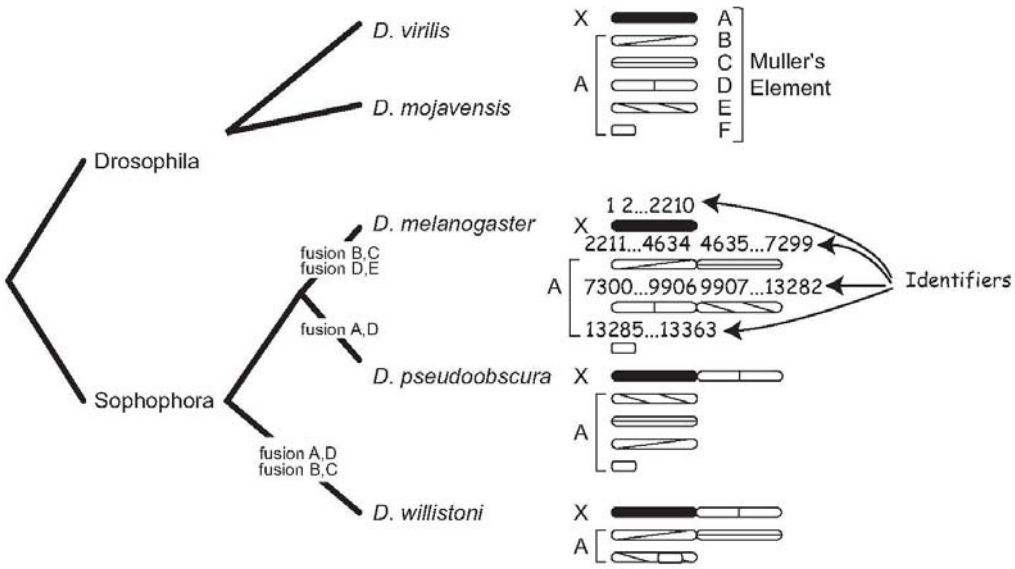
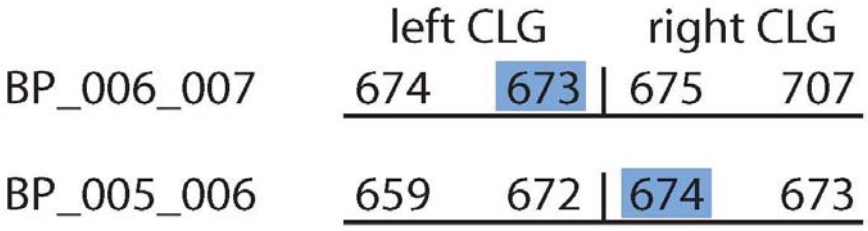


Figure 2

A



B

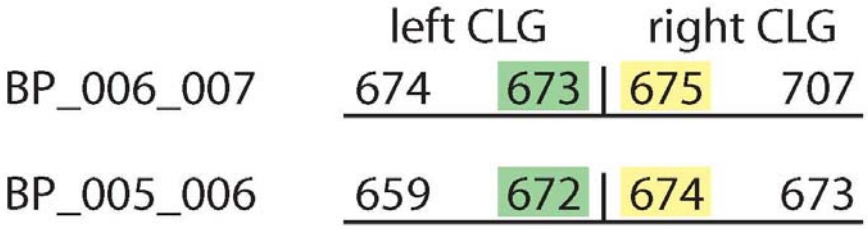


Figure 3

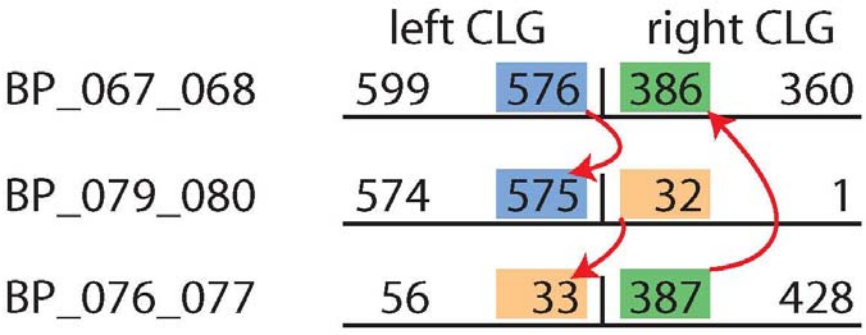


Figure 4

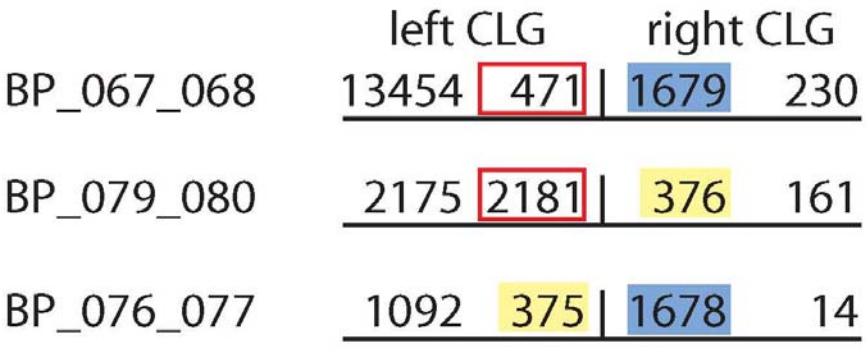


Figure 5

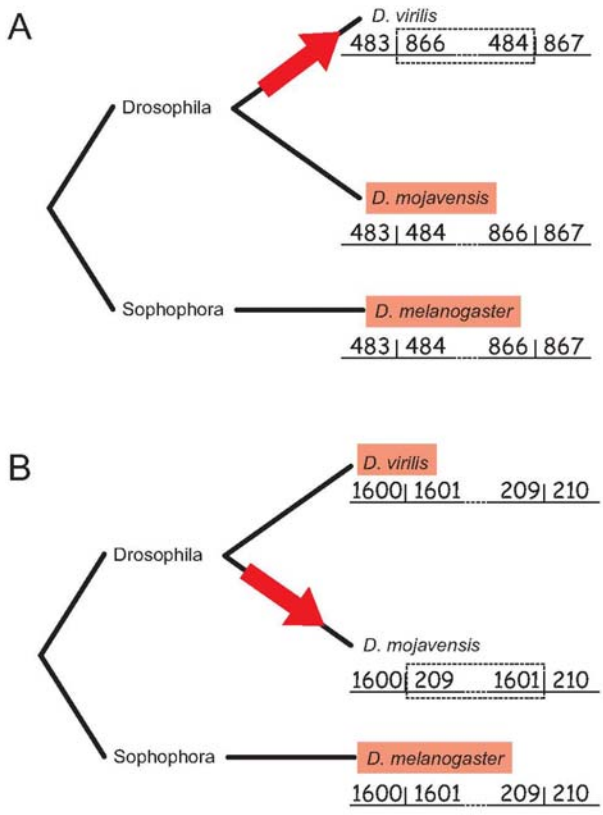


Figure 6

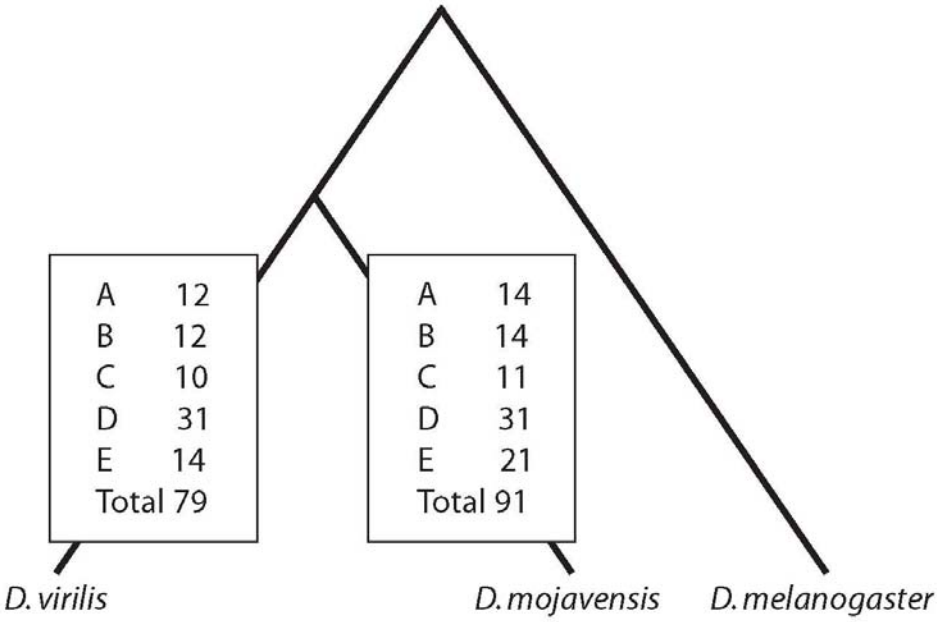

A 12
B 12
C 10
D 31
E 14
Total 79
A 14
B 14
C 11
D 31
E 21
Total 91
D. virilis
D. mojavensis
D. melanogaster

Figure 7

Chain_Anal_ID_a_Dmoj

Appendix A. Linkage Chain Analysis for the Muller A Element Comparison of D. virilis and D. mojavensis

Breakpoints Remaining= 77

Chain 1	left CLG		right CLG		
BP_001_002	0	0	1429	1426	
BP_021_022	1709	1532	2206	932	
BP_080_081	376	161	13467	13467	

Breakpoints Remaining= 75 (D.moj lineage inversion)(1)

Chain 2	left CLG		right CLG		
BP_004_005	1969	54	500	1932	A by inference
BP_077_078	1678	14	11	2174	A

Breakpoints Remaining= 73 (D.moj lineage inversion)(1)

Chain 3	left CLG		right CLG		
BP_006_007	1415	1414	1413	1661	A
BP_005_006	500	1932	1415	1414	A by inference

Breakpoints Remaining= 70 (D.vir lineage inversion)(2)

Chain 4	left CLG		right CLG		
BP_008_009	293	952	2200	2192	
BP_023_024	1202	1965	1157	1158	
BP_024_025	1157	1158	9599	958	

Breakpoints Remaining= 68 (D.vir lineage inversion)(1)

Chain 5	left CLG		right CLG		
BP_011_012	516	125	118	517	
BP_038_039	897	127	119	1032	

Breakpoints Remaining= 65 (D.vir lineage inversion)(2)

Chain 6	left CLG		right CLG		
BP_013_014	2106	992	1784	1701	A by inference
BP_040_041	199	28	27	609	A
BP_002_003	1429	1426	1424	956	A

Breakpoints Remaining= 56 (D.vir lineage inversion)(8)

Chain 7	left CLG		right CLG		
BP_062_063	1155	1155	652	557	
BP_044_045	492	696	1029	200	
BP_046_047	1031	1031	697	174	
BP_041_042	27	609	1562	699	
BP_016_017	1708	1379	928	1726	
BP_056_057	2046	745	1521	1519	
BP_035_036	1660	1386	1389	1912	A

Chain_Anal_ID_d_Dmoj

```
 54    54    54    54    54

   8471  8469  8470  8468  8467  8466  8465  8461  8460  8459  8457  8456  8452  8451  8450
8448  8447  8446  8445  8130
     54    54    54    54    54    54    54    55    55    55    55    55    55    55    55
 55    55    55    55    55

   8131  8129  8128  8040  8041  8043  8042  8044  8045  8047  8046  8048  8049  8050  8051
8052  8053  8054  8058  8061
     55    55    55    55    55    55    55    55    55    55    55    55    55    55    55
 55    55    55    55    55

   8062  8063  8064  8065  8066  8069  8068  8070  8071  8073  8074  8400  8401  8402  8403
8404  8405  7625  7624  7623
     55    55    55    55    55    55    55    55    55    55    55    56    56    56    57
 57    57    57    57    57

   7621  7620  7619  7618  7617  7836  7786  8584  8586  8587  8588  7391  7392  9308  9309
7931  7932  7933  7934  7936
     57    57    57    57    57    57    57    57    57    57    57    57    57    57    57
 57    58    58    59    59

   7937  7938  7939  7940  7941  7942  7943  7944  7945  7946  7948  7949  7950  7951  7953
7954  7955  7956  7957  7958
     59    59    59    59    59    59    59    59    59    59    59    59    59    59    59
 59    59    59    59    59

   7959  7964  7960  7961  9273  9274  7764  7579  7577  7578  7580  7581  7582  7584  7586
7588  7589  7590  7685  7576
     59    60    60    61    61    61    61    61    61    61    61    61    61    61    61
 61    61    61    61    61

   7575  7574  7573  7572  7571  7570  7569  7568  7567  7566  7565  7564  7563  7560  7559
7561  7562  7558  7557  7556
     61    61    61    61    61    61    61    61    61    61    61    61    61    62    62
 62    62    63    63    63

   7555  7553  7551  7550  7554  7552  7548  7546  7545  7544  7543  7542  8229  8228  8227
8226  8225  8224  9819  9818
     63    63    63    64    64    64    65    65    65    65    65    65    65    65    65
 65    65    65    66    66

   9817  9816  9815  9814  9813  9812  8838  8839  8840  8841  8842  8843  8846  8847  8848
8849  8853  9465  8855  8856
     66    66    66    66    66    66    66    66    66    66    66    66    66    66    66
 66    66    66    66    66

   8857  8858  8859  8860  8707  9468  9469  9470  9471  9472  9473  9474  9476  9478  9479
9480  9481  9290  9495  9496
     66    66    66    66    66    66    66    66    66    66    66    66    66    66    66
 66    66    66    67    68

   9497  9498  9501  9500  9499  9502  9503  9505  9506  9507  9509  9508  9510  9511  9513
9512  9514  9515  9516  9517
     68    69    69    69    69    69    69    69    69    69    69    69    69    69    69
 69    69    69    69    69

   9518  9519  9520  9521  9522  9523  9524  9525  9526  9527  9464  9463  9462  9460  9459
9458  9457  9456  9454  9453
     69    69    69    69    69    69    69    69    69    69    69    69    69    69    69
 69    69    69    69    69

   9452  9451  9450  9448  9447  9446  9444  9442  9441  9440  9439  9438  9437  9436  9435
9434  9433  9432  9431  9609
     69    69    69    69    69    69    69    69    69    69    69    69    69    69    69
```

```
                 ---------------------------
  BP_052_053      771   1505 |  578   1105
                 ---------------------------
  BP_051_052     2189   2186 |  771   1505
                 ---------------------------

Breakpoints Remaining= 54     (D.vir lineage inversion)(1)
Chain  8         left CLG          right CLG
  BP_057_058     1521   1519 |  491    485
                 ---------------------------
  BP_043_044     1183   2045 |  492    696
                 ---------------------------

Breakpoints Remaining= 52     (D.moj lineage inversion)(1)
Chain  9         left CLG          right CLG
  BP_073_074     2006    735 |  736    737       A
                 ---------------------------
  BP_074_075      736    737 |  741   1093       A by inference
                 ---------------------------

Breakpoints Remaining= 50     (D.moj lineage inversion)(1)
Chain 10         left CLG          right CLG
  BP_047_048      697    174 |  175    415       A
                 ---------------------------
  BP_068_069     1679    230 |   46    110       A by inference
                 ---------------------------

Breakpoints Remaining= 48     (D.vir lineage inversion)(1)
Chain 11         left CLG          right CLG
  BP_007_008     1413   1661 |  293    952
                 ---------------------------
  BP_034_035      299    294 | 1660   1386
                 ---------------------------

Breakpoints Remaining= 46     (D.moj lineage inversion)(1)
Chain 12         left CLG          right CLG
  BP_014_015     1784   1701 | 1702   1707       A
                 ---------------------------
  BP_015_016     1702   1707 | 1708   1379       A
                 ---------------------------

Breakpoints Remaining= 44     (D.moj lineage inversion)(1)
Chain 13         left CLG          right CLG
  BP_054_055      221   1559 | 1558   1555       A
                 ---------------------------
  BP_065_066     1259  13449 | 1076  13455       A by inference
                 ---------------------------

Breakpoints Remaining= 39     (D.vir lineage inversion)(4)
Chain 14         left CLG          right CLG
  BP_017_018      928   1726 | 1730    849
                 ---------------------------
  BP_027_028     1641   1971 | 1724    844
                 ---------------------------
  BP_003_004     1424    956 | 1969     54
                 ---------------------------
  BP_025_026     9599    958 |  368    301
                 ---------------------------
  BP_063_064      652    557 |  558   2185       A
                 ---------------------------

Breakpoints Remaining= 37     (D.vir lineage inversion)(1)
Chain 15         left CLG          right CLG
  BP_039_040      119   1032 |  199     28
                 ---------------------------
```

```
                                  Chain_Anal_ID_a_Dmoj
  BP_045_046         1029    200 |  1031   1031
                    ---------------------------

Breakpoints Remaining=  34     (D.vir lineage inversion)(2)
Chain 16            left CLG          right CLG
  BP_067_068        13454    471 |  1679    230
                    ---------------------------
  BP_079_080         2175   2181 |   376    161
                    ---------------------------
  BP_076_077         1092    375 |  1678     14
                    ---------------------------

Breakpoints Remaining=  32     (D.moj lineage inversion)(1)
Chain 17            left CLG          right CLG
  BP_028_029         1724    844 |   843   1448        A
                    ---------------------------
  BP_018_019         1730    849 |   848    840        A
                    ---------------------------

Breakpoints Remaining=  30     (d.vir lineage inversion)(1)
Chain 18            left CLG          right CLG
  BP_070_071         1548   1547 |  1550    281
                    ---------------------------
  BP_069_070           46    110 |  1548   1547
                    ---------------------------

Breakpoints Remaining=  28     (D.vir lineage inversion)(1)
Chain 19            left CLG          right CLG
  BP_010_011         2193   2103 |   516    125
                    ---------------------------
  BP_012_013          118    517 |  2106    992
                    ---------------------------

Breakpoints Remaining=  26     (D.vir lineage inversion)(1)
Chain 20            left CLG          right CLG
  BP_059_060          484    477 |  1824    231
                    ---------------------------
  BP_042_043         1562    699 |  1183   2045
                    ---------------------------

Breakpoints Remaining=  24     (D.moj lineage inversion)(1)
Chain 21            left CLG          right CLG
  BP_020_021          838   1367 |  1709   1532        A by inference
                    ---------------------------
  BP_009_010         2200   2192 |  2193   2103        A
                    ---------------------------

Breakpoints Remaining=  22     (D.vir lineage inversion)(1)
Chain 22            left CLG          right CLG
  BP_036_037         1389   1912 |   313   1692
                    ---------------------------
  BP_032_033          991   1911 |   310   1636
                    ---------------------------

Breakpoints Remaining=  20     (D.vir lineage inversion)(1)
Chain 23            left CLG          right CLG
  BP_050_051          410    538 |  2189   2186
                    ---------------------------
  BP_064_065          558   2185 |  1259  13449
                    ---------------------------

Breakpoints Remaining=  18     (D.moj lineage inversion)(1)
Chain 24            left CLG          right CLG
  BP_022_023         2206    932 |  1202   1965        A by inference
                    ---------------------------
```

```
                                  Chain_Anal_ID_a_Dmoj
  BP_019_020          848    840 |   838   1367        A
                    ---------------------------

Breakpoints Remaining=  16     (D.moj lineage inversion)(1)
Chain 25            left CLG          right CLG
  BP_053_054          578   1105 |   221   1559        A by inference
                    ---------------------------
  BP_058_059          491    485 |   484    477        A
                    ---------------------------

Breakpoints Remaining=  14     (D.vir lineage inversion)(1)
Chain 26            left CLG          right CLG
  BP_033_034          310   1636 |   299    294
                    ---------------------------
  BP_026_027          368    301 |  1641   1971
                    ---------------------------

Breakpoints Remaining=  11
Chain 27            left CLG          right CLG
  BP_078_079           11   2174 |  2175   2181        A
                    ---------------------------
  BP_072_073         1054    750 |  2006    735
                    ---------------------------
  BP_055_056         1558   1555 |  2046    745
                    ---------------------------

Breakpoints Remaining=   9     (D.moj lineage inversion)(1)
Chain 28            left CLG          right CLG
  BP_061_062         1156   1154 |  1155   1155        A
                    ---------------------------
  BP_060_061         1824    231 |  1156   1154        A by inference
                    ---------------------------

Breakpoints Remaining=   7     (D.moj lineage inversion)(1)
Chain 29            left CLG          right CLG
  BP_049_050          412    411 |   410    538        A
                    ---------------------------
  BP_048_049          175    415 |   412    411        A by inference
                    ---------------------------

Breakpoints Remaining=   4     (D.moj lineage inversion)(2)
Chain 30            left CLG          right CLG
  BP_075_076          741   1093 |  1092    375        A
                    ---------------------------
  BP_066_067         1076  13455 | 13454    471        A
                    ---------------------------
  BP_071_072         1550    281 |  1054    750        A by inference
                    ---------------------------

Breakpoints Remaining=   2
Chain 31            left CLG          right CLG
  BP_037_038          313   1692 |   897    127
                    ---------------------------
  BP_031_032         1453   2134 |   991   1911
                    ---------------------------

Breakpoints Remaining=   0     (D.vir lineage inversion)(1)
Chain 32            left CLG          right CLG
  BP_030_031         1452   1451 |  1453   2134
                    ---------------------------
  BP_029_030          843   1448 |  1452   1451
                    ---------------------------
```

Chain_Anal_ID_a_Dmoj

Chain Analysis Summary Data

Chains with 2 Breakpoints= 24
Chains with 3 Breakpoints= 6
Chains with 4 Breakpoints= 0
Chains with 5 Breakpoints= 1
Chains with 6 Breakpoints= 0
Chains with 7 Breakpoints= 0
Chains with 8 Breakpoints= 0
Chains with 9 Breakpoints= 1
Chains with 10 Breakpoints= 0
Chains with 11 Breakpoints= 0
Chains with 12 Breakpoints= 0

Number of Inversions= 48
Number of Breakpoints= 80
Reusage Index= 1.200

Conserved Linkage Group Intervals

CLG	No.Genes	Left_IDX	Right_IDX	Left_Gene	Right_Gene
1	1	1	1	0	0
2	4	2	5	1429	1426
3	5	6	10	1424	956
4	11	11	21	1969	54
5	14	22	35	500	1932
6	2	36	37	1415	1414
7	33	38	70	1413	1661
8	25	71	95	293	952
9	6	96	101	2200	2192
10	42	102	143	2193	2103
11	31	144	174	516	125
12	25	175	199	118	517
13	58	200	257	2106	992
14	24	258	281	1784	1701
15	5	282	286	1702	1707
16	6	287	292	1708	1379
17	11	293	303	928	1726
18	7	304	310	1730	849
19	14	311	324	848	840
20	4	325	328	838	1367
21	8	329	336	1709	1532
22	103	337	439	2206	932
23	9	440	448	1202	1965
24	2	449	450	1157	1158
25	26	451	476	9599	958
26	15	477	491	368	301
27	17	492	508	1641	1971
28	10	509	518	1724	844
29	106	519	624	843	1448
30	2	625	626	1452	1451
31	13	627	639	1453	2134
32	14	640	653	991	1911
33	12	654	665	310	1636
34	6	666	671	299	294
35	10	672	681	1660	1386
36	29	682	710	1389	1912
37	21	711	731	313	1692
38	45	732	776	897	127
39	94	777	870	119	1032
40	14	871	884	199	28
41	5	885	889	27	609

				Chain_Anal_ID_a_Dmoj	
42	13	890	902	1562	699
43	42	903	944	1183	2045
44	10	945	954	492	696
45	56	955	1010	1029	200
46	1	1011	1011	1031	1031
47	5	1012	1016	697	174
48	18	1017	1034	175	415
49	2	1035	1036	412	411
50	22	1037	1058	410	538
51	3	1059	1061	2189	2186
52	76	1062	1137	771	1505
53	14	1138	1151	578	1105
54	31	1152	1182	221	1559
55	4	1183	1186	1558	1555
56	41	1187	1227	2046	745
57	3	1228	1230	1521	1519
58	6	1231	1236	491	485
59	7	1237	1243	484	477
60	37	1244	1280	1824	231
61	2	1281	1282	1156	1154
62	1	1283	1283	1155	1155
63	30	1284	1313	652	557
64	32	1314	1345	558	2185
65	55	1346	1400	1259	13449
66	21	1401	1421	1076	13455
67	24	1422	1445	13454	471
68	27	1446	1472	1679	230
69	39	1473	1511	46	110
70	2	1512	1513	1548	1547
71	14	1514	1527	1550	281
72	31	1528	1558	1054	750
73	19	1559	1577	2006	735
74	2	1578	1579	736	737
75	53	1580	1632	741	1093
76	24	1633	1656	1092	375
77	42	1657	1698	1678	14
78	28	1699	1726	11	2174
79	2	1727	1728	2175	2181
80	32	1729	1760	376	161
81	1	1761	1761	13467	13467

Gene List and Conserved Linkage Group Calls

0	1429	1428	1427	1426	1424	1423	1422	955	956	1969	1768	1673	1672	172	171
170	169	56	55												
1	2	2	2	2	3	3	3	3	3	4	4	4	4	4	4
4	4	4	4												
54	500	51	50	49	48	1924	1925	1926	1927	1928	1929	1930	1931	1932	1415
1414	1413	1412	1410												
4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6
6	7	7	7												
1411	1408	1406	1404	1403	1400	1398	1397	1396	1395	1394	1393	1392	1391	1390	1640
1639	187	186	185												
7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
7	7	7	7												
184	183	182	181	1531	1665	1664	1663	1662	1661	293	292	531	807	808	809
810	2165	2166	2167												
7	7	7	7	7	7	7	7	7	7	8	8	8	8	8	8
8	8	8	8												
1141	1142	1143	1144	1145	1146	1147	946	947	948	1420	1421	954	953	952	

Chain_Anal_ID_a_Dmoj

```
2200  2201   754  2188  2190
      8     8     8     8     8     8     8     8     8     8     8     8     8     8     8
  9     9     9     9     9

   2192  2193  2194  2195  2196  2197  2198   951  1360  1949   884   883   882   880   879
878   877  1966  1968  1846
      9    10    10    10    10    10    10    10    10    10    10    10    10    10    10
 10    10    10    10    10

   1848  1850  1852  1854  1859  1861  1863  1864  1865  1866  1007  1008  1009  2096  2095
2094  2097  2099  2098  2100
     10    10    10    10    10    10    10    10    10    10    10    10    10    10    10
 10    10    10    10    10

   2101  2104  2103   516   136   135   134  1006  1600  1602  1601  1607  1572   283   710
712   713   714   716   717
     10    10    10    11    11    11    11    11    11    11    11    11    11    11    11
 11    11    11    11    11

    721   722   724   725   465   464   463   458   454   453   452   451   449   125   118
116   117   115   114  1542
     11    11    11    11    11    11    11    11    11    11    11    11    11    11    12
 12    12    12    12    12

   1541  1540  1539  1538  1535  1534  2209  2210   505   506 13461 13460 13462 13464   521
520   519   518   517  2106
     12    12    12    12    12    12    12    12    12    12    12    12    12    12    12
 12    12    12    12    13

   2107  2108  2109  2111  2114  2120  2123  2124  2126  2128  2129  2130  2132   901   900
1385  1384  1383   304   305
     13    13    13    13    13    13    13    13    13    13    13    13    13    13    13
 13    13    13    13    13

    303   302   906   908   907   909   910   913   911   912  1934  1923  1922  1933    47
2043  2044  2042   852   853
     13    13    13    13    13    13    13    13    13    13    13    13    13    13    13
 13    13    13    13    13

    856   855  1898  1899  1900  1901  1364  1363  1361  1362  1123  1124   847   846   997
993   992  1784  1783  1781
     13    13    13    13    13    13    13    13    13    13    13    13    13    13    13
 13    13    14    14    14

   1780  1779  1778  1777   936   937   939   938   941   942  1776  1775  1774  1773  1772
1770  1771  1769  1699  1700
     14    14    14    14    14    14    14    14    14    14    14    14    14    14    14
 14    14    14    14    14

   1701  1702  1703  1704  1705  1707  1708  1192  1193  1382  1381  1379   928   929   927
924   926   923   922  1716
     14    15    15    15    15    15    16    16    16    16    16    16    17    17    17
 17    17    17    17    17

   1717  1718  1726  1730  1729  1728  1727  1732   850   849   848   360   361   362  8636
363   364   367  1722  1721
     17    17    17    18    18    18    18    18    18    18    19    19    19    19    19
 19    19    19    19    19

   1720  1719  1733   840   838   839  1342  1367  1709  1710  1713  1711  1671  1670  1669
1532  2206  2205  2204  2203
     19    19    19    19    20    20    20    20    21    21    21    21    21    21    21
 21    22    22    22    22

   2202  1597  1049  1048  1047  1042  1041  1040  1039   915   916   917   918   919   920
```

Chain_Anal_ID_a_Dmoj

```
921  1714  1715  1659  1658
     22    22    22    22    22    22    22    22    22    22    22    22    22    22    22    22
 22    22    22    22    22

   1657  1656  1654  1653  1652  1651  1650  1649  1648  1647  1955  1954  1953  2140  2143
2141  2144  2147  2149  2150
     22    22    22    22    22    22    22    22    22    22    22    22    22    22    22    22
 22    22    22    22    22

   2146  2154  2159  2160  2161  2162  2163  2164   815   816   817   818  1375  1377  1376
1378   930   931   353   352
     22    22    22    22    22    22    22    22    22    22    22    22    22    22    22    22
 22    22    22    22    22

    351   347   346   344  1685  1000  1005   778   779   780   782   784   785   786   781
789   791   783   787   788
     22    22    22    22    22    22    22    22    22    22    22    22    22    22    22    22
 22    22    22    22    22

    790   792   793   795   797   798   801   800  1159  1161   288   287   286   285   943
944   945   934   932  1202
     22    22    22    22    22    22    22    22    22    22    22    22    22    22    22    22
 22    22    22    22    23

   1203  1204  1205  1207  1206  1209  1210  1965  1157  1158  9599  1341  1366   986   985
984   983   982   979   978
     23    23    23    23    23    23    23    23    24    24    25    25    25    25    25
 25    25    25    25    25

    977   975   974   973   972   971   970   968   966   965   964   962   961   960   959
958   368   371  1148   819
     25    25    25    25    25    25    25    25    25    25    25    25    25    25    25
 25    26    26    26    26

    820  1697  1694  1696  1695  1698  1693   888   889   890   301  1641  1642  1643  1644
1645  1646  1956  8805  1957
     26    26    26    26    26    26    26    26    26    26    26    26    27    27    27    27
 27    27    27    27    27

   1958  1959  1960  1961  1973  1972  1970  1971  1724  1725  1723  1691  1690  1688  1687
1686   845   844   843   842
     27    27    27    27    27    27    27    27    28    28    28    28    28    28    28
 28    28    28    29    29

   1734  1736  1737  1739  1738  1740  1741  1387   885   886   887  1743  1744   949   950
 34    35    36  2065  2064
     29    29    29    29    29    29    29    29    29    29    29    29    29    29    29
 29    29    29    29    29

   2063  2058  2062  2061  2060  2055  2054  2052  2050  2051  2048  2047   757   758   756
755  1605  1583  1566    58
     29    29    29    29    29    29    29    29    29    29    29    29    29    29    29
 29    29    29    29    29

     57   695  1058  1060  1061  1059  1062  1063  1064  1065  1066  1163  1162  1164     5
  7     8     9    10   507
     29    29    29    29    29    29    29    29    29    29    29    29    29    29    29
 29    29    29    29    29

    504   503   501    32    33  1346  1344  1349  1348  1350  1351  1353  1355  1356  1357
1358   834   833   832   831
     29    29    29    29    29    29    29    29    29    29    29    29    29    29    29
 29    29    29    29    29

    830   829   827   828   826   823   824   825   821  1106  1107  1109  1108  1114  1115
```

Chain_Anal_ID_a_Dmoj

1117	1118	1119	1121	1374											
29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29
29	29	29	29	29											
1444	1445	1446	1448	1452	1451	1453	1454	1950	1951	1576	9266	1582	1578	2137	
2138	2136	2135	2134	991											
29	29	29	29	30	30	31	31	31	31	31	31	31	31	31	
31	31	31	31	32											
990	989	988	987	1902	1903	1904	1905	1908	1906	1907	1909	1911	310	309	
308	307	306	1194	1195											
32	32	32	32	32	32	32	32	32	32	32	32	32	33	33	
33	33	33	33	33											
1196	1197	1638	1637	1636	299	298	297	296	295	294	1660	1212	1213	1214	
1215	1216	851	899	1388											
33	33	33	33	33	34	34	34	34	34	34	35	35	35	35	
35	35	35	35	35											
1386	1389	1635	1634	1633	1631	1632	1630	1629	1627	1628	1626	1625	1624	1623	
1622	1621	1620	1619	1616											
35	36	36	36	36	36	36	36	36	36	36	36	36	36	36	
36	36	36	36	36											
1016	1575	1580	1588	1590	1574	1913	1915	1914	1912	313	316	317	318	319	
321	322	325	326	327											
36	36	36	36	36	36	36	36	36	36	37	37	37	37	37	
37	37	37	37	37											
329	328	330	331	332	333	334	336	343	335	1692	897	1962	1963	1964	
1211	1935	1936	1937	1944											
37	37	37	37	37	37	37	37	37	37	37	38	38	38	38	
38	38	38	38	38											
1946	1947	1948	905	904	903	902	1787	1788	2169	2168	1140	1139	1138	1137	
1136	1133	1785	1132	1131											
38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	
38	38	38	38	38											
1130	1129	1128	1127	1126	359	2180	2179	355	354	133	132	131	130	128	
127	119	120	121	101											
38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	
38	39	39	39	39											
100	99	91	8302	8301	8739	90	89	88	87	86	84	79	78	77	
75	74	73	72	71											
39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	
39	39	39	39	39											
70	68	67	62	61	1868	1869	1870	1872	1874	1875	1876	1877	1878	1879	
1880	1881	1882	1883	1884											
39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	
39	39	39	39	39											
1885	1888	1889	1890	1891	1895	1896	1897	857	858	859	860	861	863	864	
865	866	867	868	869											
39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	
39	39	39	39	39											
873	874	872	1767	1765	1764	1763	1762	1755	1756	1754	1750	1749	1748	1746	
1419	1417	1418	896	895											
39	39	39	39	39	39	39	39	39	39	39	39	39	39	39	
39	39	39	39	39											
894	893	892	891	914	1038	1036	1034	1033	1032	199	198	197	196	194	

Chain_Anal_ID_a_Dmoj

```
1050  1051  1052    53    52
     39    39    39    39    39    39    39    39    39    39    40    40    40    40    40
 40    40    40    40    40

     31    30    29    28    27   612   611   610   609  1562  1563 13445 13446   709   708
707   706   705   704   703
     40    40    40    40    41    41    41    41    41    42    42    42    42    42    42
 42    42    42    42    42

    700   699  1183  1184   561   562   563   564   565   568   570   569   571   572   573
574   576   575  1683  1675
     42    42    43    43    43    43    43    43    43    43    43    43    43    43    43
 43    43    43    43    43

   1808  1172  1173  1174  1175  1176  1178  1179   222   542   545   546   544   543   547
1339  1338  1337  1334  1333
     43    43    43    43    43    43    43    43    43    43    43    43    43    43    43
 43    43    43    43    43

   2039  2040  2041  2045   492   493   494   495   496   498   499    40    39   696  1029
1028  1027  1026  1023  1021
     43    43    43    43    44    44    44    44    44    44    44    44    44    44    45
 45    45    45    45    45

   1017  1020  1018  1015  1014  1013  1010   428   427   624   623   622   621   619   618
617   616   615   614   225
     45    45    45    45    45    45    45    45    45    45    45    45    45    45    45
 45    45    45    45    45

    432   433   769   266   267  1840  1839  1838  1805  1518  1517  1516  1515  1513  1512
1511  1510  1509   743   448
     45    45    45    45    45    45    45    45    45    45    45    45    45    45    45
 45    45    45    45    45

    447   446   445   206   205   204   203   202   201   200  1031   697   698   429   173
174   175   176   224   223
     45    45    45    45    45    45    45    45    45    45    46    47    47    47    47
 47    48    48    48    48

   1071  1070  1069  1068  1067  1190  1191  1455  1456  1457   418   417   416   415   412
411   410   409   406   405
     48    48    48    48    48    48    48    48    48    48    48    48    48    48    49
 49    50    50    50    50

    403   402   401   400   399   398   397   396   395   393   392   391   390   389  1674
541   540   538  2189  2187
     50    50    50    50    50    50    50    50    50    50    50    50    50    50    50
 50    50    50    51    51

   2186   771   671   672 13450     1     2     3     4   651   650   648   647   646   645
644   643   642   641   640
     51    52    52    52    52    52    52    52    52    52    52    52    52    52    52
 52    52    52    52    52

    639   638   620   637   635   634  1561   178   177   208   209   255   254   253   252
251   250   249   248   247
     52    52    52    52    52    52    52    52    52    52    52    52    52    52    52
 52    52    52    52    52

    246   245   244   243  1994  1995   239   238   237   235   236  1321  1523  1522  1524
1526  1527  1528   626   625
     52    52    52    52    52    52    52    52    52    52    52    52    52    52    52
 52    52    52    52    52

    426   425   423   422   420   106   107   108   511   510   508   514   512   515   276
```

Chain_Anal_ID_a_Dmoj

613 1505 578 579 277
52 52 52 52 52 52 52 52 52 52 52 52 52 52 52 52
52 52 53 53 53

278 1473 1217 216 215 1100 1101 1102 1103 1104 1105 221 220 219 218
217 1269 1270 1271 1272
53 53 53 53 53 53 53 53 53 53 53 54 54 54 54
54 54 54 54 54

1275 1277 1279 1280 1281 1282 1284 1285 1283 1286 1288 1290 1291 1292 1293
1294 1295 1296 1297 1298
54 54 54 54 54 54 54 54 54 54 54 54 54 54 54
54 54 54 54 54

1560 1559 1558 1557 1556 1555 2046 759 760 761 767 762 764 765 1506
214 213 211 212 662
54 54 55 55 55 56 56 56 56 56 56 56 56 56 56
56 56 56 56 56

661 660 658 657 656 180 179 663 664 666 665 667 669 670 1239
1237 1235 1236 1233 1228
56 56 56 56 56 56 56 56 56 56 56 56 56 56 56
56 56 56 56 56

768 1218 766 1507 1508 744 745 1521 1520 1519 491 490 489 488 486
485 484 483 481 480
56 56 56 56 56 56 56 57 57 57 58 58 58 58 58
58 59 59 59 59

479 478 477 1824 1825 1826 1828 1829 1831 1832 1833 1834 1835 1837 1804
1802 1801 1803 1798 1800
59 59 59 60 60 60 60 60 60 60 60 60 60 60 60
60 60 60 60 60

1326 1325 1324 1323 259 260 261 262 263 264 1268 1266 1265 1264 1263
1315 680 679 1320 231
60 60 60 60 60 60 60 60 60 60 60 60 60 60 60
60 60 60 60 60

1156 1154 1155 652 653 1465 1462 1463 1461 1460 1464 1469 1471 1467 1468
1470 1466 1472 1474 1476
61 61 62 63 63 63 63 63 63 63 63 63 63 63 63
63 63 63 63 63

1477 1479 1480 1186 1187 1188 1189 777 776 551 552 553 557 558 191
190 188 189 1199 1200
63 63 63 63 63 63 63 63 63 63 63 63 63 64 64
64 64 64 64 64

1201 1181 1182 275 274 273 272 271 270 269 268 1842 803 804 806
532 533 534 535 536
64 64 64 64 64 64 64 64 64 64 64 64 64 64 64
64 64 64 64 64

537 467 466 726 2185 1259 1258 1257 1256 1255 1254 1253 8784 1252 1251
1250 1249 1248 1247 1246
64 64 64 64 64 65 65 65 65 65 65 65 65 65 65
65 65 65 65 65

1244 1242 1241 1240 594 593 592 589 591 590 588 1303 1305 1306 1307
1308 1309 1312 1313 580
65 65 65 65 65 65 65 65 65 65 65 65 65 65 65
65 65 65 65 65

581 582 583 584 586 585 587 1302 1301 1300 1299 633 632 630 629

Chain_Anal_ID_a_Dmoj

628 627 13447 13448 13449
65 65 65 65 65 65 65 65 65 65 65 65 65 65 65
65 65 65 65 65

1076 1075 1074 1073 289 290 291 530 529 528 526 525 524 523 522
13465 13466 13458 13457 13456
66 66 66 66 66 66 66 66 66 66 66 66 66 66 66
66 66 66 66 66

13455 13454 13453 13452 13451 678 677 41 42 43 693 689 690 691 687
686 685 684 681 683
66 67 67 67 67 67 67 67 67 67 67 67 67 67 67
67 67 67 67 67

682 475 474 473 471 1679 1055 1057 1056 37 2066 2067 2068 2069 2071
2070 2072 2073 2074 2075
67 67 67 67 67 68 68 68 68 68 68 68 68 68 68
68 68 68 68 68

2076 2077 2079 2078 2084 2085 1793 1794 1795 1796 229 230 46 431 430
608 607 1332 1331 1330
68 68 68 68 68 68 68 68 68 68 68 68 69 69 69
69 69 69 69 69

1329 1327 2038 2037 2036 2035 2034 2033 2032 241 242 1993 1992 1990 1989
1988 1987 1986 1985 1984
69 69 69 69 69 69 69 69 69 69 69 69 69 69 69
69 69 69 69 69

1982 1981 1977 1979 1980 1975 1610 1568 1615 1613 110 1548 1547 1550 1551
1552 1553 1554 439 440
69 69 69 69 69 69 69 69 69 69 69 70 70 71 71
71 71 71 71 71

441 442 443 444 279 280 281 1054 192 193 1262 1316 437 438 559
560 1482 1483 1484 1485
71 71 71 71 71 71 71 72 72 72 72 72 72 72 72
72 72 72 72 72

1486 1487 1489 1488 1490 1491 1492 1493 1494 1495 1496 1500 1502 388 753
752 751 750 2006 1809
72 72 72 72 72 72 72 72 72 72 72 72 72 72 72
72 72 72 73 73

1810 1811 1812 1813 1814 1815 1816 654 470 727 728 729 730 731 732
733 735 736 737 741
73 73 73 73 73 73 73 73 73 73 73 73 73 73 73
73 73 74 74 75

738 739 124 123 122 102 103 104 469 468 1260 1261 604 606 1165
1166 1167 1168 1169 1170
75 75 75 75 75 75 75 75 75 75 75 75 75 75 75
75 75 75 75 75

1171 2007 2008 598 597 596 595 434 436 26 25 24 22 20 21
19 23 1820 1822 1823
75 75 75 75 75 75 75 75 75 75 75 75 75 75 75
75 75 75 75 75

2093 2092 2091 2090 2089 2088 2087 2086 1792 1791 1094 1093 1092 1091 1090
1089 1088 1087 1086 1085
75 75 75 75 75 75 75 75 75 75 75 75 76 76 76
76 76 76 76 76

1084 1083 1082 1081 1080 1077 44 1152 1151 1150 373 369 372 1149 374

Chain_Anal_ID_a_Dmoj

375 1678 1677 1681 1536
76 76 76 76 76 76 76 76 76 76 76 76 76 76 76
76 77 77 77 77

2014 2015 2016 2017 2019 2020 2021 2022 2024 2025 2026 2027 2028 2029 2030
2031 2000 2001 2002 2003
77 77 77 77 77 77 77 77 77 77 77 77 77 77 77
77 77 77 77 77

2004 2005 749 748 747 746 1322 772 773 774 775 18 17 16 15
12 13 14 11 6
77 77 77 77 77 77 77 77 77 77 77 77 77 77 77
77 77 77 78 78

1544 1543 1609 1569 1573 7790 1598 603 602 601 599 2009 2010 2012 2011
2013 1098 1097 1096 1790
78 78 78 78 78 78 78 78 78 78 78 78 78 78 78
78 78 78 78 78

1789 2170 2171 2172 2173 2174 2175 2181 376 377 378 379 380 381 382
383 384 385 386 142
78 78 78 78 78 78 79 79 80 80 80 80 80 80 80
80 80 80 80 80

141 140 137 139 577 143 144 145 146 148 149 151 153 154 155
156 157 158 160 161
80 80 80 80 80 80 80 80 80 80 80 80 80 80 80
80 80 80 80 80

13467
81

Chain_Anal_ID_b_Dmoj

Appendix B. Linkage Chain Analysis for the Muller B Element Comparison of D. virilis and D. mojavensis

Breakpoints Remaining= 54

Chain 1	left CLG		right CLG		
BP_045_046	4610	4610	3518	3457	
BP_001_002	2211	2211	3479	3469	
BP_010_011	3843	3842	3841	2883	A
BP_016_017	3646	3882	3477	3647	
BP_002_003	3479	3469	3881	4398	
BP_041_042	3472	3511	3463	3524	
BP_046_047	3518	3457	2834	3276	
BP_043_044	3499	3499	3521	3522	

Breakpoints Remaining= 52 (D.moj lineage inversion)(1)

Chain 2	left CLG		right CLG		
BP_056_057	4280	4283	4284	4285	A
BP_057_058	4284	4285	2264	2722	A by inference

Breakpoints Remaining= 50 (D.moj lineage inversion)(1)

Chain 3	left CLG		right CLG		
BP_035_036	2794	2475	2476	2582	A
BP_055_056	4263	4279	4280	4283	A

Breakpoints Remaining= 48 (D.vir lineage inversion)(1)

Chain 4	left CLG		right CLG		
BP_011_012	3841	2883	2549	4459	
BP_020_021	3653	2879	3034	3240	

Breakpoints Remaining= 46 (D.moj lineage inversion)(1)

Chain 5	left CLG		right CLG		
BP_061_062	4195	4186	4197	4197	A by inference
BP_060_061	4555	4194	4195	4186	A

Breakpoints Remaining= 44 (D.moj lineage inversion)(1)

Chain 6	left CLG		right CLG		
BP_003_004	3881	4398	4399	4400	A
BP_004_005	4399	4400	4397	3910	A by inference

Breakpoints Remaining= 42 (D.moj lineage inversion)(1)

Chain 7	left CLG		right CLG		
BP_034_035	2585	3171	2794	2475	A by inference
BP_022_023	2983	3288	3287	3823	A

Breakpoints Remaining= 40 (D.vir lineage inversion)(1)

Chain 8	left CLG	right CLG

```
                                  Chain_Anal_ID_b_Dmoj
  BP_025_026          3010   2813 |  3157   2814
                     ---------------------------
  BP_026_027          3157   2814 |  4147   3731
                     ---------------------------

Breakpoints Remaining=  38     (D.vir lineage inversion)(1)
Chain  9             left CLG          right CLG
  BP_048_049          3400   3410 |  3412   3411
                     ---------------------------
  BP_049_050          3412   3411 |  3413   3575
                     ---------------------------

Breakpoints Remaining=  36     (D.vir lineage inversion)(1)
Chain 10             left CLG          right CLG
  BP_027_028          4147   3731 |  3574   4173
                     ---------------------------
  BP_050_051          3413   3575 |  3732   3736
                     ---------------------------

Breakpoints Remaining=  34     (D.vir lineage inversion)(1)
Chain 11             left CLG          right CLG
  BP_018_019          4633   2905 |  2907   2906
                     ---------------------------
  BP_019_020          2907   2906 |  3653   2879
                     ---------------------------

Breakpoints Remaining=  31     (D.moj lineage inversion)(2)
Chain 12             left CLG          right CLG
  BP_005_006          4397   3910 |  3911   3241        A
                     ---------------------------
  BP_030_031          4514   2439 |  2437   2421        A by inference
                     ---------------------------
  BP_012_013          2549   4459 |  4460   3005        A
                     ---------------------------

Breakpoints Remaining=  28     (D.vir lineage inversion)(2)
Chain 13             left CLG          right CLG
  BP_013_014          4460   3005 |  2865   3328
                     ---------------------------
  BP_008_009          4418   4417 |  4420   3845        A
                     ---------------------------
  BP_033_034          2415   4120 |  2585   3171
                     ---------------------------

Breakpoints Remaining=  26     (D.moj lineage inversion)(1)
Chain 14             left CLG          right CLG
  BP_039_040          4515   3474 |  3489   3473        A by inference
                     ---------------------------
  BP_040_041          3489   3473 |  3472   3511        A
                     ---------------------------

Breakpoints Remaining=  24     (D.moj lineage inversion)(1)
Chain 15             left CLG          right CLG
  BP_037_038          3711   3714 |  3715   4166        A
                     ---------------------------
  BP_036_037          2476   2582 |  3711   3714        A by inference
                     ---------------------------

Breakpoints Remaining=  21     (D.vir lineage inversion)(2)
Chain 16             left CLG          right CLG
  BP_021_022          3034   3240 |  2983   3288
                     ---------------------------
  BP_006_007          3911   3241 |  3275   4416
                     ---------------------------
  BP_047_048          2834   3276 |  3400   3410
```

Chain_Anal_ID_b_Dmoj

```
Breakpoints Remaining=  19
Chain 17            left CLG          right CLG
  BP_009_010         4420   3845 |  3843   3842
                    ---------------------------
  BP_054_055         4309   4260 |  4263   4279
                    ---------------------------

Breakpoints Remaining=  17     (D.vir lineage inversion)(1)
Chain 18            left CLG          right CLG
  BP_042_043         3463   3524 |  3499   3499
                    ---------------------------
  BP_044_045         3521   3522 |  4610   4610
                    ---------------------------

Breakpoints Remaining=  15     (D.vir lineage inversion)(1)
Chain 19            left CLG          right CLG
  BP_058_059         2264   2722 |  4311   4553
                    ---------------------------
  BP_053_054         4292   2723 |  4309   4260
                    ---------------------------

Breakpoints Remaining=  13     (D.vir lineage inversion)(1)
Chain 20            left CLG          right CLG
  BP_023_024         3287   3823 |  2586   3636
                    ---------------------------
  BP_059_060         4311   4553 |  4555   4194
                    ---------------------------

Breakpoints Remaining=  10     (D.moj lineage inversion)(2)
Chain 21            left CLG          right CLG
  BP_024_025         2586   3636 |  3010   2813        A by inference
                    ---------------------------
  BP_051_052         3732   3736 |  3737   4291        A
                    ---------------------------
  BP_062_063         4197   4197 |  4198   2212        A
                    ---------------------------

Breakpoints Remaining=   8     (D.vir lineage inversion)(1)
Chain 22            left CLG          right CLG
  BP_032_033         2417   2420 |  2415   4120
                    ---------------------------
  BP_031_032         2437   2421 |  2417   2420
                    ---------------------------

Breakpoints Remaining=   6     (D.moj lineage inversion)(1)
Chain 23            left CLG          right CLG
  BP_014_015         2865   3328 |  3343   3070        A by inference
                    ---------------------------
  BP_007_008         3275   4416 |  4418   4417        A by inference
                    ---------------------------

Breakpoints Remaining=   4     (D.vir lineage inversion)(1)
Chain 24            left CLG          right CLG
  BP_029_030         4168   4167 |  4514   2439
                    ---------------------------
  BP_038_039         3715   4166 |  4515   3474
                    ---------------------------

Breakpoints Remaining=   2     (D.vir lineage inversion)(1)
Chain 25            left CLG          right CLG
  BP_017_018         3477   3647 |  4633   2905
                    ---------------------------
  BP_015_016         3343   3070 |  3646   3882
```

Chain_Anal_ID_b_Dmoj

Breakpoints Remaining= 0 (D.moj lineage inversion)(1)

Chain 26	left CLG		right CLG		
BP_028_029	3574	4173 |	4168	4167	A by inference
BP_052_053	3737	4291 |	4292	2723	A

Chain Analysis Summary Data

Chains with 2 Breakpoints= 21
Chains with 3 Breakpoints= 4
Chains with 4 Breakpoints= 0
Chains with 5 Breakpoints= 0
Chains with 6 Breakpoints= 0
Chains with 7 Breakpoints= 0
Chains with 8 Breakpoints= 1
Chains with 9 Breakpoints= 0
Chains with 10 Breakpoints= 0
Chains with 11 Breakpoints= 0
Chains with 12 Breakpoints= 0

Number of Inversions= 36
Number of Breakpoints= 62
Reusage Index= 1.161

Conserved Linkage Group Intervals

CLG	No.Genes	Left_IDX	Right_IDX	Left_Gene	Right_Gene
1	1	1	1	2211	2211
2	3	2	4	3479	3469
3	15	5	19	3881	4398
4	2	20	21	4399	4400
5	21	22	42	4397	3910
6	82	43	124	3911	3241
7	43	125	167	3275	4416
8	2	168	169	4418	4417
9	70	170	239	4420	3845
10	2	240	241	3843	3842
11	75	242	316	3841	2883
12	23	317	339	2549	4459
13	29	340	368	4460	3005
14	15	369	383	2865	3328
15	55	384	438	3343	3070
16	89	439	527	3646	3882
17	21	528	548	3477	3647
18	63	549	611	4633	2905
19	2	612	613	2907	2906
20	45	614	658	3653	2879
21	84	659	742	3034	3240
22	14	743	756	2983	3288
23	59	757	815	3287	3823
24	63	816	878	2586	3636
25	68	879	946	3010	2813
26	97	947	1043	3157	2814
27	26	1044	1069	4147	3731
28	125	1070	1194	3574	4173
29	4	1195	1198	4168	4167
30	23	1199	1221	4514	2439

				Chain_Anal_ID_b_Dmoj	
31	12	1222	1233	2437	2421
32	2	1234	1235	2417	2420
33	23	1236	1258	2415	4120
34	32	1259	1290	2585	3171
35	15	1291	1305	2794	2475
36	18	1306	1323	2476	2582
37	2	1324	1325	3711	3714
38	13	1326	1338	3715	4166
39	12	1339	1350	4515	3474
40	2	1351	1352	3489	3473
41	5	1353	1357	3472	3511
42	2	1358	1359	3463	3524
43	1	1360	1360	3499	3499
44	2	1361	1362	3521	3522
45	1	1363	1363	4610	4610
46	3	1364	1366	3518	3457
47	17	1367	1383	2834	3276
48	11	1384	1394	3400	3410
49	2	1395	1396	3412	3411
50	142	1397	1538	3413	3575
51	5	1539	1543	3732	3736
52	46	1544	1589	3737	4291
53	84	1590	1673	4292	2723
54	22	1674	1695	4309	4260
55	15	1696	1710	4263	4279
56	4	1711	1714	4280	4283
57	2	1715	1716	4284	4285
58	128	1717	1844	2264	2722
59	21	1845	1865	4311	4553
60	65	1866	1930	4555	4194
61	2	1931	1932	4195	4186
62	1	1933	1933	4197	4197
63	39	1934	1972	4198	2212

Gene List and Conserved Linkage Group Calls

2211	3479	3478	3469	3881	3879	3880	3878	3876	3875	3874	3871	3868	3867	4391	4393
4395	4396	4398	4399												
1	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3
3	3	4													
4400	4397	4401	4402	4403	4404	4405	3895	3896	3897	3898	3899	3900	3901	3902	3903
3904	3905	3907	3908												
4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
5	5	5	5												
3909	3910	3911	3912	3913	3914	3917	3916	3920	3919	3918	3915	3921	3922	3923	3925
3926	3928	3929	3930												
5	5	6	6	6	6	6	6	6	6	6	6	6	6	6	6
6	6	6	6												
3931	3932	3933	3935	3939	3940	3942	3937	3934	3941	3944	3945	3946	3947	3948	3949
3950	3951	3952	3955												
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
6	6	6	6												
3956	3957	3960	3958	3961	3963	3962	3965	3966	3967	3968	3969	3970	4095	4093	4092
4091	4090	4089	4088												
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
6	6	6	6												
4086	4084	4083	4076	4077	4075	4081	4078	4085	4073	4071	4070	4067	3253	3435	3250
3251	3247	3246	3245												
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

Chain_Anal_ID_b_Dmoj

```
  6     6     6     6     6

   3244  3243  3242  3241  3275  3274  3272  3270  3268  3267  3266  3265  3263  3262  3358
3357  3356  3354  3355  3979
      6     6     6     6     7     7     7     7     7     7     7     7     7     7     7
  7     7     7     7     7

   3980  3977  3976  3974  3973  3972  4098  4097  4096  3073  3074  3072  3071 13382 13383
2601  4406  4407  4408  4410
      7     7     7     7     7     7     7     7     7     7     7     7     7     7     7
  7     7     7     7     7

   4409  4411  4412  4413  4414  4415  4416  4418  4417  4420  4419  4421  4422  4423  4424
4061  4062  4063  4065  4066
      7     7     7     7     7     7     7     8     8     9     9     9     9     9     9
  9     9     9     9     9

   3255  3256  3257  3258  3259  3261  4354  4356  4357  4358  4359  4360  4361  4362  4363
4364  4365  4368  4369  4370
      9     9     9     9     9     9     9     9     9     9     9     9     9     9     9
  9     9     9     9     9

   4372  4374  4373  4375  4376  4377  4378  4379  4380  4381  4383  4386  4388  4389  4390
4392  3866  3865  3864  3863
      9     9     9     9     9     9     9     9     9     9     9     9     9     9     9
  9     9     9     9     9

   3862  3861  3860  3859  3858  3857  3856  3855  3854  3853  3852  3851  3850  3849  3848
3847  3846  3844  3845  3843
      9     9     9     9     9     9     9     9     9     9     9     9     9     9     9
  9     9     9     9    10

   3842  3841  3837  3833  3832  3831  3830  3829  3826  3825  3824  2580  2581  2579  2577
2575  2574  4352  4351  4350
     10    11    11    11    11    11    11    11    11    11    11    11    11    11    11
 11    11    11    11    11

   4349  3455  2573  3453  3452  3450  3448  3447  3446  3444  3443  3442  3441  3440  3439
3437  3436  3433  3432  3431
     11    11    11    11    11    11    11    11    11    11    11    11    11    11    11
 11    11    11    11    11

   3429  3427  3426  3425  3424  3423  3422  3421  3420  3419  3418  3417  3365  3366  3367
3369  3370  3371  3372  3373
     11    11    11    11    11    11    11    11    11    11    11    11    11    11    11
 11    11    11    11    11

   3374  3376  3377  2563  2564  2566  2567  2568  2569  2570  4574  4022  2885  2884  3794
2883  2549  4053  4054  4058
     11    11    11    11    11    11    11    11    11    11    11    11    11    11    11
 11    12    12    12    12

   4056  4057  4055  4059  4060  3458  2985  2986  2987  2988  2989  2990  2991  2993  2992
2995  2994  4458  4459  4460
     12    12    12    12    12    12    12    12    12    12    12    12    12    12    12
 12    12    12    12    13

   4461  4462  4464  4466  4465  4467  4470  4469  4468  4471  4472  4592  4591  3289  3290
3291  3292  3297  3298  3300
     13    13    13    13    13    13    13    13    13    13    13    13    13    13    13
 13    13    13    13    13

   3301  3302  3303  3304  3305  3307  3004  3005  2865  3893  3892  3891  3890  3889  3887
3353  3352  3351  3350  3348
     13    13    13    13    13    13    13    13    14    14    14    14    14    14    14
```

Chain_Anal_ID_b_Dmoj

```
 14    14    14    14    14

   3347  3346  3328  3343  3342  4586  4585  4583  4581  4580  3345  4579  4578  4577  4576
13544  4593  4594  4595  4596
     14    14    14    15    15    15    15    15    15    15    15    15    15    15    15
 15    15    15    15    15

   4597  4598  4599  2551  2552  2560  2556  3308  3309  3313  3311  3312  3314  3315  3316
3317  3318  3319  3320  3321
     15    15    15    15    15    15    15    15    15    15    15    15    15    15    15
 15    15    15    15    15

   3322  3324  3327  3331  3332  3334  3335  3336  3338  3340  3341  2572  2571  3066  3067
3068  3069  3070  3646  3645
     15    15    15    15    15    15    15    15    15    15    15    15    15    15    15
 15    15    15    16    16

   3644  3643  3617  3616  3618  3619  3620  3621  3623  3624  3543  3542  3540  3541  3534
3529  3528  3527  3533  3532
     16    16    16    16    16    16    16    16    16    16    16    16    16    16    16
 16    16    16    16    16

   3535  3501  3506  3505  3003  3002  3001  3000  2999  2998  2997  2996  4456  4454  4452
4450  4449  4448  4447  4446
     16    16    16    16    16    16    16    16    16    16    16    16    16    16    16
 16    16    16    16    16

   4443  4442  4441  4440  4438  4437  4436  4435  4434  4433  4432  4429  4431  4430  4427
4428  4426  4425  2984  3398
     16    16    16    16    16    16    16    16    16    16    16    16    16    16    16
 16    16    16    16    16

   3397  3396  3395  4540  3394  3393  3392  3389  3391  3390  3388  3387  3386  4626  3384
3382  3383  3381  3379  3378
     16    16    16    16    16    16    16    16    16    16    16    16    16    16    16
 16    16    16    16    16

   2562  2561  3886  3885  3884  3883  3882  3477  3502  3668  3667  3666  3664  3663  3661
3660  3659  3657  3658  3655
     16    16    16    16    16    16    16    17    17    17    17    17    17    17    17
 17    17    17    17    17

   3656  3654  3652  3651  3650  3649  3648  3647  4633 13387  3811 13489 13641 13642 13639
4630  4631  4629 13391 13388
     17    17    17    17    17    17    17    17    18    18    18    18    18    18    18
 18    18    18    18    18

  13380  2220 13379 13539  3117 13385 13381  4628  4627  4625  4624  4623  4622  4621  3675
2981  2980  2979  2978  2977
     18    18    18    18    18    18    18    18    18    18    18    18    18    18    18
 18    18    18    18    18

   2976  2975  2971  2974  2973  2972  2969  2968  2967  2966  2965  2964  2963  2962  2960
2959  2957  2956  3445  2954
     18    18    18    18    18    18    18    18    18    18    18    18    18    18    18
 18    18    18    18    18

   2958  2953  2949  2948  2947  2898  2901  2902  2903  2904  2905  2907  2906  3653  2908
2909  2910  2911  2912  2913
     18    18    18    18    18    18    18    18    18    18    18    18    19    19    20    20
 20    20    20    20    20

   2914  2915  2916  2917  2918  2919  2920  2921  2922  2923  2924  3025  3024  3023  3022
3021  3065  4573  4572  4571
     20    20    20    20    20    20    20    20    20    20    20    20    20    20    20
```

Chain_Anal_ID_b_Dmoj

```
 20    20    20    20    20

   4570  4569  2864  2866  2867  2869  2868  2870  2873  2874  2875  2876  2877  2878  2880
2881  2882  2879  3034  3033
     20    20    20    20    20    20    20    20    20    20    20    20    20    20    20
 20    20    20    21    21

   3032  3031  3028  3029  3027  3026  2925  2926  2927  2928  2929  2930  2931  2932  2933
2934  2935  2936  2937  2938
     21    21    21    21    21    21    21    21    21    21    21    21    21    21    21
 21    21    21    21    21

   2939  2941  2942  2944  2943  2946  2897  2893  2892  2891  2890  3836  2889  2888  2887
4575  4020  4019  4018  4017
     21    21    21    21    21    21    21    21    21    21    21    21    21    21    21
 21    21    21    21    21

   4016  4014  4015  4013  4012  4011  4010  4009  4007  4006  4005  4004  4003  4002  4000
2644  2643  3999  3997  3996
     21    21    21    21    21    21    21    21    21    21    21    21    21    21    21
 21    21    21    21    21

   3993  3992  3991  3988  3987  4348  4347  4346  4345  4344  4343  4342  4341  4340  4541
4337  4338  4339  3237  3238
     21    21    21    21    21    21    21    21    21    21    21    21    21    21    21
 21    21    21    21    21

   3239  3240  2983  2982  4620  4618  4614  4612  4607  4603  4606  4604  4602  4601  4600
3288  3287  3286  3285  3284
     21    21    22    22    22    22    22    22    22    22    22    22    22    22    22
 22    23    23    23    23

   3283  2595  2361  2360  2359  2358  2357  2606  2826  2612  2611  3671  3672  3676  3677
3679  3681  3684  4491  2823
     23    23    23    23    23    23    23    23    23    23    23    23    23    23    23
 23    23    23    23    23

   2822  2821  2820  4142  4143  4144  4145  4146  3156  3155  3153  3152  3151  3150  3149
3795  3800  3801  3804  3802
     23    23    23    23    23    23    23    23    23    23    23    23    23    23    23
 23    23    23    23    23

   3803  3805  3806  3807  3808  3814  3815  3816  3817  3818  3819  3820  3821  3822  3823
2586  2587  2588  2589  2590
     23    23    23    23    23    23    23    23    23    23    23    23    23    23    23
 24    24    24    24    24

   2591  2592  2593  2594  2362  2365  2364  2367  2368  2369  2371  2374  2375  2376  2378
2382  2383  2384  2385  2386
     24    24    24    24    24    24    24    24    24    24    24    24    24    24    24
 24    24    24    24    24

   2388  2389  2391  2390  2392  2393  2395  2396  2398  2400  2402  2403  2405  2406  2800
2799  2453  4115  4114  4113
     24    24    24    24    24    24    24    24    24    24    24    24    24    24    24
 24    24    24    24    24

   4112  4111  4110  4109  4108  4107  4106  4105  4104  4103  4101  3642  3641  3640  3639
3638  3637  3636  3010  3635
     24    24    24    24    24    24    24    24    24    24    24    24    24    24    24
 24    24    24    25    25

   3634  3633  3631  3629  3628  3627  3626  3544  3545  3546  2399  2618  2617  2619  2620
2622  2623  2624  2626  2628
     25    25    25    25    25    25    25    25    25    25    25    25    25    25    25
```

Chain_Anal_ID_b_Dmoj

```
 25    25    25    25    25

   2629  2630  2631  2634  3741  3742  3743  3744  3746  3748  4247  4298  4297  4296  4295
3177  3176  3175  3174  2467
     25    25    25    25    25    25    25    25    25    25    25    25    25    25    25
 25    25    25    25    25

   2466  2465  2464  2461  2460  2459  2458  2457  2456  2455  2761  2760  2409  2408  2407
2801  2802  2803  2804  2805
     25    25    25    25    25    25    25    25    25    25    25    25    25    25    25
 25    25    25    25    25

   2806  2807  2808  2809  2810  2813  3157  3158  3159  3161  3162  3163  3164  3165  3168
3169  3170  2641  2642  2645
     25    25    25    25    25    25    26    26    26    26    26    26    26    26    26
 26    26    26    26    26

   2256  2255  2254  2253  2252  2250  2251  2249  2248  2246  2245  2244  2243  2242  2240
2241  2239  2238  2237  2236
     26    26    26    26    26    26    26    26    26    26    26    26    26    26    26
 26    26    26    26    26

   2235  2234  2233  2707  2705  2704  2702  2701  2700  2695  2694  2693  2692  4314  4315
4316  4317  4318  2757  2756
     26    26    26    26    26    26    26    26    26    26    26    26    26    26    26
 26    26    26    26    26

   2790  2789  2788  2787  2792  2793  3214  3213  3212  3211  3210  3209  3208  3207  3206
3205  3204  3203  2499  2498
     26    26    26    26    26    26    26    26    26    26    26    26    26    26    26
 26    26    26    26    26

   3198  3199  3201 13509  3200  3202  2500  2502  2503  2504  2506  2507  2508  2509  2510
2511  2512  2515  2514  2817
     26    26    26    26    26    26    26    26    26    26    26    26    26    26    26
 26    26    26    26    26

   2815  2816  2814  4147  4148  4149  4150  4151  4152  4153  4154  4155  4156  4157  4158
4159  3721  3722  3724  4313
     26    26    26    27    27    27    27    27    27    27    27    27    27    27    27
 27    27    27    27    27

   3725  3726  3727 13504 13655  3728  3729  3730  3731  3574  3573  3572  3571  3563  3562
3561  3552  3559  3558  3560
     27    27    27    27    27    27    27    27    27    28    28    28    28    28    28
 28    28    28    28    28

   3557  3555  3554  3553  3551  3550  3549  4550  4549  4548  4547  4546  4545  4544  4543
4539  4538  4537  4536  4535
     28    28    28    28    28    28    28    28    28    28    28    28    28    28    28
 28    28    28    28    28

   4533  4531  4529  4527  4524  4526  4525  4522  4521  2263  2257  2261  2262  2260  2259
3118  3119  3120  3121  3124
     28    28    28    28    28    28    28    28    28    28    28    28    28    28    28
 28    28    28    28    28

   2819  2818  2517  2518  2519  2520  2521  2523  2527  2528  2526  2530  2532  2529  2531
2533  2534  2536  2537  2535
     28    28    28    28    28    28    28    28    28    28    28    28    28    28    28
 28    28    28    28    28

   2538  2539  2540  2541  2542  2543  2755  2754  2753  2752  2749  2748  2746  2743  2742
2741  2738  2739  2737  4477
     28    28    28    28    28    28    28    28    28    28    28    28    28    28    28
```

Chain_Anal_ID_b_Dmoj

```
 28    28    28    28    28

   4476  4475  4023  4024  4025  4026  4027  4032  4033  4034  4035  4036  4037  4038  4039
4040  4041  4042  4043  4044
     28    28    28    28    28    28    28    28    28    28    28    28    28    28    28
 28    28    28    28    28

   4045  4048  4047  4046  4049  4050  4051  4052  2548  2547  2546  4175  4174  4173  4168
4169  4170  4167  4514  4513
     28    28    28    28    28    28    28    28    28    28    28    28    28    28    29
 29    29    29    30    30

   4512  4511  4510  4509  4508  4506  4505  4504  4503  4502  4500  4499  4498  2447  2446
2445  2444  2443  2441  2440
     30    30    30    30    30    30    30    30    30    30    30    30    30    30    30
 30    30    30    30    30

   2439  2437  2436  2435  2434  2433  2432  2429  2427  2426  2425  2419  2421  2417  2420
2415  2414  2412  2411  2410
     30    31    31    31    31    31    31    31    31    31    31    31    31    32    32
 33    33    33    33    33

   3789  4138  4137  4135  4136  4134  4133  4131  4130  4128  4125  4126  4127  4124  4123
4122  4121  4120  2585  2583
     33    33    33    33    33    33    33    33    33    33    33    33    33    33    33
 33    33    33    34    34

   3713  3709  3712  3706  3707  3708  3705  3704  3703  3701  3699  3700  3698  3697  3696
3694  3695  3693  3692  3691
     34    34    34    34    34    34    34    34    34    34    34    34    34    34    34
 34    34    34    34    34

   3690  3689  3688  3687  3686  3271  3685  3172  3173  3171  2794  2795  2731  2796  2797
2798  4495  4493  2468  2469
     34    34    34    34    34    34    34    34    34    34    35    35    35    35    35
 35    35    35    35    35

   2470  2471  2472  2474  2475  2476  2482  2486  4619  2487  2489  2490  2491  2492  2493
2494  2495  2497  2496  3197
     35    35    35    35    35    36    36    36    36    36    36    36    36    36    36
 36    36    36    36    36

   3196  3194  2582  3711  3714  3715  3716  3717  3718  3719  3084  3720  3723  4162  4163
4164  4165  4166  4515  4516
     36    36    36    37    37    38    38    38    38    38    38    38    38    38    38
 38    38    38    39    39

  13536 13529 13492 13625  3481  3487  3484  3482  3490  3474  3489  3473  3472  3480  3492
3471  3511  3463  3524  3499
     39    39    39    39    39    39    39    39    39    39    40    40    41    41    41
 41    41    42    42    43

   3521  3522  4610  3518  3496  3457  2834  2835  2836  2837  2838  2839  2840  2842  2598
2597  2596  3282  3281  3280
     44    44    45    46    46    46    47    47    47    47    47    47    47    47    47
 47    47    47    47    47

   3278  3277  3276  3400  3401  3402  3403  3404  3405  3406  3407  3408  3409  3410  3412
3411  3413  3414  3415  3416
     47    47    47    48    48    48    48    48    48    48    48    48    48    48    49
 49    50    50    50    50

   3364  3363  3362  3361  3359  3007  2828  3008  3009  3011  3012  3013  3059  3060  3061
3062  3063  3064  3015  3014
     50    50    50    50    50    50    50    50    50    50    50    50    50    50    50
```

Chain_Anal_ID_b_Dmoj

```
 50    50    50    50    50

   3016  3017  3018  3019  3058  3057  3056  3055  3053  3052  3051  3048  3050  3049  3047
3045  3044  3043  3042  3041
     50    50    50    50    50    50    50    50    50    50    50    50    50    50    50
 50    50    50    50    50

   3040  3038  3037  3035  3036  2686  2683  2682  2681  2680  2679  2677  2675  2674  2673
2672  2670  2671  2668  2669
     50    50    50    50    50    50    50    50    50    50    50    50    50    50    50
 50    50    50    50    50

   2666  2665  2664  2663  2662  2661  2660  2659  2658  2657  2656  2655  2654  2652  2651
2650  2649  2648  2647  2646
     50    50    50    50    50    50    50    50    50    50    50    50    50    50    50
 50    50    50    50    50

   3116  3115  3114  3113  3112  3111  3110  3109  3108  3107  3106  3104  3103  3102  3101
3100  3099  3098  3096  3097
     50    50    50    50    50    50    50    50    50    50    50    50    50    50    50
 50    50    50    50    50

   3095  3092  3091  3090  3089  3088  3087  3086  3085  3083  2778  2779  2780  2781  3602
3600  3599  3598  3597  3596
     50    50    50    50    50    50    50    50    50    50    50    50    50    50    50
 50    50    50    50    50

   3595  3601  3594  3591  3590  3589  3588  3587  3586  3585  3584  3583  3581  3579  3578
3577  3576  3575  3732  3733
     50    50    50    50    50    50    50    50    50    50    50    50    50    50    50
 50    50    50    51    51

   3734  3735  3736  3737  3738  3739  3740  2635  2636  2637  2638  2639  3217  3218  3215
3219  3220  3221  3222  3223
     51    51    51    52    52    52    52    52    52    52    52    52    52    52    52
 52    52    52    52    52

   3224  3225  3226  3227  3228  3229  3230  3231  3232  3233  3234  4331  4329  4328  4327
4326  4325  4324  4323  4322
     52    52    52    52    52    52    52    52    52    52    52    52    52    52    52
 52    52    52    52    52

   4321  4320  4319  4286  4287  4288  4289  4290  4291  4292  4293  4294  3178  3179  3181
3182  3183  3184  3185  3187
     52    52    52    52    52    52    52    52    52    53    53    53    53    53    53
 53    53    53    53    53

   3188  3189  3190  3191  3193  4517  4518  4519  4520  4209  4210  4211  4212  4213  4214
4215  4216  4217  4220  4219
     53    53    53    53    53    53    53    53    53    53    53    53    53    53    53
 53    53    53    53    53

   4221  4223  4224  4225  4226  4227  4228  4230  4229  4235  4237  4238  4239  4240  4241
4243  4245  4244  4246  3749
     53    53    53    53    53    53    53    53    53    53    53    53    53    53    53
 53    53    53    53    53

   3750  3754  3751  3756  3757  3758  3759  3760  4490  4488  4489  4487  3782  4486  4484
4483  4482  4481  4480  4478
     53    53    53    53    53    53    53    53    53    53    53    53    53    53    53
 53    53    53    53    53

   2736  2735  2734  2733  2732  2730  2729  2728  2727  2726  2725  2724  2723  4309  4310
4307  4306  4308  4305  4304
     53    53    53    53    53    53    53    53    53    53    53    53    53    54    54
```

Chain_Anal_ID_b_Dmoj

54 54 54 54 54

4303 4300 4299 4302 4248 4250 4249 4251 4253 4254 4255 4256 4258 4259 4260
4263 4264 4265 4267 4268
54 54 54 54 54 54 54 54 54 54 54 54 54 54 54
55 55 55 55 55

4269 4270 4271 4272 4273 4274 4275 4276 4278 4279 4280 4282 4281 4283 4284
4285 2264 2265 2266 2267
55 55 55 55 55 55 55 55 55 55 55 56 56 56 56 57
57 58 58 58 58

2268 2269 2270 2271 2272 2273 2274 2275 2276 2277 2278 2279 2280 2281 2282
2283 2284 2285 2286 2287
58 58 58 58 58 58 58 58 58 58 58 58 58 58 58
58 58 58 58 58

2288 2289 2290 2291 2292 2293 2294 2295 2296 2301 2303 2304 2308 2309 2310
2312 2313 2314 2315 2316
58 58 58 58 58 58 58 58 58 58 58 58 58 58 58
58 58 58 58 58

2317 2318 2319 2320 2321 2322 2323 2324 2325 2326 2327 2328 2329 2330 2331
2334 2335 3131 3132 3136
58 58 58 58 58 58 58 58 58 58 58 58 58 58 58
58 58 58 58 58

3135 3134 3133 3137 3141 3139 3138 3140 4560 4558 4561 4562 4563 4564 4565
4566 4567 4568 2863 2862
58 58 58 58 58 58 58 58 58 58 58 58 58 58 58
58 58 58 58 58

2861 2860 2859 2858 2857 2856 2855 2853 2854 2851 2850 2849 2848 2846 2847
2845 2602 2603 2604 2605
58 58 58 58 58 58 58 58 58 58 58 58 58 58 58
58 58 58 58 58

2356 2355 2354 2353 2352 2351 2350 2348 2347 2346 2345 2344 2343 2342 2341
2340 2339 2337 2716 2717
58 58 58 58 58 58 58 58 58 58 58 58 58 58 58
58 58 58 58 58

2719 2720 2721 2722 4311 2691 2690 2689 2688 2687 2773 2771 2770 2769 2768
2767 2766 2765 2764 2763
58 58 58 58 59 59 59 59 59 59 59 59 59 59 59
59 59 59 59 59

2762 2454 4551 4552 4553 4555 4556 4557 4559 3143 3142 3144 3145 3147 3148
3793 3792 3790 3788 3786
59 59 59 59 59 60 60 60 60 60 60 60 60 60 60
60 60 60 60 60

3787 3784 3785 3783 3781 3779 3780 3778 3774 3771 3773 3768 3767 3766 3765
3764 3761 3547 3548 2774
60 60 60 60 60 60 60 60 60 60 60 60 60 60 60
60 60 60 60 60

2775 2776 3082 3080 3079 3078 3077 3075 4099 4100 3612 3610 3609 2448 3608
3607 3605 3604 3603 2785
60 60 60 60 60 60 60 60 60 60 60 60 60 60 60
60 60 60 60 60

2786 2791 2544 4176 4179 4181 4182 4188 4193 4194 4195 4186 4197 4198 4199
4200 4201 4203 4202 4204
60 60 60 60 60 60 60 60 60 60 61 61 62 63 63

Chain_Anal_ID_b_Dmoj

63	63	63	63	63												
	4205	2758	2759	3125	3126	3127	3129	3128	3130	2714	2711	2710	2709	2708	2232	2231
2230	2228	2229	2227													
	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63
63	63	63	63	63												
	2226	2224	2225	2222	2221	2214	2215	2216	2217	2218	2219	2212	0	0	0	0
0	0	0	0	0												
	63	63	63	63	63	63	63	63	63	63	63	63	0	0	0	0
0	0	0	0	0												

Chain_Anal_ID_c_Dmoj

Appendix C. Linkage Chain Analysis for the Muller C Element Comparison of D. virilis and D. mojavensis

Breakpoints Remaining= 70 (D.vir lineage inversion)(2)

Chain 1	left CLG		right CLG		
BP_001_002	5972	7034	6247	4668	
BP_003_004	4913	5233	4842	5905	
BP_005_006	4918	4919	5109	5108	

Breakpoints Remaining= 68 (D.vir lineage inversion)(2)

Chain 2	left CLG		right CLG		
BP_004_005	4842	5905	4918	4919	
BP_002_003	6247	4668	4913	5233	

Breakpoints Remaining= 66 (D.moj lineage inversion)(1)

Chain 3	left CLG		right CLG		
BP_006_007	5109	5108	5107	4800	A
BP_064_065	4884	5964	5232	5089	A by inference

Breakpoints Remaining= 64 (D.vir lineage inversion)(1)

Chain 4	left CLG		right CLG		
BP_008_009	5090	6338	6341	6340	
BP_009_010	6341	6340	6343	5494	

Breakpoints Remaining= 62 (D.vir lineage inversion)(1)

Chain 5	left CLG		right CLG		
BP_010_011	6343	5494	6829	6633	
BP_012_013	6415	5495	6828	4849	

Breakpoints Remaining= 60 (D.vir lineage inversion)(1)

Chain 6	left CLG		right CLG		
BP_011_012	6829	6633	6415	5495	
BP_021_022	5796	6414	6632	6631	

Breakpoints Remaining= 58 (D.moj lineage inversion)(1)

Chain 7	left CLG		right CLG		
BP_014_015	4848	6906	6905	5307	A
BP_013_014	6828	4849	4848	6906	A

Breakpoints Remaining= 56 (D.moj lineage inversion)(1)

Chain 8	left CLG		right CLG		
BP_016_017	5306	6277	6278	6279	A
BP_017_018	6278	6279	6274	4949	A by inference

Breakpoints Remaining= 54 (D.moj lineage inversion)(1)

Chain 9	left CLG		right CLG		
BP_018_019	6274	4949	4948	4938	A
BP_020_021	4937	6228	5796	6414	A by inference

Chain_Anal_ID_c_Dmoj

Breakpoints Remaining= 52	(D.moj lineage inversion)(1)					
Chain 10	left CLG		right CLG			
BP_019_020	4948	4938	4937	6228	A	
BP_015_016	6905	5307	5306	6277	A	
Breakpoints Remaining= 50	(D.moj lineage inversion)(1)					
Chain 11	left CLG		right CLG			
BP_022_023	6632	6631	6630	6831	A	
BP_059_060	6024	6488	6489	5762	A	
Breakpoints Remaining= 41						
Chain 12	left CLG		right CLG			
BP_024_025	5526	7143	7144	7144	A	
BP_028_029	7132	7117	7103	7103		
BP_071_072	7107	7108	6144	5522		
BP_073_074	6437	5051	7300	7300		
BP_061_062	5763	5052	4808	4885		
BP_007_008	5107	4800	5090	6338		
BP_065_066	5232	5089	7098	7098		
BP_025_026	7144	7144	7102	7111		
BP_027_028	7115	7115	7132	7117		
Breakpoints Remaining= 39	(D.moj lineage inversion)(1)					
Chain 13	left CLG		right CLG			
BP_072_073	6144	5522	6437	5051	A by inference	
BP_053_054	6153	7176	7175	6910	A	
Breakpoints Remaining= 37	(D.vir lineage inversion)(1)					
Chain 14	left CLG		right CLG			
BP_035_036	7100	7113	7128	7128		
BP_032_033	7101	7101	7129	7129		
Breakpoints Remaining= 35	(d.vir lineage inversion)(1)					
Chain 15	left CLG		right CLG			
BP_026_027	7102	7111	7115	7115	A	
BP_067_068	7119	7119	7099	7099	A by inference	
Breakpoints Remaining= 33	(D.vir lineage inversion)(1)					
Chain 16	left CLG		right CLG			
BP_039_040	7088	7086	7080	7083		
BP_040_041	7080	7083	7078	6753		

Chain_Anal_ID_c_Dmoj

Breakpoints Remaining= 31 (D.vir lineage inversion)(2)

Chain 17	left CLG		right CLG		
BP_041_042	7078	6753	6768	6752	
BP_042_043	6768	6752	6751	6750	
BP_043_044	6751	6750	6743	5876	

Breakpoints Remaining= 29 (D.vir lineage inversion)(1)

Chain 18	left CLG		right CLG		
BP_030_031	7116	7116	7118	7131	
BP_031_032	7118	7131	7101	7101	

Breakpoints Remaining= 27 (D.moj lineage inversion)(1)

Chain 19	left CLG		right CLG		
BP_055_056	6025	5521	5523	5656	A
BP_060_061	6489	5762	5763	5052	A

Breakpoints Remaining= 24 (D.vir lineage inversion)(2)

Chain 20	left CLG		right CLG		
BP_049_050	5012	6562	6565	6169	
BP_047_048	5870	6557	6570	6558	
BP_048_049	6570	6558	5012	6562	

Breakpoints Remaining= 22 (D.vir lineage inversion)(1)

Chain 21	left CLG		right CLG		
BP_051_052	6166	6165	6163	6154	
BP_050_051	6565	6169	6166	6165	

Breakpoints Remaining= 20 (D.vir lineage inversion)(1)

Chain 22	left CLG		right CLG		
BP_057_058	5453	4686	5452	5976	
BP_056_057	5523	5656	5453	4686	

Breakpoints Remaining= 17 (D.vir lineage inversion)(2)

Chain 23	left CLG		right CLG		
BP_045_046	5872	5875	5871	5871	
BP_046_047	5871	5871	5870	6557	
BP_044_045	6743	5876	5872	5875	

Breakpoints Remaining= 15 (D.vir lineage inversion)(1)

Chain 24	left CLG		right CLG		
BP_062_063	4808	4885	4883	4882	
BP_063_064	4883	4882	4884	5964	

Breakpoints Remaining= 13 (D.vir lineage inversion)(1)

Chain 25	left CLG		right CLG		
BP_058_059	5452	5976	6024	6488	

```
                                  Chain_Anal_ID_c_Dmoj
  BP_054_055         7175   6910 |  6025   5521
                    ---------------------------

Breakpoints Remaining=  11     (D.moj lineage inversion)(1)
Chain 26            left CLG          right CLG
  BP_052_053         6163   6154 |  6153   7176        A
                    ---------------------------
  BP_023_024         6630   6831 |  5526   7143        A by inference
                    ---------------------------

Breakpoints Remaining=   1
Chain 27            left CLG          right CLG
  BP_068_069         7099   7099 |  7097   7096
                    ---------------------------
  BP_038_039         7114   7114 |  7088   7086
                    ---------------------------
  BP_070_071         7121   7139 |  7107   7108
                    ---------------------------
  BP_069_070         7097   7096 |  7121   7139
                    ---------------------------
  BP_034_035         7120   7120 |  7100   7113
                    ---------------------------
  BP_037_038         7130   7130 |  7114   7114
                    ---------------------------
  BP_033_034         7129   7129 |  7120   7120
                    ---------------------------
  BP_036_037         7128   7128 |  7130   7130
                    ---------------------------
  BP_029_030         7103   7103 |  7116   7116
                    ---------------------------
  BP_066_067         7098   7098 |  7119   7119
                    ---------------------------

Breakpoints Remaining=   0
Chain 28            left CLG          right CLG



Chain Analysis Summary Data
---------------------------

Chains with  2 Breakpoints=  22
Chains with  3 Breakpoints=   4
Chains with  4 Breakpoints=   0
Chains with  5 Breakpoints=   0
Chains with  6 Breakpoints=   0
Chains with  7 Breakpoints=   0
Chains with  8 Breakpoints=   0
Chains with  9 Breakpoints=   1
Chains with 10 Breakpoints=   1
Chains with 11 Breakpoints=   0
Chains with 12 Breakpoints=   0

Number of Inversions=  45
Number of Breakpoints=  73
Reusage Index=     1.233


Conserved Linkage Group Intervals
---------------------------------

CLG  No.Genes  Left_IDX  Right_IDX  Left_Gene  Right_Gene
  1        29         1         29       5972        7034
  2        29        30         58       6247        4668
```

				Chain_Anal_ID_c_Dmoj	
3	22	59	80	4913	5233
4	162	81	242	4842	5905
5	2	243	244	4918	4919
6	2	245	246	5109	5108
7	20	247	266	5107	4800
8	41	267	307	5090	6338
9	2	308	309	6341	6340
10	9	310	318	6343	5494
11	6	319	324	6829	6633
12	20	325	344	6415	5495
13	147	345	491	6828	4849
14	84	492	575	4848	6906
15	9	576	584	6905	5307
16	79	585	663	5306	6277
17	2	664	665	6278	6279
18	48	666	713	6274	4949
19	8	714	721	4948	4938
20	130	722	851	4937	6228
21	12	852	863	5796	6414
22	2	864	865	6632	6631
23	75	866	940	6630	6831
24	24	941	964	5526	7143
25	1	965	965	7144	7144
26	2	966	967	7102	7111
27	1	968	968	7115	7115
28	4	969	972	7132	7117
29	1	973	973	7103	7103
30	1	974	974	7116	7116
31	2	975	976	7118	7131
32	1	977	977	7101	7101
33	1	978	978	7129	7129
34	1	979	979	7120	7120
35	2	980	981	7100	7113
36	1	982	982	7128	7128
37	1	983	983	7130	7130
38	1	984	984	7114	7114
39	6	985	990	7088	7086
40	6	991	996	7080	7083
41	182	997	1178	7078	6753
42	2	1179	1180	6768	6752
43	2	1181	1182	6751	6750
44	41	1183	1223	6743	5876
45	2	1224	1225	5872	5875
46	1	1226	1226	5871	5871
47	34	1227	1260	5870	6557
48	2	1261	1262	6570	6558
49	2	1263	1264	5012	6562
50	65	1265	1329	6565	6169
51	2	1330	1331	6166	6165
52	6	1332	1337	6163	6154
53	22	1338	1359	6153	7176
54	33	1360	1392	7175	6910
55	29	1393	1421	6025	5521
56	93	1422	1514	5523	5656
57	2	1515	1516	5453	4686
58	45	1517	1561	5452	5976
59	14	1562	1575	6024	6488
60	115	1576	1690	6489	5762
61	32	1691	1722	5763	5052
62	89	1723	1811	4808	4885
63	2	1812	1813	4883	4882
64	29	1814	1842	4884	5964
65	39	1843	1881	5232	5089
66	1	1882	1882	7098	7098
67	1	1883	1883	7119	7119

				Chain_Anal_ID_c_Dmoj	
68	1	1884	1884	7099	7099
69	2	1885	1886	7097	7096
70	2	1887	1888	7121	7139
71	2	1889	1890	7107	7108
72	20	1891	1910	6144	5522
73	18	1911	1928	6437	5051
74	1	1929	1929	7300	7300

Gene List and Conserved Linkage Group Calls

5972	5971	5970	5342	5341	5339	5338	5337	5336	5567	5566	5564	5563	5562	5561	5560
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5559	5603	5604	5122												
1	1	1	1												

6674	6675	5143	5144	5145	7039	7037	7035	7034	6247	6246	6245	6244	5469	5468	5467
1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2
5464	5459	5458	5457												
2	2	2	2												

5456	5455	5454	4684	4683	4682	4681	4680	4679	4677	4703	4675	4674	4673	4672	4671
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
4669	4668	4913	4912												
2	2	3	3												

4911	4909	4908	4907	4906	4905	4904	4903	4900	4899	5352	5351	5350	5348	5347	5346
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
5345	5967	5966	5233												
3	3	3	3												

4842	4841	4840	4839	4838	4837	5099	5100	5101	5102	5103	5104	4767	4766	4765	4764
4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
4763	4762	4756	4755												
4	4	4	4												

5121	5120	5119	5118	5117	5116	5115	5113	5112	5111	6619	6618	6617	6614	6607	6605
4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
6604	6601	6600	6599												
4	4	4	4												

5647	6598	6597	6596	6595	6594	6593	6592	6590	6589	6588	6587	6585	6584	6583	6582
4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
6581	6580	6578	6051												
4	4	4	4												

6052	6053	6054	7262	7263	7264	7266	7267	7265	7268	7269	5393	5392	5391	5389	5387
4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
5388	5558	5557	5555												
4	4	4	4												

5554	5553	5148	5149	5150	5151	5152	5153	5154	5155	5156	5157	5158	5159	5160	5161
4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
5162	5163	5164	6381												
4	4	4	4												

5353	5354	5146	5366	5376	5377	5378	5379	5380	5381	5386	5385	5602	5601	5600	5599
4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
5598	5597	5596	5595												
4	4	4	4												

5594	5593	5592	5591	5590	5589	6055	6056	6057	6058	6059	6060	6061	7004	7005	7006
4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
7007	7008	6800	6826												
4	4	4	4												

Chain_Anal_ID_c_Dmoj

```
   6803  6804  6807  6808  6904  4663  4664  4665  5921  5920  4910  5917  5916  5915  5914
5913  5912  5911  5909  5908
      4     4     4     4     4     4     4     4     4     4     4     4     4     4     4
  4     4     4     4     4

   5907  5905  4918  4919  5109  5108  5107  5106  5105  4768  4769  4770  4772  4771  4788
4789  4790  4791  4793  4794
      4     4     5     5     6     6     7     7     7     7     7     7     7     7     7
  7     7     7     7     7

   4796  4795  4797  4799  4801  4800  5090  5091  5092  5094  6240  6242  6243  6299  5221
5220  5219  5218  5217  5234
      7     7     7     7     7     7     8     8     8     8     8     8     8     8     8
  8     8     8     8     8

   5235  5236  5939  5938  5936  5933  5932  5930  5929  5927  5926  5924  5923  5922  4678
4666  4667  7181  6317  6320
      8     8     8     8     8     8     8     8     8     8     8     8     8     8     8
  8     8     8     8     8

   6321  6322  6323  6324  6325  6337  6338  6341  6340  6343  6344  6366  5488  5490  5491
5492  5493  5494  6829  6830
      8     8     8     8     8     8     8     9     9    10    10    10    10    10    10
 10    10    10    11    11

   6636  6635  6634  6633  6415  6416  6417  6418  6421  6424  6423  6425  6427  6429  6430
6431  6434  6435  6316  5019
     11    11    11    11    12    12    12    12    12    12    12    12    12    12    12
 12    12    12    12    12

   5018  5016  5015  5495  6828  6827  6825  6824  6823  6819  6818  6817  6815  6813  6812
6903  6902  6901  6900  6899
     12    12    12    12    13    13    13    13    13    13    13    13    13    13    13
 13    13    13    13    13

   6897  6896  5791  5790  5789  5788  5787  5786  5785  5784  5783  4852  4853  5249  5248
5247  6676  5246  6677  6680
     13    13    13    13    13    13    13    13    13    13    13    13    13    13    13
 13    13    13    13    13

   6679  6682  6683  6081  6080  6079  6078  6077  6074  6076  6075  6073  6072  6071  6068
6067  6066  6064  6678  7003
     13    13    13    13    13    13    13    13    13    13    13    13    13    13    13
 13    13    13    13    13

   7002  7001  7000  6998  6997  6996  6995  6994  6993  6987  6985  6984  6983  6982  6981
6975  6976  7022  7023  7024
     13    13    13    13    13    13    13    13    13    13    13    13    13    13    13
 13    13    13    13    13

   7026  6973  6974  6979  6977  7016  7015  7014  7012  7010  7009  6799  6798  6797  5549
6459  6460  6461  6467  5527
     13    13    13    13    13    13    13    13    13    13    13    13    13    13    13
 13    13    13    13    13

   5534  5539  5540  5542  5547  5548  5551  5552  5583  5582  5581  5578  5577  6086  6084
6083  6684  6685  6686  6688
     13    13    13    13    13    13    13    13    13    13    13    13    13    13    13
 13    13    13    13    13

   6689  6690  6692  6693  6694  6695  6697  6698  6699  6702  6706  6708  6709  6710  5769
5770  5771  5772  5774  5775
     13    13    13    13    13    13    13    13    13    13    13    13    13    13    13
 13    13    13    13    13
```

Chain_Anal_ID_c_Dmoj

5776	5451	5777	5778	5779	5780	5781	5782	4851	4850	4849	4848	4845	4844	4843	5213
5212	5211	6011	6010												
13	13	13	13	13	13	13	13	13	13	13	14	14	14	14	14
14	14	14	14												
6009	6007	6006	6005	6004	6003	6002	6001	6000	5999	5998	5997	5996	5995	5993	5994
5992	5991	5990	5989												
14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
14	14	14	14												
5988	5987	5986	5984	5985	5983	7270	7271	7273	7274	7275	7276	7277	7278	7280	7281
7282	7283	7285	7286												
14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
14	14	14	14												
5575	5574	5573	5572	5571	5569	6272	6271	6268	6269	6266	6265	6264	6263	6262	6261
6260	6259	6258	6257												
14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
14	14	14	14												
6256	6255	6253	6252	6251	7197	4924	4926	4928	4923	5974	5975	6908	6907	6906	6905
4662	5314	5313	5312												
14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	15
15	15	15	15												
5311	5310	5308	5307	5306	5305	5304	5303	5302	5300	5299	5298	5297	5296	5295	5294
5292	5291	5290	5288												
15	15	15	15	16	16	16	16	16	16	16	16	16	16	16	16
16	16	16	16												
5287	5286	5282	5281	5279	5276	5274	5273	5272	5271	5270	5269	5268	5267	5266	5264
5265	5263	5261	5259												
16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
16	16	16	16												
5258	5257	5256	5254	5253	5252	6311	6312	5614	5613	5612	5609	5606	5605	4753	4752
4751	4750	4748	4747												
16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
16	16	16	16												
4746	4745	4744	4743	4742	4741	4740	4739	4738	4736	4735	4734	4733	4729	4730	4728
4727	4726	4725	4724												
16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
16	16	16	16												
4723	6273	6277	6278	6279	6274	6281	6282	6283	6284	6285	6288	6292	6294	6295	6296
6297	6298	5222	5223												
16	16	16	17	17	18	18	18	18	18	18	18	18	18	18	18
18	18	18	18												
5245	5243	5242	5241	5240	5941	5942	5943	5944	5945	5946	5251	5195	7145	7146	7147
7148	7149	7150	7152												
18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
18	18	18	18												
7153	7154	4963	4960	4959	4958	4957	4956	4955	4953	4952	4950	4949	4948	4947	4944
4943	4942	4941	4939												
18	18	18	18	18	18	18	18	18	18	18	18	18	19	19	19
19	19	19	19												
4938	4937	4935	4934	4933	4931	4930	4929	7198	7200	7201	7203	7204	7205	7206	7207
7208	7209	7210	7211												
19	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
20	20	20	20												

Chain_Anal_ID_c_Dmoj

7212	7213	7214	7215	4881	4879	4880	4878	4877	4876	4875	4874	4873	4870	4868	4863
4864	4862	4861	4860												
20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
20	20	20	20												
4859	4858	4857	4856	4855	5134	5133	5132	5131	5126	5124	5123	6673	6672	6671	6670
6668	6667	6666	6664												
20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
20	20	20	20												
6663	6662	6385	6386	6388	6390	6392	6393	6394	6396	6398	6395	6400	6401	6402	6403
6404	6405	6407	6408												
20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
20	20	20	20												
6889	6888	6887	6885	6884	6883	6882	6880	6879	6876	6319	6875	6873	6872	6871	6870
6868	6867	6866	6865												
20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
20	20	20	20												
6859	6858	6857	6034	6035	6036	6037	6038	6039	6040	6041	6042	6044	6046	6048	6050
6577	6576	6575	6574												
20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
20	20	20	20												
5811	5810	5809	5808	5807	5805	5803	5801	5800	5799	6228	5796	5798	5795	5794	5793
5792	6895	6409	6410												
20	20	20	20	20	20	20	20	20	20	20	21	21	21	21	21
21	21	21	21												
6411	6412	6414	6632	6631	6630	6629	6628	6627	6626	6625	6624	6622	6621	6620	5615
5616	5618	5619	5409												
21	21	21	22	22	23	23	23	23	23	23	23	23	23	23	23
23	23	23	23												
5410	5411	5412	5413	5414	5415	5416	5417	5418	5420	5422	5424	5426	5427	5428	5429
5430	5431	5432	5433												
23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23
23	23	23	23												
5436	6179	6180	6181	6182	6183	6184	6185	6186	6187	6188	6192	6193	6194	6195	6196
6198	6201	6202	6203												
23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23
23	23	23	23												
6204	6205	6206	5856	5857	5858	5859	5860	5862	5863	5864	6841	6840	6839	6837	6834
6833	5238	6832	6831												
23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23
23	23	23	23												
5526	6637	6640	6641	6642	5323	5322	5321	5320	5318	5317	5316	5315	4651	4661	4642
4636	4644	4646	4645												
24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
24	24	24	24												
7140	7141	7122	7143	7144	7102	7111	7115	7132	7137	7110	7117	7103	7116	7118	7131
7101	7129	7120	7100												
24	24	24	24	25	26	26	27	28	28	28	28	29	30	31	31
32	33	34	35												
7113	7128	7130	7114	7088	7092	7091	7090	7087	7086	7080	7079	7081	7082	7085	7083
7078	7077	7073	7074												
35	36	37	38	39	39	39	39	39	39	40	40	40	40	40	40
41	41	41	41												

Chain_Anal_ID_c_Dmoj

7075	7071	7072	7070	7069	7068	7067	7066	7062	7061	6472	6473	6474	6478	6477	6476
6475	6480	6481	6482												
41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41
41	41	41	41	41											
6015	6014	5209	5208	5207	6013	6012	5141	5206	5205	5204	5203	5202	5201	5200	5199
6791	6788	6790	6789												
41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41
41	41	41	41	41											
6786	6785	6784	6783	6781	6780	6779	6133	6778	6777	6776	6773	6771	6772	6770	6769
6767	6765	6764	6763												
41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41
41	41	41	41	41											
6761	6762	6760	6238	6239	5042	5036	5035	5029	5027	5026	5045	5025	5023	5022	5021
5020	5829	5830	5831												
41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41
41	41	41	41	41											
6234	6233	6231	6230	6227	6225	6226	6224	6223	6222	6221	6220	6471	5645	6384	5712
5713	4721	4722	6540												
41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41
41	41	41	41	41											
6541	6543	6542	6544	6545	6546	6548	6550	5329	5328	5327	5326	5324	6643	6645	6646
6647	6648	6649	6650												
41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41
41	41	41	41	41											
6651	6652	6653	6655	6656	6657	6658	6659	6660	5659	5660	5661	4836	4835	4833	4832
4831	4830	4829	4827												
41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41
41	41	41	41	41											
4823	4821	4820	4819	4816	6115	6116	6117	6118	7043	7044	7045	7048	7049	7050	7051
5844	5846	5848	5849												
41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41
41	41	41	41	41											
5850	5851	5852	5853	5854	6207	6208	6209	6210	6235	6237	6236	6759	6758	6757	6755
6754	6753	6768	6752												
41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41
41	41	41	42	42											
6751	6750	6743	6742	6739	6738	6736	6735	6734	6733	6732	5819	5820	5821	5822	5823
5824	5825	5826	5827												
43	43	44	44	44	44	44	44	44	44	44	44	44	44	44	44
44	44	44	44	44											
5828	5904	5903	5902	5900	5898	5897	5896	5895	5893	5891	5889	5887	5888	5886	5884
5883	5882	5880	5879												
44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44
44	44	44	44	44											
5878	5877	5876	5872	5875	5871	5870	5013	5010	5009	5004	4995	5000	4999	4998	4994
4993	4992	4991	4985												
44	44	44	45	45	46	47	47	47	47	47	47	47	47	47	47
47	47	47	47	47											
4982	4979	4978	4973	4972	4971	4970	4967	4966	4965	4964	5894	6930	6931	6551	6552
6553	6555	6556	6557												
47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47
47	47	47	47	47											

Chain_Anal_ID_c_Dmoj

6570	6558	5012	6562	6565	6566	6567	6568	6569	6572	6027	6028	6029	6030	6031	6032
6310	6309	6308	6307												
48	48	49	49	50	50	50	50	50	50	50	50	50	50	50	50
50	50	50	50	50											
6306	6305	6304	6303	6302	6301	6300	5470	5472	5473	5474	5475	5476	5477	5478	5480
5481	5482	5483	5485												
50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
50	50	50	50	50											
5486	5487	5740	5739	5738	5736	5733	5731	5730	5729	5728	5727	5726	5725	5722	5717
5721	5719	5716	5715												
50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
50	50	50	50	50											
5714	4720	4719	4718	5438	5439	6178	6177	6169	6166	6165	6163	6162	6157	6156	6155
6154	6153	6152	6151												
50	50	50	50	50	50	50	50	50	51	51	52	52	52	52	52
52	53	53	53												
6249	6250	7196	7195	7194	7193	7188	7187	7186	7185	7191	7184	7183	7182	7180	7179
7178	7177	7176	7175												
53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53
53	53	53	54												
7174	7173	7172	7171	7170	7169	7168	7167	7166	7164	7163	7161	7160	7159	7158	7157
7156	7155	6928	6927												
54	54	54	54	54	54	54	54	54	54	54	54	54	54	54	54
54	54	54	54	54											
6926	6925	6924	6922	6921	6917	6916	6915	6914	6912	6911	6910	6025	6026	5812	5815
5816	5817	5818	6731												
54	54	54	54	54	54	54	54	54	54	54	54	55	55	55	55
55	55	55	55	55											
5765	5766	5865	5866	5867	5868	5869	5497	5499	5502	5503	5505	5504	5508	5509	5513
5514	5515	5517	5520												
55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55
55	55	55	55	55											
5521	5523	5524	5525	6468	6469	6470	4688	4687	5657	5658	5951	5952	5953	5954	5957
5959	6371	6368	6367												
55	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56
56	56	56	56	56											
5741	5742	5744	5746	5747	5748	6137	6134	6132	6131	5750	5751	5752	5753	5754	5250
6147	6148	6149	5749												
56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56
56	56	56	56	56											
6138	6139	5333	5334	5197	5196	5194	5192	5191	5190	5188	5187	5186	5185	5184	5181
5180	5179	5175	5174												
56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56
56	56	56	56	56											
5173	5171	5170	5169	6749	5168	5167	5166	5165	5408	5394	5689	5981	5980	5979	5832
5839	5840	7055	6519												
56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56
56	56	56	56	56											
7056	7057	7058	7059	7060	5646	5648	5649	5650	5651	5652	5654	5655	5656	5453	4686
5452	5450	5449	5448												
56	56	56	56	56	56	56	56	56	56	56	56	56	56	57	57
58	58	58	58												

Chain_Anal_ID_c_Dmoj

4717	5440	5441	5442	5445	5443	5444	5446	5447	4716	4715	4714	4713	4710	4709	4706
4705	4704	4701	4699												
58	58	58	58	58	58	58	58	58	58	58	58	58	58	58	58
58	58	58	58	58											
4696	4695	4694	4693	4692	6531	4691	4690	4689	6219	6218	6217	6216	6215	6214	6213
6212	6211	5978	5977												
58	58	58	58	58	58	58	58	58	58	58	58	58	58	58	58
58	58	58	58	58											
5976	6024	6023	6022	6021	6020	6019	6018	6017	6483	6484	6485	6486	6487	6488	6489
6491	6493	6494	6495												
58	59	59	59	59	59	59	59	59	59	59	59	59	59	59	60
60	60	60	60	60											
6496	6497	6498	6500	6501	6502	6503	6505	6506	6507	6508	6512	6513	6514	6515	6517
5512	6520	7192	6522												
60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
60	60	60	60	60											
6523	6525	6526	6527	6528	6529	6530	6532	6533	6534	6535	6536	6537	6539	5568	6140
6720	6719	6718	6717												
60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
60	60	60	60	60											
6715	6714	6713	6971	6970	6968	6965	6961	6958	6954	6953	6950	6949	6944	6943	6942
6938	6933	6932	6795												
60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
60	60	60	60	60											
6796	6458	6456	6088	6089	6090	6091	6092	6093	6094	6095	6096	6098	6097	6099	6103
6106	6107	6108	5588												
60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
60	60	60	60	60											
5587	5586	5585	5584	5147	6119	6120	6125	6126	6127	6128	6130	6248	7289	7290	7291
7292	7296	7299	5072												
60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
60	60	60	60	60											
7298	7297	5696	5757	5755	5758	5759	5760	5761	5762	5763	5764	6725	6726	6727	5686
5687	5690	5691	5693												
60	60	60	60	60	60	60	60	60	60	61	61	61	61	61	61
61	61	61	61	61											
6730	6729	6728	5070	5069	5068	5067	5066	5065	5064	5063	5062	5061	5060	5059	5058
5057	5056	5055	5054												
61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61
61	61	61	61	61											
5053	5052	4808	4809	4810	4811	4812	4813	4814	4815	6111	6110	6109	7261	7260	7259
7258	7256	7255	7254												
61	61	62	62	62	62	62	62	62	62	62	62	62	62	62	62
62	62	62	62	62											
7253	7252	7251	7250	7249	7248	7247	7245	7244	7243	7242	7241	7240	7239	7238	7237
5227	5225	5142	5139												
62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62
62	62	62	62	62											
5137	5136	5135	4854	7033	7032	7030	7029	7028	7027	6972	6712	6711	6842	6843	6844
6845	6846	6847	6848												
62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62
62	62	62	62	62											

Chain_Anal_ID_c_Dmoj

6849	6851	5947	7236	7235	7234	7233	7232	7231	7230	7229	7227	7226	7225	7223	7222
7221	7219	7218	6383												
62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62
62	62	62	62	62											
4897	4896	4895	4894	4893	4892	5237	4888	4887	4886	4885	4883	4882	4884	7216	7217
5644	5642	5641	5639												
62	62	62	62	62	62	62	62	62	62	62	63	63	64	64	64
64	64	64	64	64											
5638	5637	5636	5634	5632	5631	5630	5629	5627	5625	5624	5623	5622	5621	5620	6379
6378	6377	6375	6374												
64	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64
64	64	64	64	64											
6372	5964	5232	5230	5229	5228	5948	5949	5950	6313	5095	5096	5098	5662	5663	5664
5665	5666	5667	5669												
64	64	65	65	65	65	65	65	65	65	65	65	65	65	65	65
65	65	65	65	65											
5672	5673	5674	5675	5676	5677	5678	5680	5682	5073	5074	5076	5075	5077	5078	5079
5083	5084	5087	5088												
65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65
65	65	65	65	65											
5089	7098	7119	7099	7097	7096	7121	7139	7107	7108	6144	6143	6142	6141	6722	6723
5694	5695	5697	5698												
65	66	67	68	69	69	70	70	71	71	72	72	72	72	72	72
72	72	72	72	72											
5699	5701	5702	5703	5704	5705	5706	5708	5710	5522	6437	6438	6439	6440	6442	6443
6444	6445	6446	6448												
72	72	72	72	72	72	72	72	72	72	73	73	73	73	73	73
73	73	73	73	73											
6449	6454	6455	5044	5046	5047	5050	5051	7300	0	0	0	0	0	0	0
0	0	0	0	0											
73	73	73	73	73	73	73	73	74	0	0	0	0	0	0	0
0	0	0	0	0											

Chain_Anal_ID_d_Dmoj

Appendix D. Linkage Chain Analysis for the Muller D Element Comparison of D. virilis and D. mojavensis

Breakpoints Remaining= 126 (D.moj lineage inversion)(1)

Chain 1	left CLG		right CLG		
BP_092_093	8377	9871	9868	9415	A
BP_076_077	8868	8864	8410	8409	A by inference

Breakpoints Remaining= 123

Chain 2	left CLG		right CLG	
BP_117_118	9068	9064	9066	9059
BP_116_117	9347	9072	9068	9064
BP_118_119	9066	9059	9057	8832

Breakpoints Remaining= 120 (D.vir lineage inversion)(2)

Chain 3	left CLG		right CLG		
BP_104_105	8863	9732	9733	9736	A
BP_105_106	9733	9736	8183	8223	
BP_041_042	8235	8202	9737	9739	

Breakpoints Remaining= 118 (D.vir lineage inversion)(1)

Chain 4	left CLG		right CLG	
BP_113_114	9353	9354	9350	9350
BP_112_113	9405	9355	9353	9354

Breakpoints Remaining= 115 (D.moj lineage inversion)(2)

Chain 5	left CLG		right CLG		
BP_066_067	9819	9290	9495	9495	A by inference
BP_067_068	9495	9495	9496	9497	A
BP_068_069	9496	9497	9498	8683	A

Breakpoints Remaining= 107

Chain 6	left CLG		right CLG	
BP_054_055	8114	8465	8461	8074
BP_010_011	9162	9163	8464	8462
BP_001_002	7308	7308	7339	7753
BP_013_014	7524	7525	7522	7738
BP_119_120	9057	8832	8823	8609
BP_012_013	7982	7982	7524	7525
BP_046_047	7988	7987	7986	7986
BP_011_012	8464	8462	7982	7982

Breakpoints Remaining= 105 (D.moj lineage inversion)(1)

Chain 7	left CLG		right CLG		
BP_018_019	8182	8188	9251	9253	A by inference

```
                         ---------------------------
  BP_019_020              9251   9253 |  9252   8314        A
                         ---------------------------

Breakpoints Remaining= 103     (D.vir lineage inversion)(1)
Chain  8                 left CLG          right CLG
  BP_120_121              8823   8609 |  8612   8610
                         ---------------------------
  BP_121_122              8612   8610 |  8613   9804
                         ---------------------------

Breakpoints Remaining= 101     (D.moj lineage inversion)(1)
Chain  9                 left CLG          right CLG
  BP_070_071              8687   8688 |  8969   9094
                         ---------------------------
  BP_069_070              9498   8683 |  8687   8688
                         ---------------------------

Breakpoints Remaining=  99     (D.moj lineage inversion)(1)
Chain 10                 left CLG          right CLG
  BP_023_024              8349   8351 |  8354   9337        A by inference
                         ---------------------------
  BP_022_023              8317   8348 |  8349   8351        A
                         ---------------------------

Breakpoints Remaining=  97     (D.moj lineage inversion)(1)
Chain 11                 left CLG          right CLG
  BP_086_087              8127   8126 |  8125   8515        A
                         ---------------------------
  BP_085_086              7395   8583 |  8127   8126        A by inference
                         ---------------------------

Breakpoints Remaining=  95     (D.moj lineage inversion)(1)
Chain 12                 left CLG          right CLG
  BP_082_083              7770   7769 |  7388   7390        A by inference
                         ---------------------------
  BP_081_082              7651   7771 |  7770   7769        A
                         ---------------------------

Breakpoints Remaining=  93
Chain 13                 left CLG          right CLG
  BP_107_108              9820   9387 |  9389   9390
                         ---------------------------
  BP_108_109              9389   9390 |  9393   9395
                         ---------------------------

Breakpoints Remaining=  91     (D.vir lineage inversion)(1)
Chain 14                 left CLG          right CLG
  BP_006_007              7762   8020 |  8037   8035
                         ---------------------------
  BP_007_008              8037   8035 |  8036   9159
                         ---------------------------

Breakpoints Remaining=  89     (D.vir lineage inversion)(1)
Chain 15                 left CLG          right CLG
  BP_106_107              8183   8223 |  9820   9387
                         ---------------------------
  BP_065_066              7548   8224 |  9819   9290
                         ---------------------------

Breakpoints Remaining=  87     (D.moj lineage inversion)(1)
Chain 16                 left CLG          right CLG
  BP_047_048              7986   7986 |  7985   7984        A
                         ---------------------------
  BP_048_049              7985   7984 |  7983   7974        A
```

Chain_Anal_ID_d_Dmoj

Breakpoints Remaining= 85 (D.moj lineage inversion)(1)

Chain 17	left CLG		right CLG		
BP_098_099	9614	9617	8798	8797	A by inference
BP_097_098	9673	9615	9614	9617	A

Breakpoints Remaining= 83 (D.moj lineage inversion)(1)

Chain 18	left CLG		right CLG		
BP_094_095	9575	8926	8927	8928	A
BP_095_096	8927	8928	8929	9582	A

Breakpoints Remaining= 81 (D.vir lineage inversion)(1)

Chain 19	left CLG		right CLG		
BP_102_103	8413	8416	8412	8417	
BP_101_102	8411	8415	8413	8416	

Breakpoints Remaining= 79 (D.moj lineage inversion)(1)

Chain 20	left CLG		right CLG		
BP_035_036	7684	7440	7438	7379	A by inference
BP_099_100	8798	8797	8796	8418	A

Breakpoints Remaining= 74 (D.vir lineage inversion)(4)

Chain 21	left CLG		right CLG		
BP_032_033	8242	7678	7680	7679	
BP_033_034	7680	7679	7683	7681	
BP_034_035	7683	7681	7684	7440	A
BP_017_018	8179	8181	8182	8188	A
BP_016_017	7735	8178	8179	8181	A

Breakpoints Remaining= 72 (D.moj lineage inversion)(1)

Chain 22	left CLG		right CLG		
BP_088_089	8516	8518	8520	8549	A
BP_087_088	8125	8515	8516	8518	A

Breakpoints Remaining= 70 (D.vir lineage inversion)(1)

Chain 23	left CLG		right CLG		
BP_044_045	9742	7991	7989	7990	
BP_045_046	7989	7990	7988	7987	

Breakpoints Remaining= 68 (D.vir lineage inversion)(1)

Chain 24	left CLG		right CLG		
BP_040_041	8762	8762	8235	8202	
BP_029_030	9755	8761	8236	8239	

Breakpoints Remaining= 66 (D.vir lineage inversion)(1)

```
                                  Chain Anal ID d Dmoj
Chain 25            left CLG          right CLG
  BP_073_074         9099   9102 |  8914   8872
                    ---------------------------
  BP_096_097         8929   9582 |  9673   9615
                    ---------------------------

Breakpoints Remaining=  64     (D.vir lineage inversion)(1)
Chain 26            left CLG          right CLG
  BP_021_022         8316   8315 |  8317   8348
                    ---------------------------
  BP_020_021         9252   8314 |  8316   8315
                    ---------------------------

Breakpoints Remaining=  62     (D.moj lineage inversion)(1)
Chain 27            left CLG          right CLG
  BP_042_043         9737   9739 |  9740   9741        A
                    ---------------------------
  BP_043_044         9740   9741 |  9742   7991        A
                    ---------------------------

Breakpoints Remaining=  60     (D.vir lineage inversion)(1)
Chain 28            left CLG          right CLG
  BP_080_081         7642   7641 |  7651   7771
                    ---------------------------
  BP_079_080         8406   7640 |  7642   7641
                    ---------------------------

Breakpoints Remaining=  58     (D.vir lineage inversion)(1)
Chain 29            left CLG          right CLG
  BP_061_062         7961   7563 |  7560   7562
                    ---------------------------
  BP_062_063         7560   7562 |  7558   7551
                    ---------------------------

Breakpoints Remaining=  56     (D.moj lineage inversion)(1)
Chain 30            left CLG          right CLG
  BP_059_060         7934   7959 |  7964   7960        A by inference
                    ---------------------------
  BP_060_061         7964   7960 |  7961   7563        A
                    ---------------------------

Breakpoints Remaining=  53     (D.vir lineage inversion)(2)
Chain 31            left CLG          right CLG
  BP_053_054         8116   8115 |  8114   8465        A
                    ---------------------------
  BP_051_052         7970   8119 |  8117   8118
                    ---------------------------
  BP_052_053         8117   8118 |  8116   8115
                    ---------------------------

Breakpoints Remaining=  51     (D.vir lineage inversion)(1)
Chain 32            left CLG          right CLG
  BP_103_104         8412   8417 |  8863   9732
                    ---------------------------
  BP_100_101         8796   8418 |  8411   8415
                    ---------------------------

Breakpoints Remaining=  49     (D.moj lineage inversion)(1)
Chain 33            left CLG          right CLG
  BP_056_057         8400   8402 |  8403   7931        A
                    ---------------------------
  BP_055_056         8461   8074 |  8400   8402        A by inference
                    ---------------------------

Breakpoints Remaining=  46     (D.vir lineage inversion)(2)
```

```
                                    Chain_Anal_ID_d_Dmoj
Chain 34            left CLG          right CLG
  BP_111_112         9401   9403 |  9405   9355        A
                    ---------------------------
  BP_109_110         9393   9395 |  9397   9396
                    ---------------------------
  BP_110_111         9397   9396 |  9401   9403
                    ---------------------------

Breakpoints Remaining=  44     (D.moj lineage inversion)(1)
Chain 35            left CLG          right CLG
  BP_083_084         7388   7390 |  7393   7394        A by inference
                    ---------------------------
  BP_084_085         7393   7394 |  7395   8583        A
                    ---------------------------

Breakpoints Remaining=  42     (D.moj lineage inversion)(1)
Chain 36            left CLG          right CLG
  BP_063_064         7558   7551 |  7550   7552        A
                    ---------------------------
  BP_064_065         7550   7552 |  7548   8224        A by inference
                    ---------------------------

Breakpoints Remaining=  39
Chain 37            left CLG          right CLG
  BP_128_129         9413   9409 |  9343   9363
                    ---------------------------
  BP_093_094         9868   9415 |  9575   8926
                    ---------------------------
  BP_127_128         9797   9785 |  9413   9409
                    ---------------------------

Breakpoints Remaining=  37     (D.vir lineage inversion)(2)
Chain 38            left CLG          right CLG
  BP_024_025         8354   9337 |  8366   9336        A by inference
                    ---------------------------
  BP_025_026         8366   9336 |  9333   9335
                    ---------------------------
  BP_026_027         9333   9335 |  9332   8099
                    ---------------------------


Breakpoints Remaining=  35     (D.moj lineage inversion)(1)
Chain 39            left CLG          right CLG
  BP_014_015         7522   7738 |  7737   7736        A
                    ---------------------------
  BP_015_016         7737   7736 |  7735   8178        A
                    ---------------------------

Breakpoints Remaining=  33     (D.vir lineage inversion)(1)
Chain 40            left CLG          right CLG
  BP_003_004         7755   7754 |  7756   7759
                    ---------------------------
  BP_002_003         7339   7753 |  7755   7754
                    ---------------------------

Breakpoints Remaining=  30     (D.vir lineage inversion)(2)
Chain 41            left CLG          right CLG
  BP_090_091         8381   8378 |  8380   8380
                    ---------------------------
  BP_091_092         8380   8380 |  8377   9871
                    ---------------------------
  BP_089_090         8520   8549 |  8381   8378
                    ---------------------------

Breakpoints Remaining=  28     (D.vir lineage inversion)(1)
```

```
                                  Chain_Anal_ID_d_Dmoj
Chain 42            left CLG          right CLG
  BP_077_078         8410   8409 |  8407   8408
                    ---------------------------
  BP_078_079         8407   8408 |  8406   7640
                    ---------------------------

Breakpoints Remaining=  26     (D.moj lineage inversion)(1)
Chain 43            left CLG          right CLG
  BP_037_038         7370   7375 |  7374   8766
                    ---------------------------
  BP_036_037         7438   7379 |  7370   7375
                    ---------------------------

Breakpoints Remaining=  24     (D.vir lineage inversion)(1)
Chain 44            left CLG          right CLG
  BP_038_039         7374   8766 |  8763   8764
                    ---------------------------
  BP_039_040         8763   8764 |  8762   8762
                    ---------------------------

Breakpoints Remaining=  22     (D.moj lineage inversion)(1)
Chain 45            left CLG          right CLG
  BP_058_059         7932   7933 |  7934   7959        A
                    ---------------------------
  BP_057_058         8403   7931 |  7932   7933        A
                    ---------------------------

Breakpoints Remaining=  20     (D.moj lineage inversion)(1)
Chain 46            left CLG          right CLG
  BP_074_075         8914   8872 |  8870   8869        A
                    ---------------------------
  BP_075_076         8870   8869 |  8868   8864        A
                    ---------------------------

Breakpoints Remaining=  18     (D.moj lineage inversion)(1)
Chain 47            left CLG          right CLG
  BP_008_009         8036   9159 |  9160   9161        A
                    ---------------------------
  BP_009_010         9160   9161 |  9162   9163        A
                    ---------------------------

Breakpoints Remaining=  16     (D.moj lineage inversion)(1)
Chain 48            left CLG          right CLG
  BP_114_115         9350   9350 |  9349   9348        A
                    ---------------------------
  BP_115_116         9349   9348 |  9347   9072        A
                    ---------------------------

Breakpoints Remaining=  14     (D.moj lineage inversion)(1)
Chain 49            left CLG          right CLG
  BP_004_005         7756   7759 |  7760   7761        A
                    ---------------------------
  BP_005_006         7760   7761 |  7762   8020        A
                    ---------------------------

Breakpoints Remaining=  12     (D.moj lineage inversion)(1)
Chain 50            left CLG          right CLG
  BP_031_032         8240   8241 |  8242   7678        A
                    ---------------------------
  BP_030_031         8236   8239 |  8240   8241        A
                    ---------------------------

Breakpoints Remaining=  10     (D.moj lineage inversion)(1)
Chain 51            left CLG          right CLG
  BP_123_124         9803   9802 |  9799   9799        A by inference
```

```
                                Chain_Anal_ID_d_Dmoj
                          --------------------------
  BP_126_127               9798   9798 |  9797   9785        A
                          --------------------------

Breakpoints Remaining=   8     (D.vir lineage inversion)(1)
Chain 52                left CLG          right CLG
  BP_027_028               9332   8099 |  9756   8101
                          --------------------------
  BP_028_029               9756   8101 |  9755   8761
                          --------------------------

Breakpoints Remaining=   6     (D.moj lineage inversion)(1)
Chain 53                left CLG          right CLG
  BP_071_072               8969   9094 |  9096   9098        A by inference
                          --------------------------
  BP_072_073               9096   9098 |  9099   9102        A
                          --------------------------

Breakpoints Remaining=   4     (D.vir lineage inversion)(1)
Chain 54                left CLG          right CLG
  BP_049_050               7983   7974 |  7971   7973
                          --------------------------
  BP_050_051               7971   7973 |  7970   8119
                          --------------------------

Breakpoints Remaining=   0     (D.moj lineage inversion)(2)
Chain 55                left CLG          right CLG
  BP_122_123               8613   9804 |  9803   9802        A
                          --------------------------
  BP_125_126               9800   9800 |  9798   9798        A by inference
                          --------------------------
  BP_124_125               9799   9799 |  9800   9800        A
                          --------------------------


Chain Analysis Summary Data
---------------------------

Chains with  2 Breakpoints=  44
Chains with  3 Breakpoints=   9
Chains with  4 Breakpoints=   0
Chains with  5 Breakpoints=   1
Chains with  6 Breakpoints=   0
Chains with  7 Breakpoints=   0
Chains with  8 Breakpoints=   1
Chains with  9 Breakpoints=   0
Chains with 10 Breakpoints=   0
Chains with 11 Breakpoints=   0
Chains with 12 Breakpoints=   0

Number of Inversions=  73
Number of Breakpoints= 128
Reusage Index=     1.141


Conserved Linkage Group Intervals
---------------------------------

CLG  No.Genes  Left_IDX  Right_IDX  Left_Gene  Right_Gene
  1         1         1          1       7308        7308
  2        44         2         45       7339        7753
  3         2        46         47       7755        7754
  4         2        48         49       7756        7759
  5         2        50         51       7760        7761
  6        92        52        143       7762        8020
```

				Chain_Anal_ID_d_Dmoj	
7	16	144	159	8037	8035
8	35	160	194	8036	9159
9	2	195	196	9160	9161
10	2	197	198	9162	9163
11	3	199	201	8464	8462
12	1	202	202	7982	7982
13	2	203	204	7524	7525
14	11	205	215	7522	7738
15	2	216	217	7737	7736
16	83	218	300	7735	8178
17	3	301	303	8179	8181
18	6	304	309	8182	8188
19	2	310	311	9251	9253
20	50	312	361	9252	8314
21	2	362	363	8316	8315
22	28	364	391	8317	8348
23	5	392	396	8349	8351
24	19	397	415	8354	9337
25	2	416	417	8366	9336
26	2	418	419	9333	9335
27	38	420	457	9332	8099
28	2	458	459	9756	8101
29	49	460	508	9755	8761
30	4	509	512	8236	8239
31	2	513	514	8240	8241
32	48	515	562	8242	7678
33	2	563	564	7680	7679
34	3	565	567	7683	7681
35	40	568	607	7684	7440
36	50	608	657	7438	7379
37	3	658	660	7370	7375
38	33	661	693	7374	8766
39	2	694	695	8763	8764
40	1	696	696	8762	8762
41	20	697	716	8235	8202
42	3	717	719	9737	9739
43	2	720	721	9740	9741
44	14	722	735	9742	7991
45	2	736	737	7989	7990
46	2	738	739	7988	7987
47	1	740	740	7986	7986
48	2	741	742	7985	7984
49	7	743	749	7983	7974
50	2	750	751	7971	7973
51	5	752	756	7970	8119
52	2	757	758	8117	8118
53	2	759	760	8116	8115
54	47	761	807	8114	8465
55	44	808	851	8461	8074
56	3	852	854	8400	8402
57	22	855	876	8403	7931
58	2	877	878	7932	7933
59	23	879	901	7934	7959
60	2	902	903	7964	7960
61	30	904	933	7961	7563
62	4	934	937	7560	7562
63	6	938	943	7558	7551
64	3	944	946	7550	7552
65	12	947	958	7548	8224
66	40	959	998	9819	9290
67	1	999	999	9495	9495
68	2	1000	1001	9496	9497
69	100	1002	1101	9498	8683
70	2	1102	1103	8687	8688
71	29	1104	1132	8969	9094

				Chain_Anal_ID_d_Dmoj	
72	4	1133	1136	9096	9098
73	4	1137	1140	9099	9102
74	13	1141	1153	8914	8872
75	3	1154	1156	8870	8869
76	3	1157	1159	8868	8864
77	2	1160	1161	8410	8409
78	2	1162	1163	8407	8408
79	12	1164	1175	8406	7640
80	2	1176	1177	7642	7641
81	21	1178	1198	7651	7771
82	5	1199	1203	7770	7769
83	3	1204	1206	7388	7390
84	2	1207	1208	7393	7394
85	20	1209	1228	7395	8583
86	2	1229	1230	8127	8126
87	5	1231	1235	8125	8515
88	3	1236	1238	8516	8518
89	23	1239	1261	8520	8549
90	2	1262	1263	8381	8378
91	1	1264	1264	8380	8380
92	39	1265	1303	8377	9871
93	78	1304	1381	9868	9415
94	17	1382	1398	9575	8926
95	2	1399	1400	8927	8928
96	21	1401	1421	8929	9582
97	58	1422	1479	9673	9615
98	2	1480	1481	9614	9617
99	5	1482	1486	8798	8797
100	39	1487	1525	8796	8418
101	3	1526	1528	8411	8415
102	2	1529	1530	8413	8416
103	2	1531	1532	8412	8417
104	58	1533	1590	8863	9732
105	4	1591	1594	9733	9736
106	18	1595	1612	8183	8223
107	35	1613	1647	9820	9387
108	2	1648	1649	9389	9390
109	2	1650	1651	9393	9395
110	2	1652	1653	9397	9396
111	5	1654	1658	9401	9403
112	15	1659	1673	9405	9355
113	2	1674	1675	9353	9354
114	1	1676	1676	9350	9350
115	2	1677	1678	9349	9348
116	9	1679	1687	9347	9072
117	2	1688	1689	9068	9064
118	2	1690	1691	9066	9059
119	15	1692	1706	9057	8832
120	72	1707	1778	8823	8609
121	3	1779	1781	8612	8610
122	64	1782	1845	8613	9804
123	2	1846	1847	9803	9802
124	1	1848	1848	9799	9799
125	1	1849	1849	9800	9800
126	1	1850	1850	9798	9798
127	13	1851	1863	9797	9785
128	5	1864	1868	9413	9409
129	10	1869	1878	9343	9363

Gene List and Conserved Linkage Group Calls

	7308	7339	7337	7336	7335	7333	7332	7331	7330	7328	7327	7326	7309	7310	7707
8725	7601	7600	7599	7598											
	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2

Chain_Anal_ID_d_Dmoj

```
  2     2     2     2     2

   7597  7596  7595  7594  7593  7592  7591  7505  7506  7507  7508  7509  7510  7511  7512
7513  7514  7515  7516  7746
      2     2     2     2     2     2     2     2     2     2     2     2     2     2     2
  2     2     2     2     2

   7748  7749  7750  7751  7753  7755  7754  7756  7759  7760  7761  7762  7763  7686  7687
7688  7689  7691  7692  7693
      2     2     2     2     2     3     3     4     4     5     5     6     6     6     6
  6     6     6     6     6

   7695  7696  7905  7903  7904  7902  7901  7900  7899  7898  7897  7896  7895  7894  7893
7891  7892  7885  7890  7887
      6     6     6     6     6     6     6     6     6     6     6     6     6     6     6
  6     6     6     6     6

   7886  7884  7883  7882  7881  7880  7879  7878  7877  7876  7875  7872  7871  7869  7867
7866  7865  7864  7863  7860
      6     6     6     6     6     6     6     6     6     6     6     6     6     6     6
  6     6     6     6     6

   7859  7856  7858  7853  7852  7851  7850  7848  7847  7846  7844  7843  7842  7841  7840
7652  7653  7656  9657  9656
      6     6     6     6     6     6     6     6     6     6     6     6     6     6     6
  6     6     6     6     6

   9655  7657  7658  7401  7402  7406  7407  7408  7410  7313  7314  7315  7316  7317  7318
7319  8013  8014  8015  8017
      6     6     6     6     6     6     6     6     6     6     6     6     6     6     6
  6     6     6     6     6

   8018  8019  8020  8037  8025  8021  8023  8024  8030  8031  8032  8033  8029  8026  8034
8022  8027  8028  8035  8036
      6     6     6     7     7     7     7     7     7     7     7     7     7     7     7
  7     7     7     7     8

   8038  8039  9707  9706  8392  8393  8394  8395  8399  8077  8078  8079  8080  8081  7320
9123  9124  9125  9127  9128
      8     8     8     8     8     8     8     8     8     8     8     8     8     8     8
  8     8     8     8     8

   9129  9130  9131  9132  9133  9134  9135  9140  9143  9146  9147  9148  9149  9159  9160
9161  9162  9163  8464  8463
      8     8     8     8     8     8     8     8     8     8     8     8     8     8     9
  9    10    10    11    11

   8462  7982  7524  7525  7522  7521  7520  7519  7518  7517  7744  7743  7742  7741  7738
7737  7736  7735  7734  7733
     11    12    13    13    14    14    14    14    14    14    14    14    14    14    14
 15    15    16    16    16

   7732  7731  7727  7726  7725  7724  7723  7722  9753  8276  8277  8278  8279  8281  8280
8282  8283  8284  8285  8286
     16    16    16    16    16    16    16    16    16    16    16    16    16    16    16
 16    16    16    16    16

   8289  8291  8292  8293  8295  8294  8296  8297  8298  9280  9277  9276  9275  7616  7615
7614  7613  7612  7611  7610
     16    16    16    16    16    16    16    16    16    16    16    16    16    16    16
 16    16    16    16    16

   7608  7609  7607  7606  7605  7604  7603  7710  7706  7481  7480  7479  7478  7477  7476
7474  8151  8152  8153  8154
     16    16    16    16    16    16    16    16    16    16    16    16    16    16    16
```

Chain_Anal_ID_d_Dmoj

16 16 16 16 16

8155 8960 8157 8158 8159 8160 8156 8161 8162 8167 8168 8169 8170 8172 8173
8174 8175 8176 8177 8178
16 16 16 16 16 16 16 16 16 16 16 16 16 16 16
16 16 16 16 16

8179 8180 8181 8182 8184 8185 8186 8187 8188 9251 9253 9252 9250 9248 9247
9244 9245 9243 9242 7446
17 17 17 18 18 18 18 18 18 19 19 20 20 20 20
20 20 20 20 20

7447 7362 7363 9307 9305 9306 9304 9303 9302 9301 9300 9299 9297 9296 9295
9294 9293 9292 9291 9287
20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
20 20 20 20 20

9288 9285 9284 9282 8299 8300 8738 8737 8736 8734 8735 8733 8732 8731 8730
8729 8728 8311 8312 8313
20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
20 20 20 20 20

8314 8316 8315 8317 8318 8319 8320 8321 8322 8323 8324 8325 8326 8327 8328
8329 8330 8331 8332 8333
20 21 21 22 22 22 22 22 22 22 22 22 22 22 22
22 22 22 22 22

8334 8335 8337 8338 8339 8340 8341 8343 8345 8346 8348 8349 8347 8350 8352
8351 8354 8353 8355 8356
22 22 22 22 22 22 22 22 22 22 22 22 23 23 23 23
23 24 24 24 24

8357 8358 8359 8360 8362 8363 8364 8365 8590 8589 9341 9340 9339 9338 9337
8366 9336 9333 9335 9332
24 24 24 24 24 24 24 24 24 24 24 24 24 24 24 24
25 25 26 26 27

9331 9330 9329 9328 9327 9326 9325 9324 9323 9322 9321 9319 9318 7719 7718
7717 7716 7715 7714 7712
27 27 27 27 27 27 27 27 27 27 27 27 27 27 27 27
27 27 27 27 27

8082 8084 8083 8085 8086 8087 8088 8089 8090 8091 8092 8093 8094 8095 8097
8098 8099 9756 8101 9755
27 27 27 27 27 27 27 27 27 27 27 27 27 27 27 27
27 27 28 28 29

8275 8274 8273 8272 8270 8142 8143 8144 8145 8146 8147 8148 8149 9317 9316
8102 8104 8103 8105 8106
29 29 29 29 29 29 29 29 29 29 29 29 29 29 29 29
29 29 29 29 29

8107 8108 8109 8110 8564 7660 7659 7661 7662 7663 7664 7665 8746 8747 8748
8749 8750 8751 8752 8753
29 29 29 29 29 29 29 29 29 29 29 29 29 29 29 29
29 29 29 29 29

8754 8755 8756 8757 8758 8759 8760 8761 8236 8237 8238 8239 8240 8241 8242
7908 7909 7910 7911 7912
29 29 29 29 29 29 29 29 30 30 30 30 31 31 32
32 32 32 32 32

7913 7914 7915 7916 7917 7918 7919 7920 7921 7922 7923 7924 7925 7926 7927
7928 7929 7930 9310 9311
32 32 32 32 32 32 32 32 32 32 32 32 32 32 32 32

Chain_Anal_ID_d_Dmoj

```
 32    32    32    32    32

   9314  8309  8310  8307  8308  8305  8306  8304  8303  8742  8743  8744  8745  7667  7666
7668  7669  7670  7675  7676
     32    32    32    32    32    32    32    32    32    32    32    32    32    32    32
 32    32    32    32    32

   7677  7678  7680  7679  7683  7682  7681  7684  8134  8133  8132  8442  8441  8440  8439
8438  8437  8436  8435  8434
     32    32    33    33    34    34    34    35    35    35    35    35    35    35    35
 35    35    35    35    35

   8433  8432  7965  7966  7967  7968  9222  9223  9224  9225  9227  9231  9232  9233  9234
9235  9236  9237  9238  9239
     35    35    35    35    35    35    35    35    35    35    35    35    35    35    35
 35    35    35    35    35

   9241  9240  7445  7444  7443  7442  7440  7438  7439  7437  7436  7435  7434  7433  7432
7431  7430  7429  7428  7427
     35    35    35    35    35    35    35    36    36    36    36    36    36    36    36
 36    36    36    36    36

   7426  7425  7423  7421  7422  7420  8494  8492  8493  8491  8490  8488  8487  8489  8486
8485  8484  8483  8482  8481
     36    36    36    36    36    36    36    36    36    36    36    36    36    36    36
 36    36    36    36    36

   8480  8479  8478  8477  7831  7832  7833  7834  7835  7387  7386  7385  7384  7383  7381
7380  7379  7370  7376  7375
     36    36    36    36    36    36    36    36    36    36    36    36    36    36    36
 36    36    37    37    37

   7374  7373  7372  7371  7369  7367  7366  7365  7364  8367  8499  8500  8501  8502  8503
8504  8506  8507  8508  8509
     38    38    38    38    38    38    38    38    38    38    38    38    38    38    38
 38    38    38    38    38

   8510  8511  8512  8513  8514  9105  9106  9107  9108  8769  8768  8767  8766  8763  8764
8762  8235  8234  8233  8232
     38    38    38    38    38    38    38    38    38    38    38    38    38    39    39
 40    41    41    41    41

   8231  8230  7541  7540  7539  7538  7537  7536  7535  7534  7533  9118  8199  8200  8201
8202  9737  9738  9739  9740
     41    41    41    41    41    41    41    41    41    41    41    41    41    41    41
 41    42    42    42    43

   9741  9742  9743  9745  9744  9746  9747  9750  9749  9751  9752  7721  7720  7992  7991
7989  7990  7988  7987  7986
     43    44    44    44    44    44    44    44    44    44    44    44    44    44    44
 45    45    46    46    47

   7985  7984  7983  7981  7980  7979  7976  7975  7974  7971  7973  7970  7969  8121  8120
8119  8117  8118  8116  8115
     48    48    49    49    49    49    49    49    49    50    50    51    51    51    51
 51    52    52    53    53

   8114  8113  8112  8111  8561  8560  8558  8557  8556  7473  7470  7471  7472  7469  7468
7467  7465  7644  7697  7702
     54    54    54    54    54    54    54    54    54    54    54    54    54    54    54
 54    54    54    54    54

   9267  9265  9264  9263  9261  9260  9259  9258  9257  9255  9254  8420  8421  8422  8424
8423  8425  8426  8427  8472
     54    54    54    54    54    54    54    54    54    54    54    54    54    54    54
```

Do Physically Active Parents of Preschool Aged Children have Physically Active Children?

Shartaya M. Mollett, McNair Scholar, Penn State University

Lori A. Francis, Ph.D.
Assistant Professor
Department of Biobehavioral Health
Penn State University

Lack of physical activity is a leading cause of childhood obesity. For this study, children between the ages of 3-to-6 years-old were observed in a childcare setting during their normal playtime. Children had the opportunity to choose from 2 sedentary activities and 2 physical activities. Observations were carried out to investigate the choices made over a 20-minute period. Height and weight measurements were collected and one-on-one interviews were conducted with each child using flash cards to assess children's preferences for different activities. Parent questionnaires were used to gather data from parents on their own physical activity levels and their children's overall physical activity levels. We hypothesized that will be tested is that children with parents that engage in high levels of physical activity would be more likely to have children that take part in physical versus sedentary activities in a childcare setting compared to children with parents with lower levels of participation in physical activity.

INTRODUCTION

Understanding what motivates children to take part in moderate to vigorous physical activity will help researchers to develop programs to increase children's participate in physical activity (Kimiecik, Horn, & Shurin, 1996). The structural and environmental features of a community relates to physical activity levels in which a family can engage in (Soubhi, Potvin, & Paradis, 2004). Peers, communities, coaches, teachers, school, media, and families are all involved in determining children's physical activity behavior(Anderssen & Wold, 1992; Kimiecik, Horn, & Shurin, 1996). The role of the family is most essential, because children grow up in the family environment for many years, providing an opportunity for parents to influence their children's behaviors (Kimiecik, Horn, & Shurin, 1996). In addition to the family environment, area of residence influences physical activity (Soubhi, Potvin, & Paradis, 2004).

Since physical activity behaviors that are learned by children may persist into adulthood (Gustafson & Rhodes, 2006), parents that instill healthy behaviors in their children at a young age will make a difference in their child's life as he or she ages. Children learn by observing individuals in the environment in which they are surrounded. Parents and

siblings serve as the most important behavioral role model in early childhood (Sallis, 2000). A moderate predictor of short and long term health of children is physical activity (Gustafson & Rhodes, 2006). Sedentary activities are replacing physical activities and promoting children to have more structured activities, hence, causing children to become less active. Parents of young children have some control over the types of activities that their children engage in, as parents are usually responsible of determining how children spend their time.

To study children's physical activity levels it is important to study their parents, because it is assumed that active parents have active children (Pan, Frey, Bar-Or, & Longmuir, 2005) (Sallis, Prochaska, & Taylor, 2000). The activity patterns of parents correlate with those of their preschool school-aged children (Irwin, He, Bouck, Tucker, & Pollett, 2005).Children that engage in more physical forms of activity will reduce their chances of becoming obese. Parents' physical activity levels may be important in modifying children's physical activity and in treating pediatric obesity (Kalakanis, Goldfield, Paluch, & Epstein, 2001).

Recent studies suggest that overweight parents tend to have overweight children (Davison & Birch, 2002). Childhood obesity is determined by genetic predisposition, dietary intake and energy expenditure (Irwin, He, Bouck, Tucker, & Pollett, 2005). Families show similarities in behavioral risk factors associated with obesity which include physical activity (Davison & Birch, 2002)(Anderssen & Wold, 1992; Freedson & Evenson, 1991; Moore et al., 1991; Sallis, Patterson, McKenzie, & Nader, 1988) (Wold & Anderssen, 1992). Because parents' and their children's activity levels are related (Kalakanis, Goldfield, Paluch, & Epstein, 2001), families can be successful in shaping healthy behaviors in the members of their family(Soubhi, Potvin, & Paradis, 2004) (Sallis et al., 1993).

Developmental changes during youth include substantial declines in physical activity with age (Sallis, Taylor, Dowda, Freedson, & Pate, 2002). Family influence on youth participation in physical activity decreases with age while the influence of physical activity from a peer increases with age (Sallis, Taylor, Dowda, Freedson, & Pate, 2002). Un addition, after-school recreation is associated with more physical activity than sedentary activity (Sallis, Taylor, Dowda, Freedson, & Pate, 2002). It is essential for parents to encourage their children to become involved in sports and recreation in order to gain some control over the type of activities that their children engage in.

Most children in the United States are enrolled in school or some form of childcare which provides ongoing contact to study activities that children participate in (Stolley et al., 2003). Parents that send their children to licensed daycare programs feel that their child receives a routine physical activity experience (Irwin, He, Bouck, Tucker, & Pollett, 2005). However, through observations researchers found that children that are in childcare settings are engaged in both physical activity and structured sedentary activities. Children are limited to the scheduled physical activity they can engage in while in childcare. When children in childcare settings are given the opportunity to take part in

activities, some children will choose physical activities and some will choose sedentary activities.

The purpose of the present study was to assess associations between parents' physical activity levels and that of their children. The study investigated children's reported activity preferences and observations of children's physical activity in a childcare setting. This paper will explain the importance of prevention programs to reduce the chances of children becoming obese.

METHODS

Participants

Participants consisted of 51 three to six- year-old African American, Caucasian, and Asian boys and girls and their parents. Eligibility criteria for each boy and girl included a child, three to six years old that had the ability to be physically active. Parents were required to complete questionnaires providing information about their family background, their own activities, and their children's activities at home. Families were recruited during multiple visits to childcare centers with posters advertising the study, information explaining the study, and consent forms.

Measures

Family Background. Parents provided information on several background and demographic variables, including combined family income, parental education and family history of disease.

Child Activity Preferences. Children's preferences for physical activity were measured using (1) a behavioral observation procedure (2) a pictorial rating system. We used a 20-minute behavioral observation protocol was used to rate children's preferences for standard sedentary activities such as reading and listening to a book on tape, and children's preferences for moderate to vigorous physical activities such as jumping rope and dancing along to music. Children were able to choose from 4 activities (2 sedentary, 2 active) during this 20-minute period. Trained research assistants observed and rated the choices children made during activity time and the length of time they participate in each activity. Lastly, children were asked to view pictures of several different activities ranging from very sedentary (e.g. reading or watching television), to very vigorous (e.g. swimming or running around outside) and rated their preference for that activity on a scale of 1 (do not like) to 3 (really like).

Parents' Physical Activity Level. The amount of time parents have spent being physically active in the last 7 days were assessed using the International Physical Activity Questionnaire (IPAQ) developed by Craig and colleagues (Craig et al., 2003). The measure consisted of 7 items pertaining to job-related physical activity (i.e. *During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, digging, heavy construction, or climbing up stairs as part of your work?*), 6 items related to transportation physical activity (i.e. *During the last 7 days, on how many days did you travel in a motor vehicle like a train, bus, or car?*), 6 items related to housework, house maintenance, and caring for family activity (i.e. *During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, chopping wood, shoveling snow, or digging in the garden or yard?*), 6 items related to recreation, sport and leisure time physical activity (i.e. *During the last 7 days, on how many days did you do vigorous physical activities like aerobics, running, fast bicycling, or fast swimming in your leisure time?*), and 2 items on time spent sitting (i.e. *During the last 7 days, how much time in total did you usually spend sitting on a weekday?*). Activities are defined as either vigorous or moderate, vigorous being those activities that take hard physical effort and make breathing much harder than normal and moderate being those activities that take some physical effort and make breathing somewhat harder than normal. Scoring was based upon the time spent involved in each type of activity.

Procedure

Prior to making the childcare center visits, the Family Health Study research team obtained permission from the directors of each center. The study was approved by the Institutional Review Board. The team met with teachers and parents to give a brief overview of the study. Parents provided written consent for their child prior to data collection. Visits were made to the childcare centers on 6 different occasions. The first two visits consisted of observations that were made to investigate the children's activity choices made over a 20- minute period. The third visit was to drop off 2 sedentary activities and 2 physical activities after introducing each activity to the children. The 2 sedentary and 2 physical activities were in the childcare centers for a 1-week acclimation period before the research team began making observations. During the fourth and fifth visits, observations were conducted to investigate children's activity choices made over a 20-minute period after new activities were placed in the childcare centers. On the last visit, height, weight, and bioimpedence measurements were collected. To gain more knowledge about activity preferences of children, a one-on-one interview was conducted using flash cards to rate different activities.

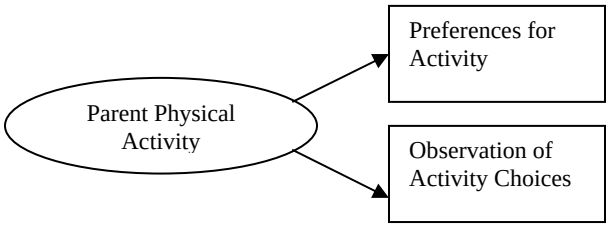
The study was conducted in the Child Development Laboratory and the Bennett Family Childcare Center at The Pennsylvania State University. The Activity Choices in Youth Study was completed during the summer of 2006 by the Family and Child Health Laboratory research team.

RESULTS

Statistical Analyses

Descriptive statistics were used to describe the variables of interest in this study. Multiple regressions were used to test the hypothesis that parents' physical activity level is associated with children's activity preferences. Outcome variables of interest include (1) children's activity preferences measured by the pictorial rating system and (2) children's activity choices measured using the behavioral observation in the childcare setting. Figure 1 outlines the conceptual model that will be tested in this study.

Figure 1. Conceptual Model



Descriptive Statistics

The parents in the study had an income level above $50,000, had fourteen years plus of education, had a two-parent family household, and were over the age of 30. Descriptive statistics for children's pre-toys and post-toy observations, activity level, and activity choices appear in Table 1. On, average most children reported a high preference for sedentary, moderate, and vigorous activities on the pictorial measure, and participated in slow, easy movement level activities during the observations.

Table 1. Mean levels of children's pre-toys and post-toy observations, including activity level and activity choices

Variable	B	Mean	SD	Range
Pre-Toys Activity Level	48	2.3	.23	1.6 - 2.9
Post-Toys Activity Choice	48	2.8	.59	1.5 – 3.8
Pre-Toys Activity Level	48	2.5	2.0	2.0 – 3.8
Post-Toys Activity Choice	46	2.9	1.0	1.0 – 4.1

Note. Activity level refers to the level of energy expended (1=no movement, 4=fast, vigorous movement). Activity choice refers to the type of activity children chose (1=sedentary activity, 4=vigorous activity). SD = standard deviation

Parents' Physical Activity Level

Descriptive information on parents' physical activity level appears in Table 2. Fathers reported slightly higher levels on all activity variables compared to mothers, apart from walking; mothers reported slightly higher levels of walking than fathers. Mothers and

fathers reported participating in vigorous and moderate forms of physical activity approximately 2 days each week. Mothers reported walking approximately 4 days each week, while fathers reported walking approximately 3 days each week. Both mothers and fathers reported sitting for approximately 7 hours each day.

Table 2. Mothers' (N = 27) and fathers' (N = 24) mean levels of physical activity.

	MOTHERS		FATHERS	
Variable	**Mean**	**SD**	**Mean**	**SD**
Vigorous Activity (days/week)	1.6	1.6	2.0	2.2
Vigorous Activity (minute/session)	53.7	25.9	94.1	57.9
Moderate Activity (days/week)	2.1	2.4	2.3	2.3
Moderate Activity (minute/session)	45.0	28.5	52.9	33.3
Walking (days/week)	4.2	3.0	3.1	2.6
Walking (minutes/day)	50	40.7	62.1	62.9
Sitting (minutes/day)	409.5	130.7	440.6	197.7

Parents' Influence on Children's Physical Activity

Correlations among parent and child variables appear in Table 3. Mothers that reported engaging in vigorous activities had children that engaged in physical activity in their normal childcare setting during pre-toy observations. In the childcare setting, children's pre-toy activity level was correlated with their mothers' activity levels. There was a trend for mothers' moderate physical activity level to be correlated with children's reported preference for vigorous activity. We did not find any other activities with moderate and sedentary activities.

Among fathers, fathers who reported higher levels of moderate physical activity had children who reported a higher preference for vigorous physical activity. There were no other relationships between fathers' and children's physical activity.

Table 3. Correlations among parent and child physical activity variables

Variable	**N**	**Child Preference for Vigorous Activity**	**Child Pre-Toy Activity Level**
Mothers' vigorous activity (days/week)	26	NS	.40*
Mothers' moderate activity (days/week)	24	.34†	NS
Mothers' walking (days/week)	18	.40†	NS
Fathers' moderate activity (days/week)	13	.56*	NS

*p ≤.05, †p<.10 (trend)

DISCUSSION

The primary goal of this study was to determine whether children with parents that engage in high levels of physical activity were more likely to have children that take part in physical versus sedentary activities in a childcare setting compared to children whose parents had lower levels of participation in physical activity. The hypothesis was supported by mother's moderate activity level correlating with their children's vigorous activity levels. The results of the study indicate that when both parents are physically active, their children are as well. However, the small sample size for this study may decrease the generalizabilty of the results.

In examining the relationship between parents and their preschool-aged children's physical activity levels, this study determined that children's physical levels correlate with their parents' physical activity levels. Mothers that engage in vigorous activities have children that participated in more physical activities in the childcare setting during pre-toy observations. This data indicated that mothers that reported daily vigorous activities may be role models for their children in the home and the behavior is put to use in the childcare centers.

In the literature the association between physical activity levels and children is influenced by family, communities, teachers, coaches, peers, and media. Family is the most influential of all. Parents and siblings are role models to children in fostering healthy behaviors during early childhood. It is important for parents to introduce healthy physical activity behaviors to their children at a very early age. Because children grow up in a home environment for many years, it is essential that parents influence their children choices in different activities.

By replacing some of the sedentary and physical activities in each childcare center it gave children the opportunity to choose from different activities from those normally found in their childcare setting. The approach that was implemented gave the Family and Child Health Laboratory research team a better understanding of which activities children are more likely to participate in. The new styles and structures of the sedentary activities are what captured young children's eyes. When debating between using a physical activity or an interactive book, children preferred sedentary activities that were fun and easy to use.

Most children are not always given the opportunity to go outside and be active. Sedentary activities can be of use when the space is limited inside. However, activities that promote physical activity are best for a child's overall health and development. It is important for parents to promote activities for their children that are educational and healthy. In the home, a child should have access to and be able to choose from as many physical activities as sedentary activities. One limitation of this study was not being able to observe children and their parents at their home to see if what was self-reported about their physical activity levels was true.

Parents that engage in high levels of physical activity should participate in high levels of physical activities with their children. Parents that have their children involved in sports and recreational activities at a young age will allow children to get used to being physically active into adulthood and reduce their children's chances of becoming obese. Parents that are overweight tend to have children that are overweight as well. If being physically active is a way to keep a child living happy and healthy and avoiding childhood obesity it is worth it. An additional limitation of this study was that it relied solely on self-reported measures of parents' physical activity levels. The parent physical activity levels were measured using an International Physical Activity Questionnaire (IPAQ). Another limitation of this study was not being able to observe children in an outdoor environment. Even though the study was limited to indoor environment it allowed the opportunity to explore more activities that children are more likely to engage in when they are inside.

RECOMMENDATIONS

Recommendations for further studies most consider implementing activities that will give children in childcare settings the opportunity to be more physically active. When considering a childcare setting to observe, consider the supportive environment. It is important to study with a center that has a supportive staff. It is especially essential to examine a childcare center that has both physical activities and sedentary activities available for children to engage in. Focus on the childcare environment and the amount of space that is available for a child to engage in physical activity and the time observations are conducted. Therefore, future research must consider parents as a key factor in finding modeling healthy behaviors and encouraging their children to participate in more physical activities versus sedentary activities.

References

Anderssen, N., & Wold, B. (1992). Parental and Peer Influences on Leisure-Time Physical-Activity in Young Adolescents. *Research Quarterly for Exercise and Sport, 63*(4), 341-348.

Craig, C. L., Marshall, A. L., Sjostrom, M., Bauman, A. E., Booth, M. L., Ainsworth, B. E., et al. (2003). International physical activity questionnaire: 12-country reliability and validity. *Medicine and Science in Sports and Exercise, 35*(8), 1381-1395.

Davison, K. K., & Birch, L. L. (2002). Obesigenic families: parents' physical activity and dietary intake patterns predict girls' risk of overweight. *International Journal of Obesity, 26*(9), 1186-1193.

Freedson, P. S., & Evenson, S. (1991). Familial Aggregation in Physical-Activity. *Research Quarterly for Exercise and Sport, 62*(4), 384-389.

Gustafson, S. L., & Rhodes, R. E. (2006). Parental correlates of physical activity in children and early adolescents. *Sports Medicine, 36*(1), 79-97.

Irwin, J. D., He, M. Z., Bouck, L. M. S., Tucker, P., & Pollett, G. L. (2005). Preschoolers' physical activity behaviours - Parents' perspectives. *Canadian Journal of Public Health-Revue Canadienne De Sante Publique, 96*(4), 299-303.

Kalakanis, L. E., Goldfield, G. S., Paluch, R. A., & Epstein, L. H. (2001). Parental activity as a determinant of activity level and patterns of activity in obese children. *Research Quarterly for Exercise and Sport, 72*(3), 202-209.

Kimiecik, J. C., Horn, T. S., & Shurin, C. S. (1996). Relationships among children's beliefs, perceptions of their parents' beliefs, and their moderate-to-vigorous physical activity. *Research Quarterly for Exercise and Sport, 67*(3), 324-336.

Moore, L. L., Lombardi, D. A., White, M. J., Campbell, J. L., Oliveria, S. A., & Ellison, R. C. (1991). Influence of Parents Physical-Activity Levels on Activity Levels of Young-Children. *Journal of Pediatrics, 118*(2), 215-219.

Pan, C. Y., Frey, G. C., Bar-Or, O., & Longmuir, P. (2005). Concordance of physical activity among parents and youth with physical disabilities. *Journal of Developmental and Physical Disabilities, 17*(4), 395-407.

Sallis, J. F. (2000). Age-related decline in physical activity: a synthesis of human and animal studies. *Medicine and Science in Sports and Exercise, 32*(9), 1598-1600.

Sallis, J. F., Nader, P. R., Broyles, S. L., Berry, C. C., Elder, J. P., McKenzie, T. L., et al. (1993). Correlates of Physical-Activity at Home in Mexican-American and Anglo-American Preschool-Children. *Health Psychology, 12*(5), 390-398.

Sallis, J. F., Patterson, T. L., McKenzie, T. L., & Nader, P. R. (1988). Family Variables and Physical-Activity in Preschool-Children. *Journal of Developmental and Behavioral Pediatrics, 9*(2), 57-61.

Sallis, J. F., Prochaska, J. J., & Taylor, W. C. (2000). A review of correlates of physical activity of children and adolescents. *Medicine and Science in Sports and Exercise, 32*(5), 963-975.

Sallis, J. F., Taylor, W. C., Dowda, M., Freedson, P. S., & Pate, R. R. (2002). Correlates of vigorous physical activity for children in grades 1 through 12: Comparing parent-reported and objectively measured physical activity. *Pediatric Exercise Science*, *14*(1), 30-44.

Soubhi, H., Potvin, L., & Paradis, G. (2004). Family process and parent's leisure time physical activity. *American Journal of Health Behavior*, *28*(3), 218-230.

Stolley, M. R., Fitzgibbon, M. L., Dyer, A., Van Horn, L., KauferChristoffel, K., & Schiffer, L. (2003). Hip-Hop to Health Jr., an obesity prevention program for minority preschool children: baseline characteristics of participants. *Preventive Medicine*, *36*(3), 320-329.

Wold, B., & Anderssen, N. (1992). Health Promotion Aspects of Family and Peer Influences on Sport Participation. *International Journal of Sport Psychology*, *23*(4), 343-359.

Parity of Claim: When All Groups Are Created Equal

Courtnee-Evan Spino, McNair Scholar, Penn State University

Dr. Phillip Atiba Goff
Assistant Professor of Psychology
The College of Liberal Arts
Penn State University

Whites experience a greater concern with appearing racist. It was hypothesized that Whites would seek to highlight similarities between social categories while engaging in racial dialogues in an effort to reduce this threat. This equating of social groups—called Parity of Claim—can trivialize issues of history and power and, consequently, harm other participants in racial dialogues. Group dialogues from Penn State's Race Relations Project (RRP) were coded for use of Parity of Claim arguments and were analyzed to test the hypothesis that Whites were disproportionately likely to use such arguments, and that these arguments were used in contexts that made salient the possibility of Whites being seen as racist. Similarly, it was hypothesized that Whites would be less inclined to mention historical events in situations when being seen as racist was made salient.

Keywords: racial dialogue, racist, stereotype threat

While in racial dialogues, Whites experience concern with appearing racist (Goff, Steele, & Davies, under review). In an attempt to inoculate themselves from this anxiety, participants may use conversation techniques designed to prevent others in a dialogue from viewing them as prejudiced. One such conversation technique, which we call Parity of Claim, equates two races or social categories to one another. While this technique may be adopted with genuinely pro-social motives, the emphasis on commonalities may effectively erase issues of history and power.

It was hypothesized that White participants would employ more Parity of Claim comments, but fewer mentions of history when Blacks were present because the presence of Blacks in the dialogue would make salient the possibility of appearing racist. Blacks may make this possibility salient because of the racial differences between the races throughout history. Because this concern is greater for Whites, it was hypothesized that they would represent a greater percentage of Parity of Claim comments and employ comments that specifically erase history and power.

The diversity of these discussion groups may make differences in power and privilege between the participants salient (Miller & Fraser, 2004) which can foster additional inter-ethnic anxiety, that is anxiety that can come from being around those that are different from oneself (Stephan & Stephan, 2000). Other individuals may have prejudicial or racist views and experience anxiety when around these groups or through the ways that they try to control such views (Plant & Devine, 1998; Dutton & Fazio, 1997).
Whites' concern with appearing racist is supported by the theory of stereotype threat, in which an individual is concerned with conforming to or being evaluated in terms of a

negative stereotype about one's group (Steele, 1992; 1997). In this context, Whites will fear appearing racist while engaging in discussions about race.

If participants emphasize the commonalities that they share, then their differences and corresponding anxiety may be minimized. In an attempt to insulate against appearing racist participants may equate two races or social groups, such as through Parity of Claim comments. In this equating both groups are the same, their differences are erased, and therefore no one group has the advantage. If no group has the advantage then how can one be racist towards another? Often it is group differences in history and power that are erased. It is in this context—when the power that racial privilege bestows and the history that privilege has written are erased—that the threat of appearing racist could not exist because racism could also not exist.

Methods

For this study, sessions of Penn State's Race Relations Project were examined and coded for comments about history and Parity of Claims comments. The Race Relations Project (RRP) is run through the Sociology department and is privately funded with a mission to provide an open forum for racial dialogues. Two undergraduate student facilitators run Socratic-style discussions designed to promote open dialogue between all participants. They are each trained through exercises involving active listening skills, being opened to the opinions and experiences of others, asking non-leading or loaded questions, reading body language, and educated to critically focus on participants' comments and the possible thoughts behind them.

RRP sessions are run throughout the academic year and consist of 5 and 12 undergraduate participants per session. Students can volunteer to participate or may receive partial course credit for their participation. Each student signs a consent form before any dialogue or observation begins.

Twenty-Three 90-minute video-taped sessions of the RRP were watched and coded for content by a trained researcher. In total, two hundred and seventy-three undergraduate participants were observed.

Parity of Claim comments were operationalized as any statement that equated two different racial or social groups to each other. The social categories consisted of such non-racial groups as social clubs, religious affiliations, or sexual orientations. Each time a Parity of Claim comment was made, it was transcribed. Additionally, the race, gender, and time at which the comment was made were noted. Whether the individual making the comment was a student facilitator or a student participant was also noted. Lastly, the comment immediately before and immediately after the Parity of Claim comment was transcribed and coded in the same manner.

Whenever a comment was made that explicitly mentioned history or a historical event was made it was transcribed and coded in a manner identical to that of Parity of Claim comments. Similarly, the gender and race of each speaker were noted as well as whether they were a facilitator or participant.

A second trained research assistant independently viewed 14 of the sessions to establish inter-rater. One hundred percent inter-rater reliability was established.

Results

Recall that it was predicted that Whites would represent a disproportionate number of Parity of Claim comments. Whites represented 75 percent of the total number of participants, yet accounted for 87 percent of the total Parity of Claim comments made. It was also hypothesized that Whites would use more Parity of Claim comments that erased history or power.

Recall it was hypothesized that these Parity of Claim comments would occur more often in groups where Blacks were present than in groups without Blacks present. A significant difference in the number of Parity of Claim comments made by Whites was found between groups with no Black participants (M = .60) and groups with Black participants (M = 4.89), t (21) =2.43, $p < .05$. And, again, it was hypothesized that there would be more mentions of history in groups without Black participants than in groups with Black participants. A significant difference was also observed here, such that when Blacks were present, there were fewer mentions of history made per session (M = .56) than when Blacks were not present (M = 2), t (21) = 2.23, $p < .05$.

Discussion

While in racial dialogues, Whites are sharing a different experience than other races such that they are responding to a concern with appearing racist more than any other racial group. The support found for our first hypothesis demonstrates that Whites are using more Parity of Claim comments than other races. Although a person may not hold racist views the threat of appearing racist is still very present for them and affects the choices that they make while engaging in racial dialogues.

When Blacks are present in the group, the number of Parity of Claim comments increases fourfold, whereas the mentions of history decrease. This is consistent with our second and third hypothesis and shows that participants want to focus on perceived commonalities while eschewing the racist past that divides us.

Limitations

This study looked solely at undergraduate students engaging in dialogues for course credit. The setting effected the conversation and the results may not be generalizable to the greater population because of the specific age group and context for the conversations. Although the presence of a single Black person was enough to affect the rates at which Parity of Claim comments were made, Blacks represented a very small (10 percent) portion of participants in The Race Relations Project sessions. This under representation may not adequately reflect the comments that Blacks could use during these racial dialogues and may also not be generalizable. Also, having higher rates of Blacks present in these dialogues may also strengthen the current findings or create additional trends not found studying the present data.

The study was conducted using video taped sessions of racial dialogue; therefore there was no opportunity to question participants as to what they were feeling in the sessions.

The intent behind comments not questioned during the dialogues, such as many of the Parity of Claim arguments, could not be ascertained nor could the reactions of the other participants.

Conclusions

The present research demonstrated Whites in racial dialogues exhibiting conversation techniques different from those of other races. Whites were more often equating the experiences of different races or social groups through Parity of Claim comments as well as making more such comments that erase history and power. These commonalities were emphasized more when Blacks were present then when they were not, but the references to history were reduced, suggesting that Whites did not want to focus on issues that make racism salient.

References

Devine, P.G., Plant, E.A., Amodio, D.M., Harmon-Jones, E., & Vance, S.L., (2002). The regulation of explicit and implicit race bias: the role of motivations to respond without prejudice. *Journal of Personality and Social Psychology, 82 (5),* 835-848.

Fazio, R.H., & Dunton, B.C. (1997). Categorization by race: the impact of automatic and controlled components of racial prejudice. *Journal of Experimental Social Psychology, 33 (5),* 451-470.

Gaetner, S.L., & Dovidio, J.F., (2004). Understanding and addressing contemporary racism: from aversive racism to the common ingroup identity model.

Goff, P.A., Steele, & Davies (Under review). The space between us: Stereotype threat and avoidance in interracial contexts.

Miller, J., Donner, S., & Fraser, E., (2004). Talking when talking is tough: taking on conversations about race, sexual orientation, gender, class and other aspects of social identity. *Smith College Studies in Social Work, 74 (2),* 377-393.

Plant, E.A., & Devine, P.G., (1998). Internal and external motivation to respond without prejudice. *Journal of Personality and Social Psychology, 75 (3),* 811-832.

Richeson, J.A., & Ambady, N., (2003). Effects of situational power on automatic racial prejudice. *Journal of Experimental Social Psychology, 39,* 177-183.

Sellers, R.M., & Shelton, J.N., (2003). The role of racial identity in perceived racial discrimination. *Journal of Personality and Social Psychology, 84 (5),* 1079-1092.

Shelton, J.N., & Richeson, J.A., (2005). Intergroup contact and pluralistic ignorance. *Journal of Personality and Social Psychology, 88 (1),* 91-107.

Shelton, J.N., Richeson, J.A., & Salvatore, J., (2005). Expecting to be the target of prejudice: implications of interethnic interactions. *Personality and Social Psychology Bulletin, 31 (9),* 1189-1202.

Stephan, W.G., Stephan, C.W., & Gudykunst, W.B., (1999). Anxiety in intergroup relations: a comparison of anxiety/uncertainty management theory and integrated threat theory. *International Journal Intercultural Relations, 23 (4),* 613-628.

The Houston Pollution Problem: An analysis of the primary and secondary regional pollution peak

Joshua T. Walker, McNair Scholar, Penn State University
Dr. Anne Thompson, Ph.D[10]
Professor of Meteorology
Department of Meteorology
Penn State University

Abstract

In the spring of 2006, a joint study was conducted in the Houston area to assess the secondary regional pollution peak that occurs at that time. The primary peak occurs in the summer and was heavily investigated during the summer of 2000. The possibility of contribution from Mexico and Central America was suggested. Data archives from summer 2000 showed frequent high pollution episodes, which correlated with stagnant weather patterns and high temperatures. During spring 2006, pollution episodes were less severe and frequent, but pollutant accumulation was noted. On March 15, a day when ozone peaked at 55 ppb and remained near 40 ppb well into the night, trajectories and surface analysis showed transport of air from the Gulf of Mexico and northern and central Mexico. This contrasted with March 6, where pollutants accumulated, with ozone peaking at 45 ppb, but reduced back to very low-levels in the evening. Continued analysis of the spring 2006 data will allow for a more definite assessment of the secondary regional pollution peak.

1. Introduction

Approximately an hour inland from the western Gulf of Mexico lays the Houston metropolitan area, the seventh most populous region in the United States[1]. This massive region is also home to the largest petrochemical manufacturing area in the world and the Port of Houston, ranked first in the US for international commerce[2], both to the south and east of downtown Houston. The region is sprawled over 10 counties in southeastern Texas and has an extensive highway system, making the automobile the dominant mode of transport. Excessive automotive traffic combined with busy industry and local meteorology makes Houston a prime location for unhealthy air quality episodes. In fact, the region experiences unhealthy exposure to ozone and other pollutants frequently each year, with more occurrences during the summer months. The National Ambient Air Quality Standards (NAAQS), set by the US Environmental Protection Area (EPA), dictate levels of various pollutants that US cities must follow[3]. One standard, for example, indicates that ozone concentration averages over an 8 hour period may not exceed 80 parts per billion (ppb). However, locations in and around Houston can easily observe concentrations near 150 ppb, which is unhealthy for all people[4].

A significant portion of the US experiences episodes of unhealthy pollution exposure, with one-third of the US experiencing unhealthy exposure to ozone (Kleinman et al., 2002). This exposure is in large part due to anthropogenic sources including emissions of volatile organic compounds (VOCs), carbon monoxide (CO) and nitrogen oxides (NOx) from industry, automobiles, and power plants, amongst other things (Lelieveld et al., 2000; Duncan et al., 1998; EPA 2000). Unhealthy air quality episodes can be identified by the general public by the

reduced visibility caused by light scattering from the pollutants (Dzubay et al., 1982). Air quality can be improved by the reduction of NOx and VOC emissions, which in turn will also reduce the ozone byproduct (Duncan et al., 1998). If a region with air quality issues can identify the effect of each contribution to the unhealthy episodes, regulations of emissions can be established. Houston is a special case in that source emissions typically found in other cities exist in addition to emissions from the region's petrochemical industry causing extreme and rapid ozone formation. Such high amounts of NOx and VOCs can be dumped into the air early, that once the solar processes to form ozone begin, they proceed rapidly (Kleinman et al., 2002). Even areas of the region with low ozone formation may experience an unhealthy exposure when the Gulf of Mexico sea breeze transports the high concentrations from the port and petrochemical industry areas north and west over the rest of Houston (Daum et al., 2004).

In the summer of 2000, a joint study called the Texas Air Quality Study (Texas AQS 2000) was conducted to identify and assess the air quality issue in southeastern Texas, including Houston[5]. From this study came many findings that explained the high pollution exposure and most notably the high ozone occurrences in the area. Indeed, the Port of Houston and associated Houston Ship Channel, along which most of the petrochemical industry is located, proved to be the culprit. A less significant contributor was simply the abundance of cars and trucks traversing Houston's extensive hub and spoke highway system (Daum et al., 2003).

Recently, in the early spring of 2006 another study, which was a conglomeration of the INTEX-B, IONS-06, Milagro, and NATIVE campaigns, was conducted with ground and air measurements of Houston regional air. At the surface, ozone and other pollutants were measured, while the DC-8 air plane operated by NASA flew above southeastern Texas to measure ambient air above the surface. Additionally, sondes were launched to measure profiles of the atmosphere from the surface to the upper atmosphere.

In the early spring, particularly in March, the Houston area experiences a second peak in pollution. While the summer peak is well understood, the cause of the spring peak is unknown. Air above the region is suggested to not only come from local production, but to also come from air that originated in Mexico and Central America. The Mexico City area experiences higher pollution during winter (Raga et al., 2000; Riveros et al., 1998) and early spring and biomass burning in Mexico and Central America is prevalent at the same time. This research:

- Reviews the data from summer 2000,
- Compares the spring 2006 conglomerate study data with summer 2000 data,
- Identifies two examples of the daily pollutant accumulation and dispersal from spring 2006.

Whereas, during the summer months, weather patterns in the latitude of Houston and Mexico City tend to be stagnant, spring is known for more defined air transport. This may validate the suggestion that Houston area ozone episodes during the spring are actually due to Mexico City pollution episodes.

2. Methodology

To conduct a comparison and analysis of the summer 2000 and spring 2006 observations required massive data collection. All summer 2000 data was obtained from the Texas AQS 2000[6], which includes surface ozone (O_3), CO, sulfur dioxide (SO_2), and NOx measurements. Data from the spring 2006 study was obtained from the following campaigns: INTEX-B[7], IONS[8], and NATIVE[9]. Flight data from the NASA DC-8 aircraft (part of INTEX-B) was derived from

flight summaries of missions between the Mexico City area, the Gulf of Mexico, and Houston. NATIVE provided ground-level measurements from southeastern Houston and IONS provided sonde and air trajectory data. Correlations between summer 2000 and spring 2006 high pollution level occurrences and observed atmospheric air rich in ozone, VOCs, and NOx were assessed.

3. Findings and Discussion

3.1 Texas AQS 2000

Texas AQS 2000 provided data for analysis of the summer air pollution situation in Houston. The study ran from August 15 to September 15 which saw a major poor air quality episode around the first of September. Pollution levels frequently exceeded the standards dictated by the EPA, including those for ozone and CO.

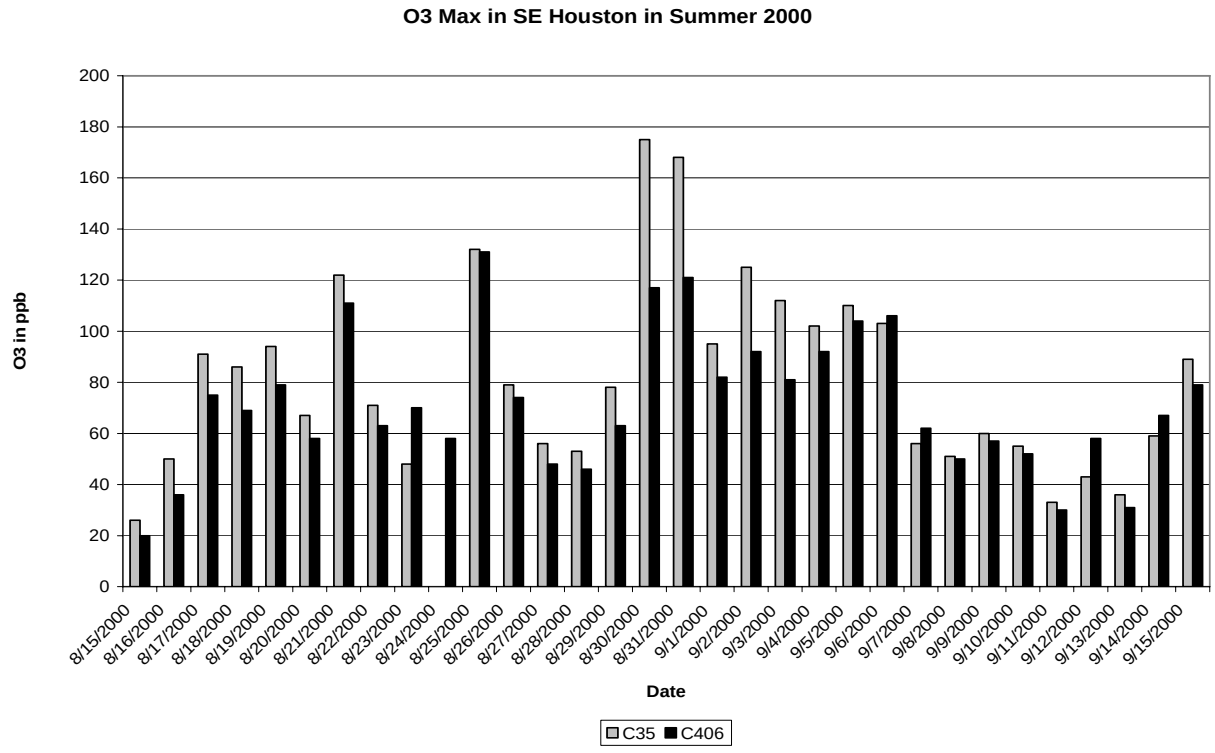


Figure 1: This table shows the daily maxima in ozone concentration at two reporting stations in SE Houston near the site of the 2006 NATIVE measurements.

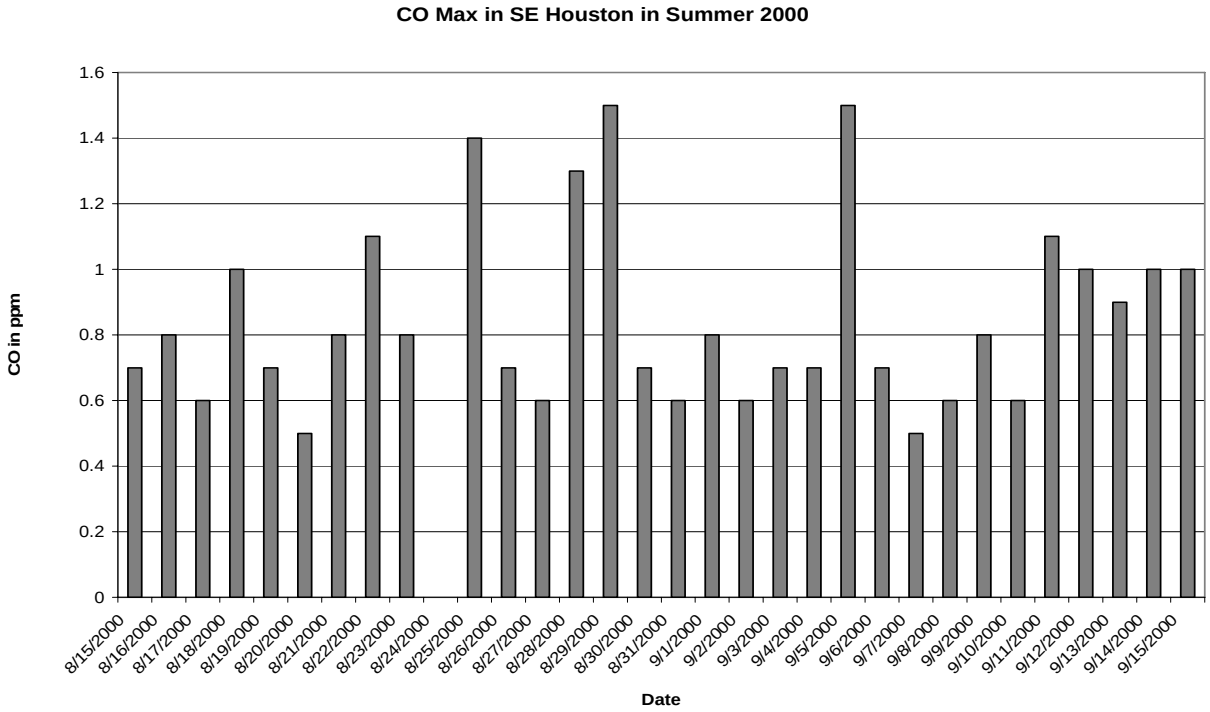


Figure 2: This table shows the daily maxima in CO concentration at the C35 reporting station in SE Houston near the site of the 2006 NATIVE measurements.

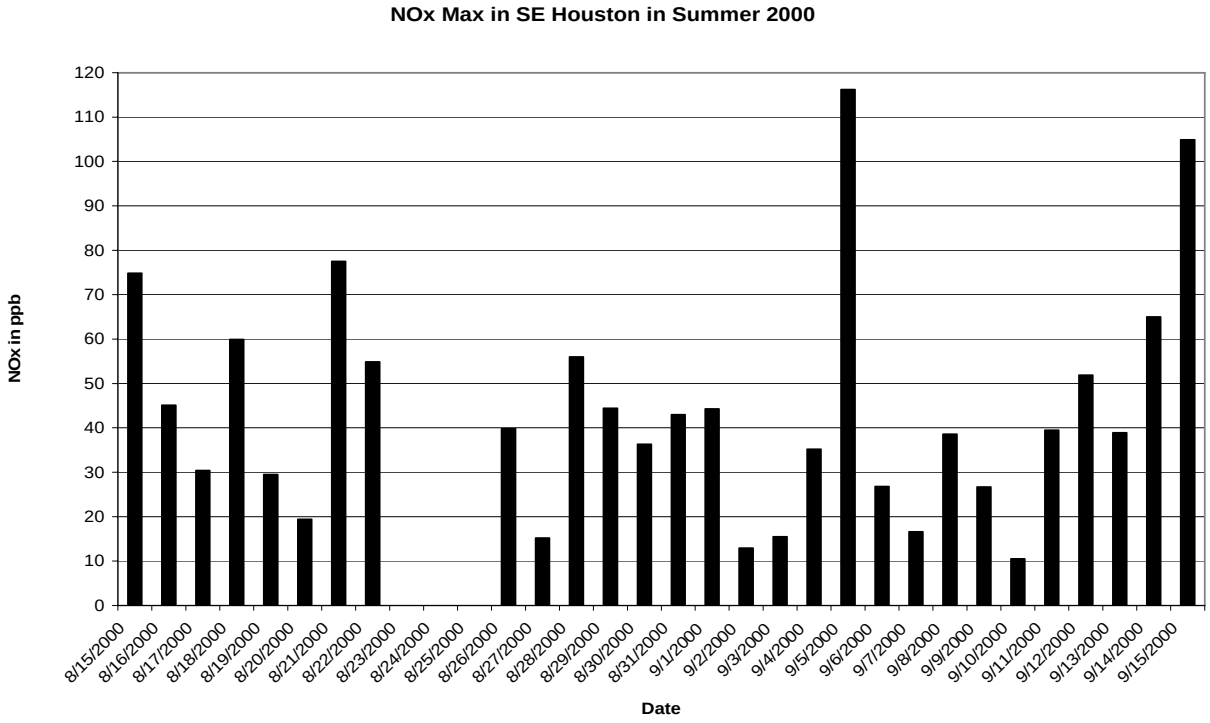


Figure 3: This table shows the daily maxima in NOx concentration at the C35 reporting stations in SE Houston near the site of the 2006 NATIVE measurements.

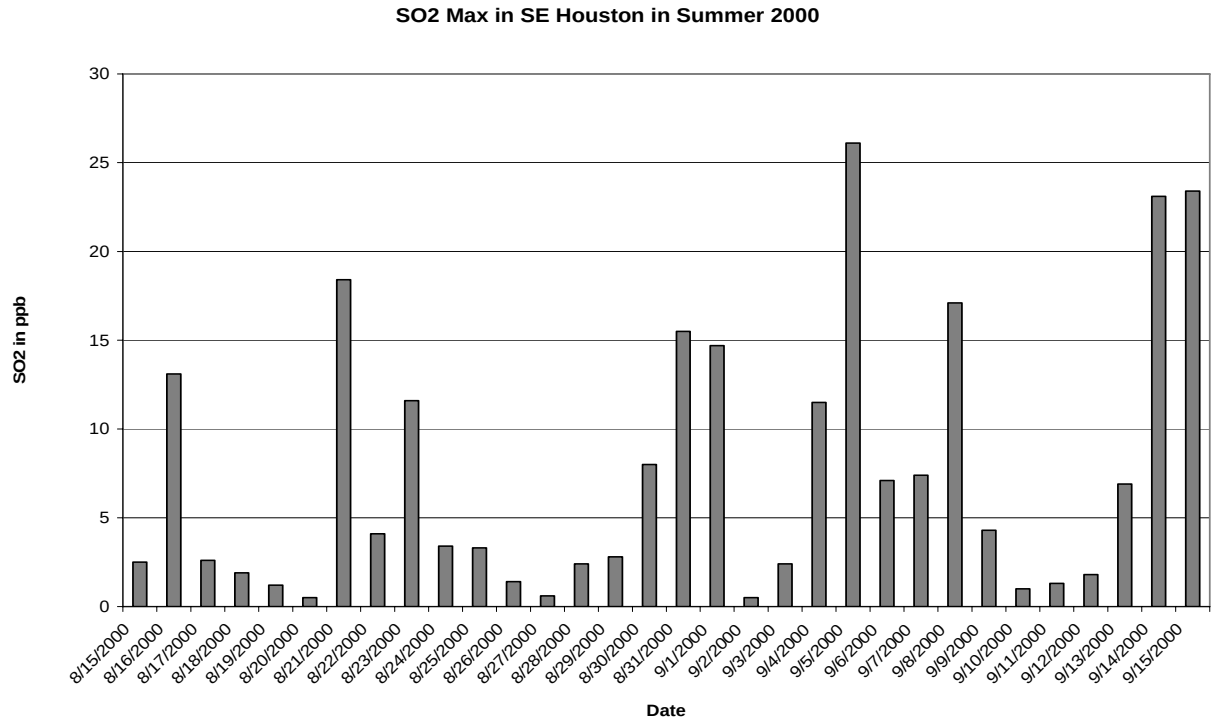


Figure 4: This table shows the daily 1-hour average maximums in sulfur dioxide (SO_2) concentration at the C406 reporting station in SE Houston near the site of the 2006 NATIVE measurements.

As shown in Figure 1, much of Texas AQS 2000 was marked with several periods of notably high ozone. For episodes in which high ozone was observed, higher amounts of SO_2, NOx and CO were also observed. Higher chemical concentrations correlate with warmer temperatures and a stagnant summer pattern. For the periods of higher measurements, especially ozone, the readings indicated in Figures 1-4 are actually conservative because of their location in the city. Measurements at stations further south and east toward the Houston Ship Channel and directly downwind of the heavy industry actually recorded ozone and other pollutant levels much higher, near 150 and 200 ppb. These levels fall in the unhealthy category according to the EPA[4]. The pollution episode around September 1 correlates with a heat wave that struck the Houston area with full sunshine and temperatures above 100 degrees Fahrenheit. The weather pattern was stagnant with slow moving air throughout much of the atmosphere and no significant feature to scour out the accumulated pollution. This verifies the fact that high heat, typical of summer, combined with a stagnant weather pattern results in the worst pollution episodes.

3.2 Spring 2006

In the spring of 2006 a combination of data was collected to observe pollution in Houston and in the atmosphere over Mexico and southeastern Texas. Sondes were launched from Houston to give pollution profiles of the atmosphere. NATIVE measured ground level pollution. The NASA DC-8 plane was flown to follow air believed to be coming from Mexico. The spring study lasted three weeks in March. During the time period no ozone violations occurred at the ground level where NATIVE was located; however, there are periods of notable pollutant accumulation, especially with ozone.

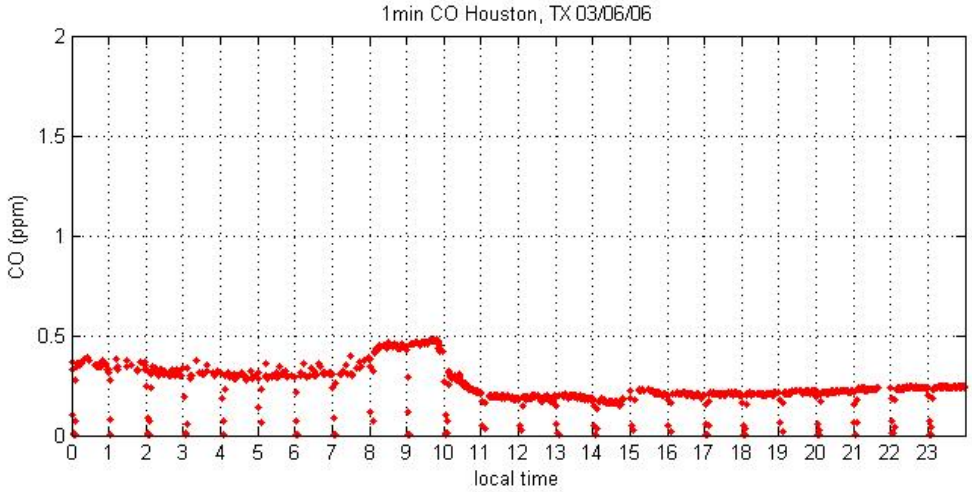
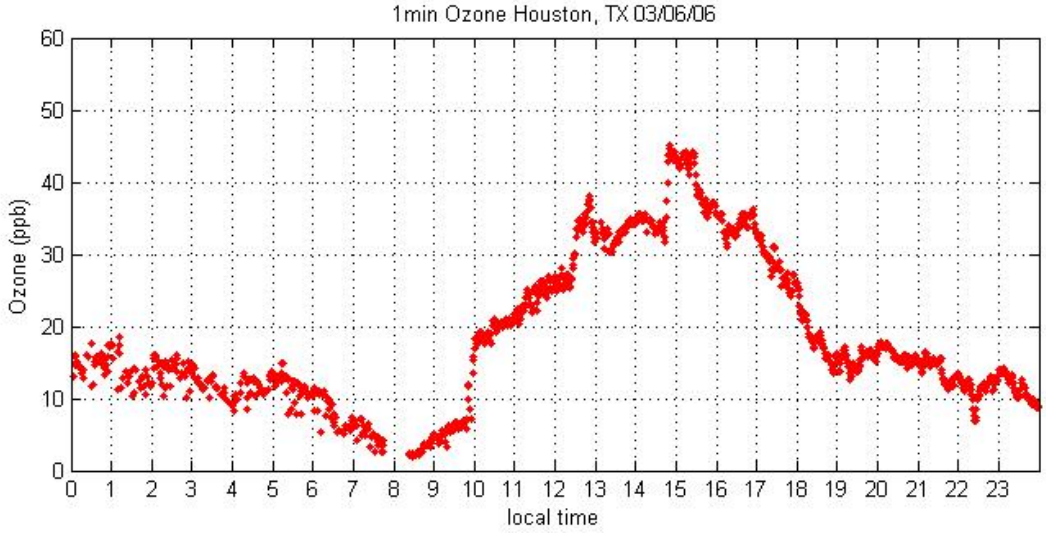


Figure 5 shows the carbon monoxide measurements from NATIVE on March 6, 2006, a typical day for pollution in the Houston area.



Figured 6 shows the ozone as measured by NATIVE on March 6, 2006.

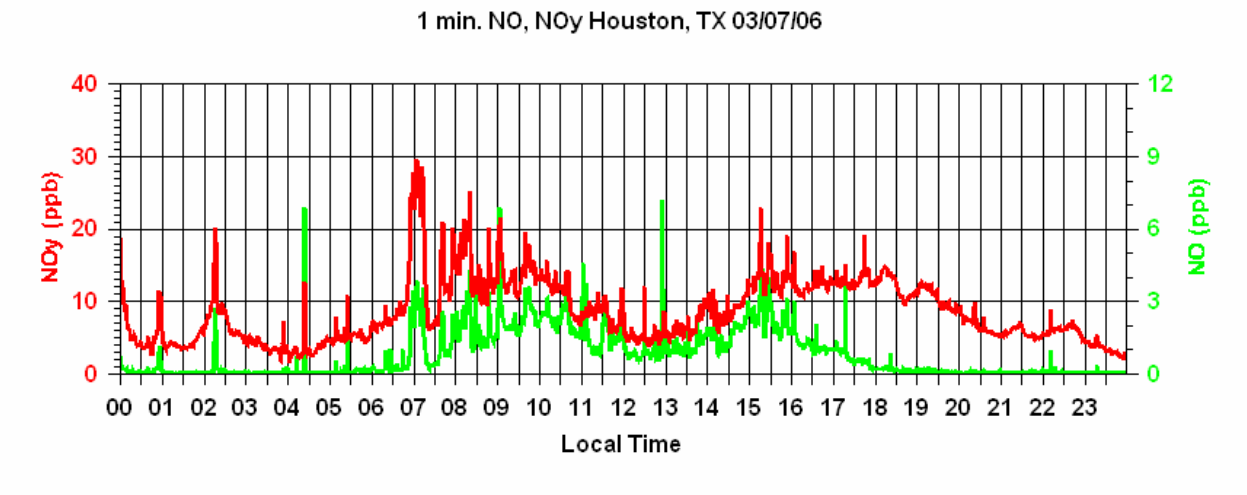


Figure 7 shows the nitric oxides as measured by NATIVE on March 6, 2006

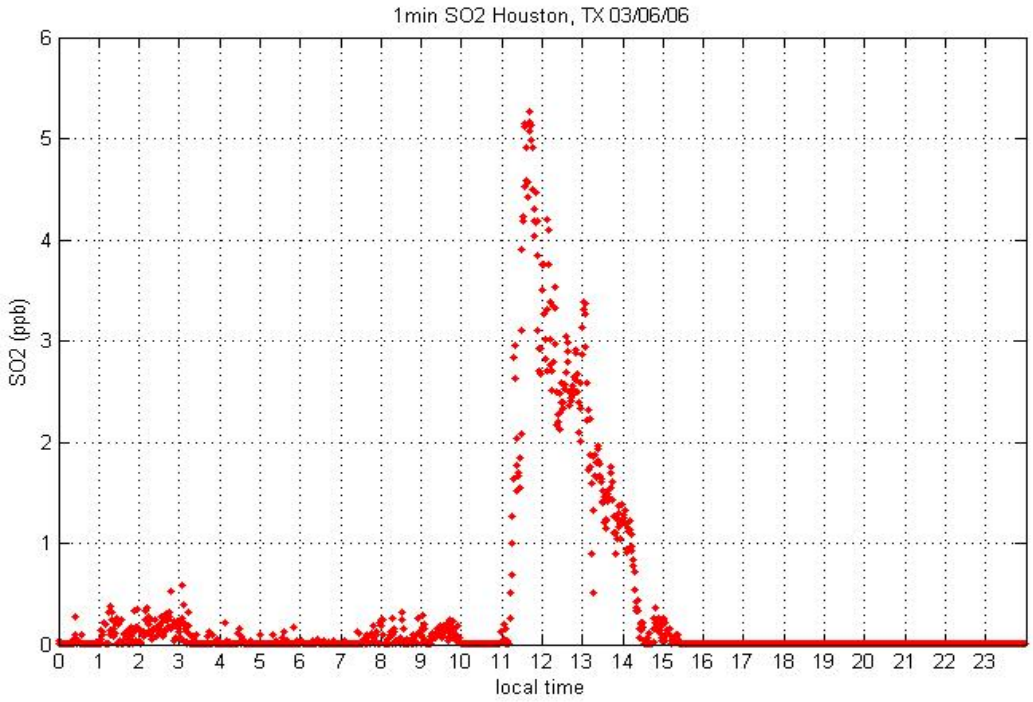


Figure 8 shows the SO_2 as measured by NATIVE on March 6, 2006

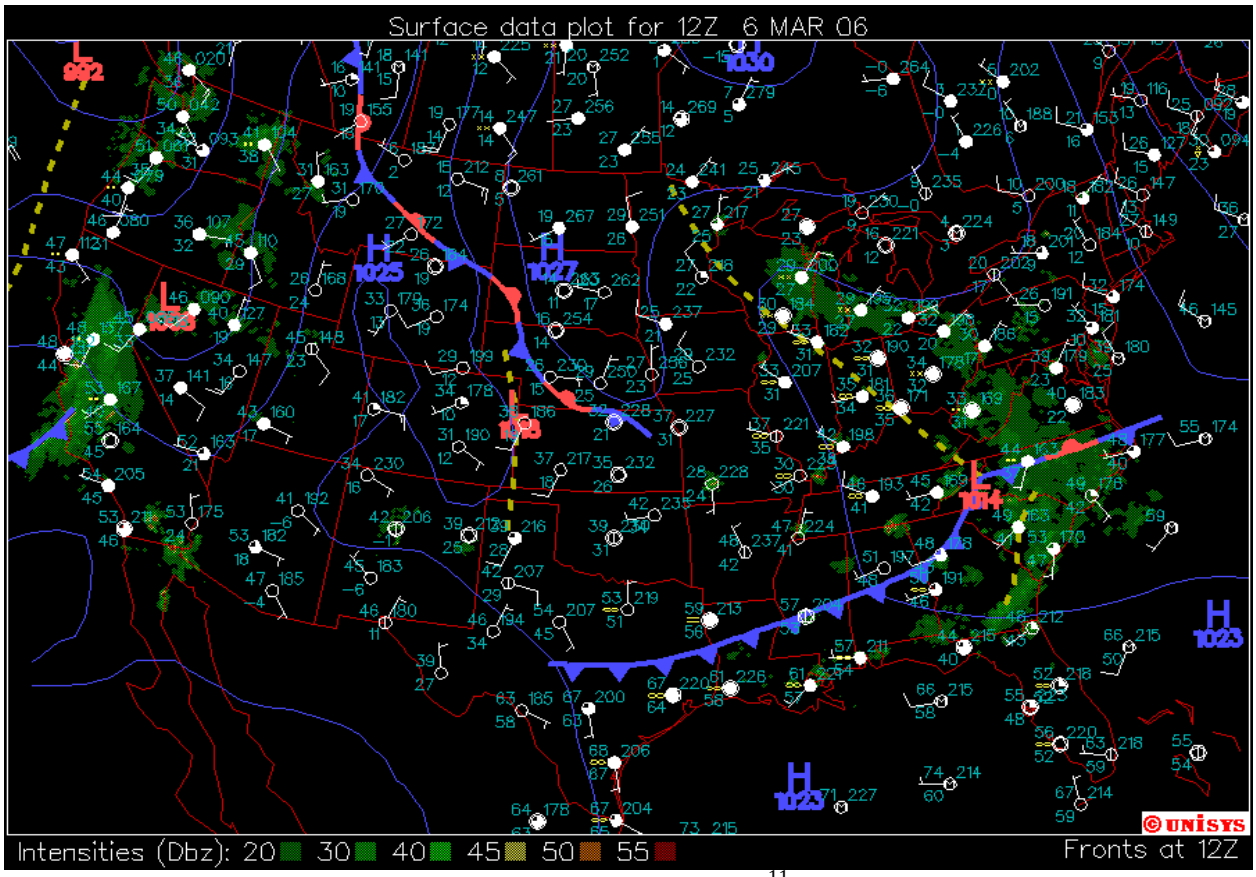


Figure 9 shows the surface weather map on March 6, 2006 by Unisys[11].

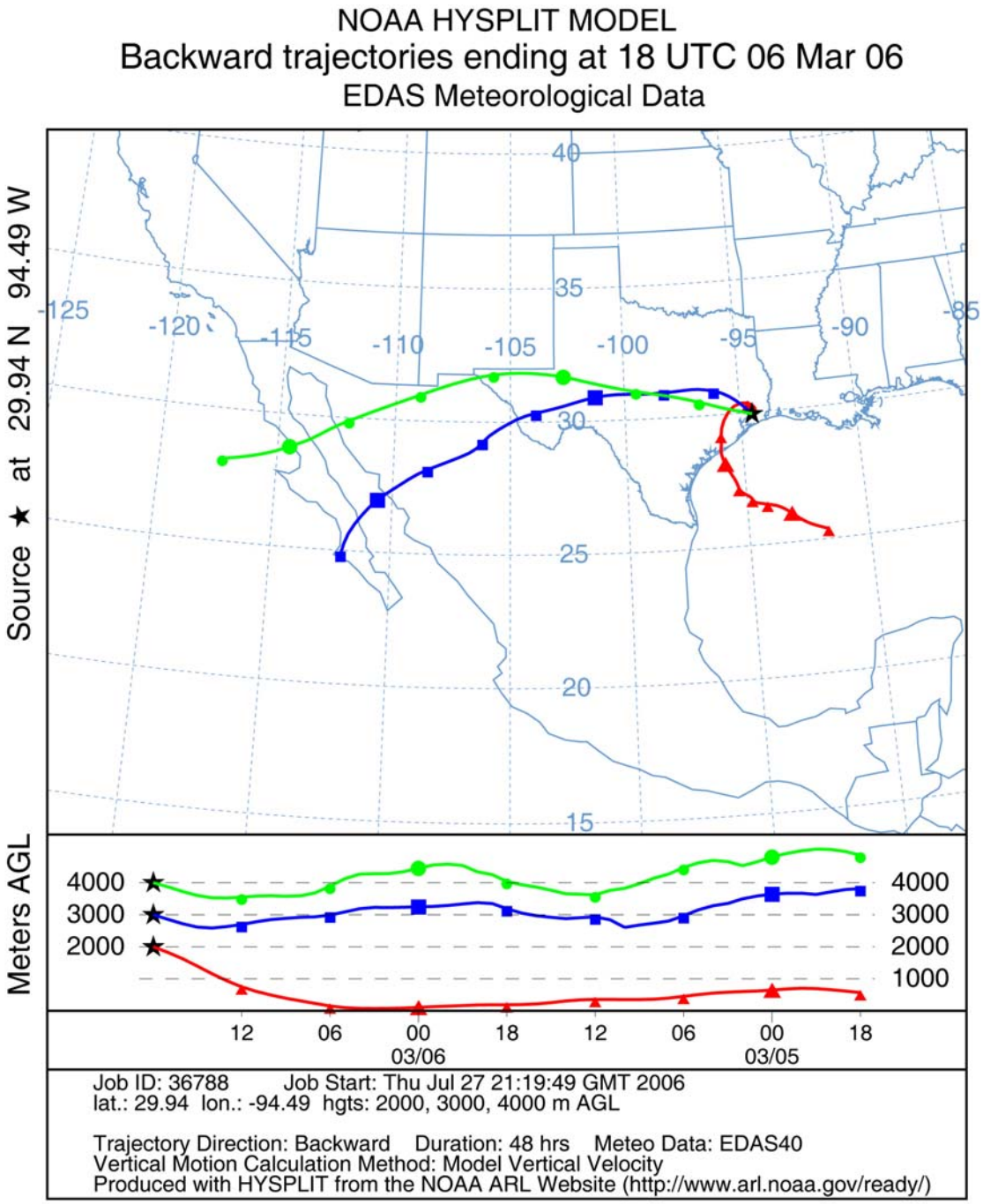


Figure 10 shows the back trajectory of air parcels over Houston using the HYSPLIT model.

On March 6, 2006, a generally typical day was observed in the Houston area. The ozone precursor pollutants, specifically CO and the nitric oxides, peaked during the morning as the

morning rush hour took place and the industry geared up (Figure 5 & 7). Sulfur dioxide also peaked early in the day, though a little later than the rush hour (Figure 8). These emissions set the stage for ozone production in the afternoon. The ozone peaked in mid-afternoon near 45 ppb and then cleared out by evening as shown in Figure 6. Factors that help clear out the ozone and other pollutants are a strong meteorological pattern that transports the pollutants to other regions and convective processes which transport the pollutants into the free troposphere higher in the atmosphere. Sometimes the sea breeze from the Gulf of Mexico helps disperse higher, more dangerous concentrations of pollution over a wider region. These occurrences allow for healthy exposures to pollutants as opposed to a build-up of pollutants that can lead to high levels.

Figure 9 shows the national surface weather map for the day. A cold front was passing through the Houston metropolitan area. The winds were nearly calm, indicated by the lack of wind barbs on the station model. Usually, a light wind and stagnation would allow a build-up of pollutants, but passage of the cold front dispersed the afternoon peak build up. Cold fronts are followed by cooler and drier air, which is perfect for scouring out pollutant-rich, hazy air that was found in Houston on March 6. Figure 10 is an air trajectory analysis from the HYSPLIT model. This indicates the origin of the air at various levels in the atmosphere. On March 6, the model shows that the air over Houston was primarily from the Pacific Ocean. Because oceanic air is usually clean, most of the measured pollution on March 6 was from local sources.

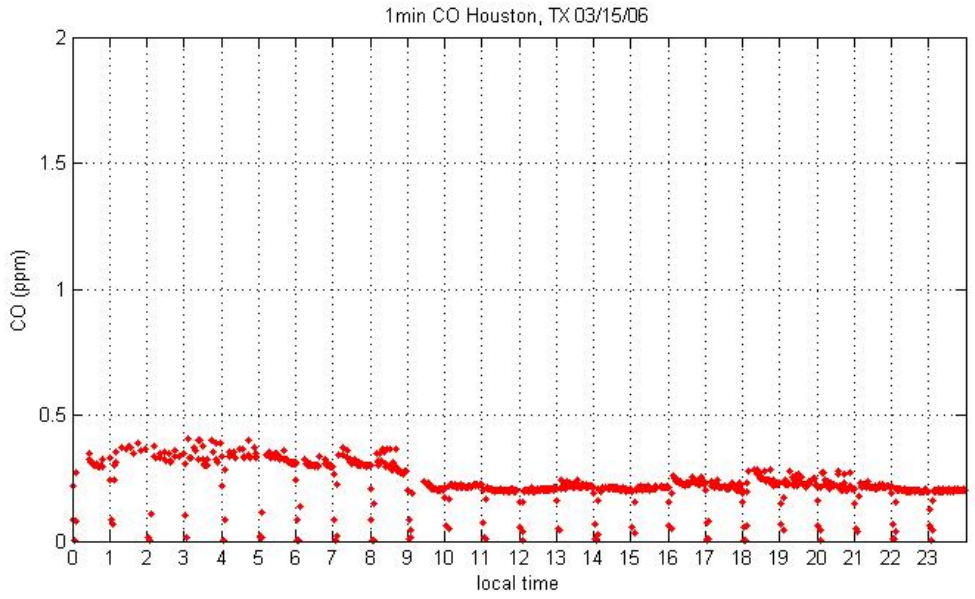


Figure 11 shows the carbon monoxide levels measured by NATIVE on March 15, 2006.

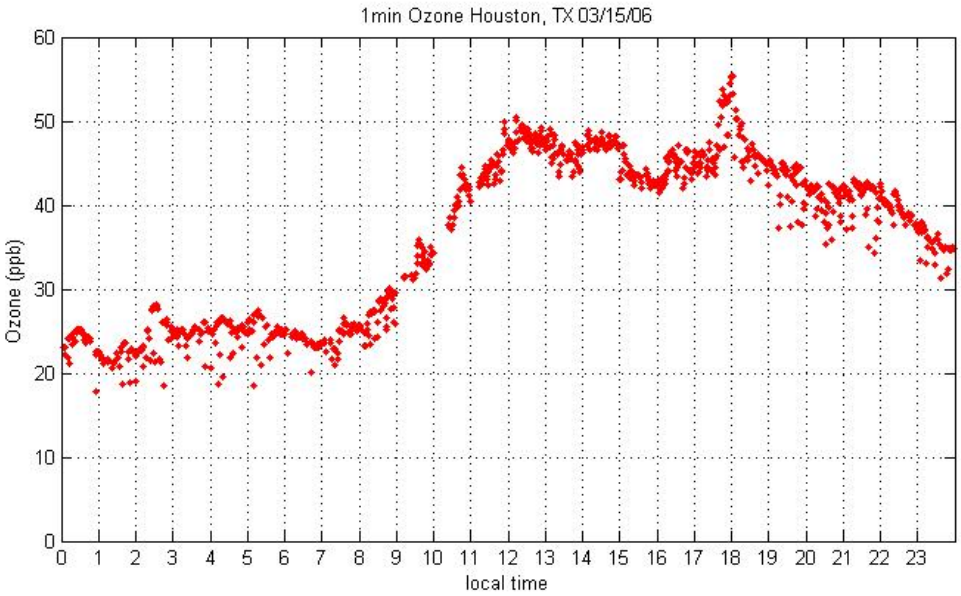


Figure 12 shows the ozone levels as measured by NATIVE on March 15, 2006.

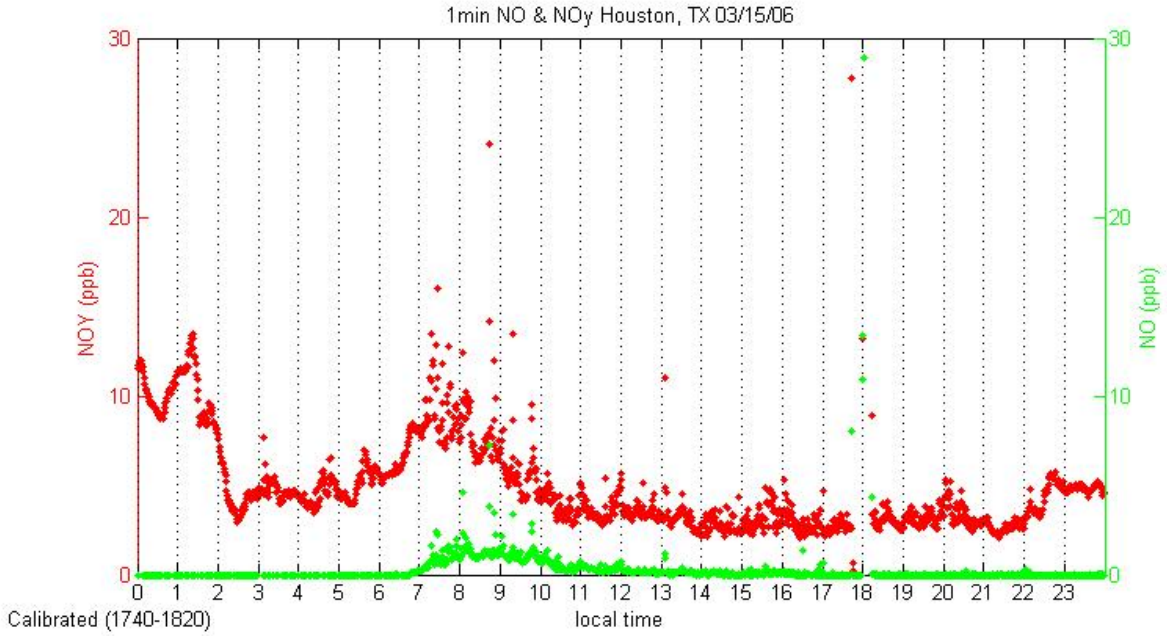


Figure 13 shows the nitric oxides as measured by NATIVE on March 15, 2006

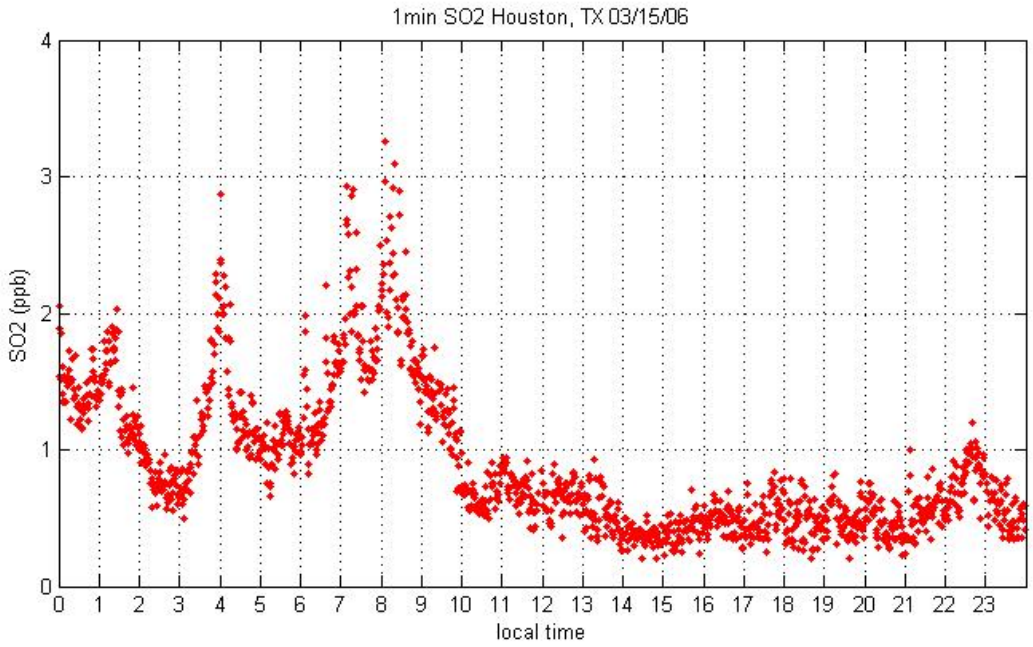


Figure 14 shows the SO_2 as measured by NATIVE on March 15, 2006

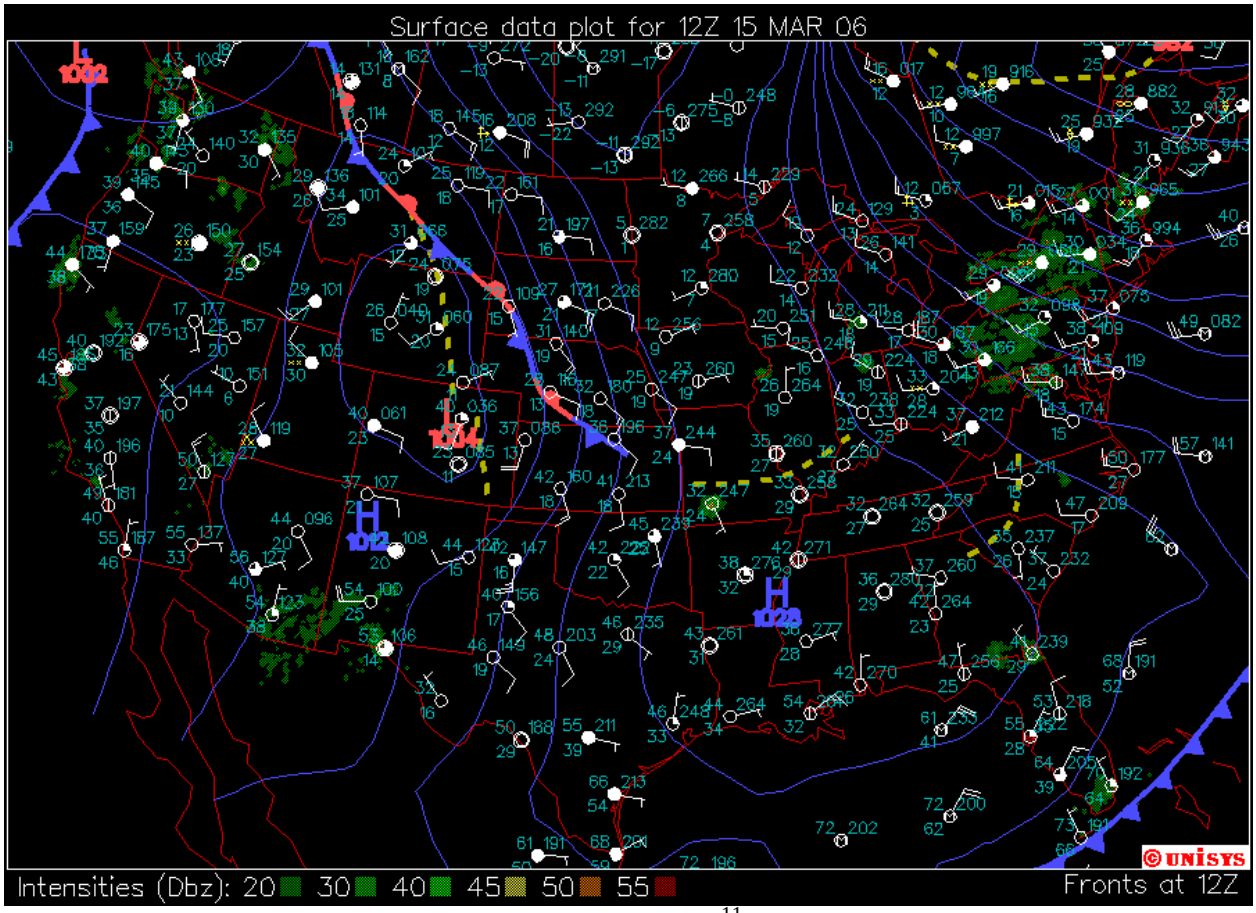


Figure 15 the surface weather map on March 15, 2006 by Unisys[11].

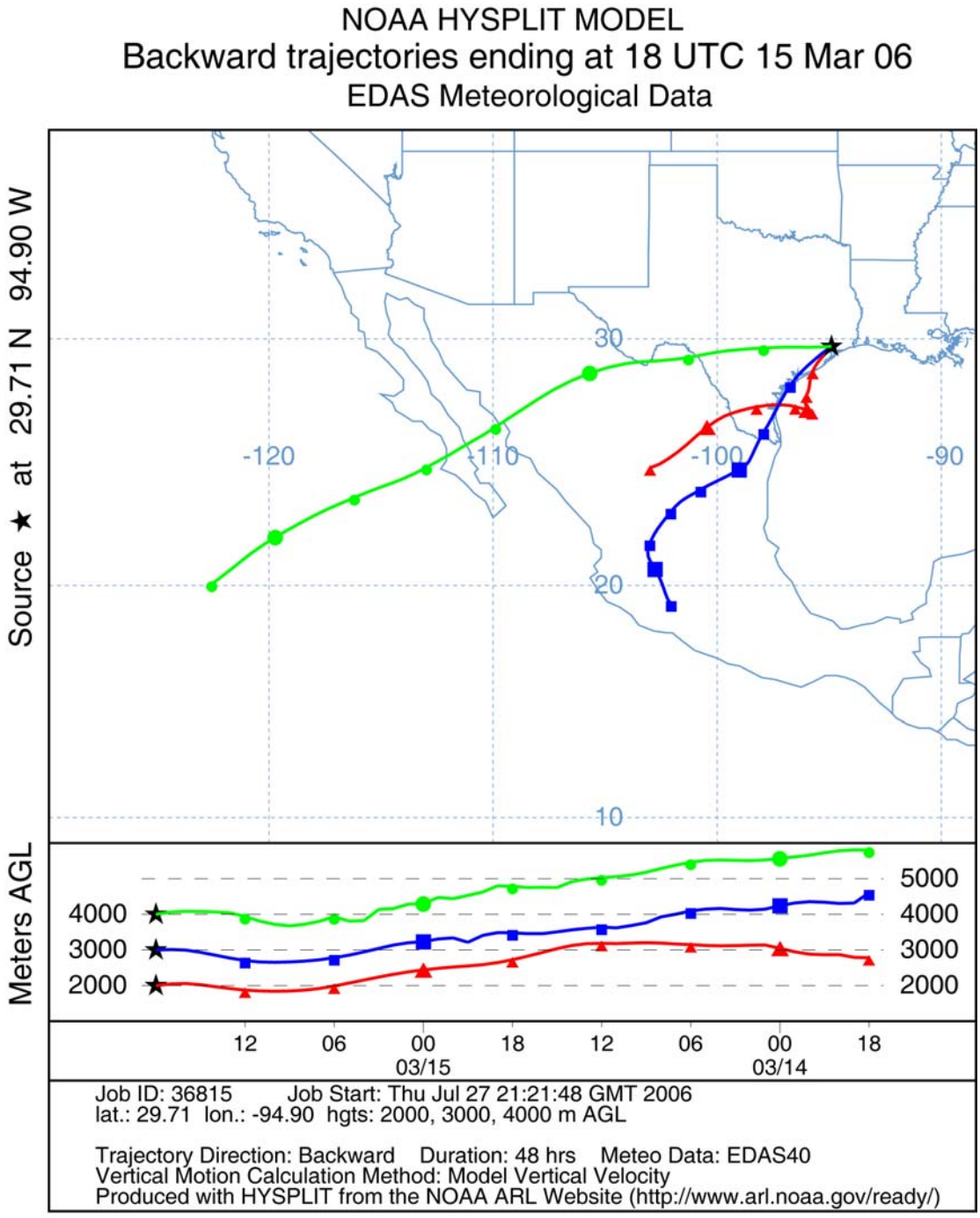


Figure 16 shows the back trajectory of air parcels over Houston using the HYSPLIT model.

March 15 was an example of pollutant accumulation in the Houston area indicative of the springtime secondary peak. The CO emission levels were higher in the morning hours than on

March 6 and there was a small, but steady increase in CO levels during the evening (Figure 11). The nitric oxides and SO_2 also showed the peak as expected during the morning rush hour time frame, although both pollutants also showed some early morning activity (Figures 13 &14). The ozone peaked in the afternoon as expected with a reading of 55 ppb, very similar to March 6 (Figure 12). As the evening progressed, however, the ozone levels did not reduce back to the morning levels. The ozone levels dropped from the mid-afternoon peak, but remained relatively high, near 40 ppb. On the next day, this remnant ozone could pose a problem as more emissions can accumulate, especially CO to create more ozone.

Figure 15 shows the national surface weather map for March 15. According to the map, a ridge of high pressure was over the southeastern US. Winds in Houston, indicated by the wind barb were out of the northeast at the time of map analysis; however, surrounding stations reported a light southerly and southeasterly wind. These winds would mean that air from the Gulf of Mexico was moving over eastern Texas at the surface. The back trajectory from this day shows that the air was generally coming from northern Mexico and central areas of Mexico.

4. Summary & Future Research

Summer 2000 shows the primary peak in regional pollution for the Houston area. Stagnant weather patterns and high heat and sunshine make production of ozone and accumulation of ozone, nitric oxides, carbon monoxide, and sulfur dioxides a frequent occurrence. The concentrations of these pollutants reach unhealthy levels with no relief until a significant pattern scours out the air. During the spring, the weather patterns are more defined. As the spring 2006 indicates, accumulation of pollutants tends to be less severe because the temperatures are lower and the passage of cold fronts and other weather features are more frequent.

Houston does experience a second regional pollution peak, however, with suspicion of contributions from Mexico and Central America. Currently, the analysis has not led to a definitive conclusion of outside contributions to Houston pollution during the early spring. The examples presented in the research are rather ambiguous can neither confirm nor reject the suggestion of Mexico City and Central American influence on Houston. More in-depth analysis is underway and will continue using the spring 2006 data. If Mexico City pollution outflow and biomass burning outflow from Central America and Mexico proves to directly affect Houston's early spring pollution peak, the pollutants would transport over Houston well above the surface and mix down to the surface as daytime heating progresses.

5. References & Citations

1 www.census.gov
2 http://www.portofhouston.com/geninfo/overview1.html
3 http://www.epa.gov/air/criteria.html
4 http://airnow.gov/index.cfm?action=aqibroch.index
5 http://www.utexas.edu/research/ceer/texaqs/visitors/about.html
6 http://www.tceq.state.tx.us/
7 http://croc.gsfc.nasa.gov/intexb/
8 http://croc.gsfc.nasa.gov/intexb/ions06.html

[9] http://www.meteo.psu.edu/%7Ebtaubman/Webpage/native.html

[10] Meteorology Department, Penn State University, 503 Walker Building, University Park, PA 16802-5013; 814-865-0479, fax-814-865-3663; anne@met.psu.edu

[11] http://weather.unisys.com/index.html

Daum, P.H., Kleinman, L.I., Springston, S.R., Nunnermacker, L.J., Lee, Y.-N., Weinstein-Lloyd, J., Zheng, J., Berkowitz, C.M., Origin and properties of plumes of high ozone observed during the Texas 2000 Air Quality Study (TexasAQS 2000). *Journal of Geophysical Research*, 109, D17306, 2004.

Daum, P.H., Kleinman, L.I., Springston, S.R., Nunnermacker, L.J., Lee, Y.-N., Weinstein-Lloyd, J., Zheng, J., Berkowitz, C.M., A comparative study of O3 formation in the Houston urban and industrial plumes during the 2000 Texas Air Quality Study. *Journal of Geophysical Research*, 108, D23, 4715, 2004.

Duncan, B.N., Chameides, W.L., Effects of urban emission control strategies on the export of ozone precursors from the urban atmosphere to the troposphere. *Journal of Geophysical Research*, 103, D21, 28,159-28,179, 1998

Dzubay, T.G., Stevens, R.K., Lewis, C.W., Visibility and aerosol composition in Houston, Texas. *Environmental Science and Technology*, 16, No. 8, 514-525, 1982.

Environmental Protection Agency, National Air Quality and Emissions Trends Report 1998 EPA 454/R-00-003, US Environmental Protection Agency, Washington, DC, 2000.

Kleinman, L.I., Daum, P.H., Imre, D., Lee, Y.-N., Nunnermacker, L.J., Springston, S.R., Weinstein- Lloyd, J., Rudolph, J, Ozone production rate and hydrocarbon reactivity in 5 urban areas: A cause of high ozone concentration in Houston. *Geophysical Research Letters*, 2002.

Lelieveld, J., Dentener, F., What controls tropospheric ozone? *Journal of Geophysical Research*, 105, D3, 3531-3551, 2000.

Raga, G.B, Castro, T., Baumgardner, D., The impact of megacity pollution on local climate and implications for the regional environment: Mexico City. *Atmospheric Environment*, 35, 1805-1811, 2001.

Riveros, H.G., Alba, A., Ovalle, P., Silva, B., Sandoval, E., Carbon monoxide trend, meteorology, and three-way catalysts in Mexico City. *Journal of Air & Waste Management Association*, 48, 459-462, 1998.

Examination of Racial Categorization within Group Dialogue

Robert Allen Young, McNair Scholar, Penn State University
Dr. Phillip Atiba Goff
Assistant Professor of Psychology
The College of Liberal Arts
Penn State University

The present research hypothesized that participants in race dialogue avoid racial categorization in an attempt not to be seen as racist. Using video taped conversations of undergraduate students at Penn State, the present research identified examples of avoidance of racial categorization. It was hypothesized that, in mixed-race group dialogues, where the possibility of being seen as racist was elevated, White participants would avoid racial categorization more often than in all-White group dialogues.

Key Words: racial dialogue, categorization, color-blindness

It was hypothesized that, if White participants participating in racial dialogue are uncomfortable with issues of history and power, the avoidance of racial categorization will occur in an attempt not to be seen as racist. There has been much research done examining how interpersonal concerns affect individuals within interracial encounters. These issues of concern may focus around issues of prejudice, which, like other interpersonal concerns can effect individual's perceptions and behaviors, (Devine, Evett, & Vasquez Suson 1996). The approach to reducing interracial tension, *color-blindness*, proposes that racial categories should not be considered when making decisions such as hiring and school admission. The primary argument of this approach is that social categories should be dismantled and disregarded, and everyone should be treated as an individual (Firebaugh & Davis, 1998). This approach directly applies to this research, in that we are observing how this "disregarding" of racial categories affects racial dialogue. The purpose of this research was to examine whether or not the avoidance of racial categorization stems from this concern with being seen as racist. And, if so, what might this suggest about the causes of so-called "color-blind" approaches to racial difficulties?

Within group dialogue it was observed that participants placed more emphasis alternate descriptors such as way of dress, personality, non-verbal cues, and social interactions than on racial identity. We have found examples of participants placing more emphasis on these within video taped sessions. Participants have been quoted saying: "It is more personality than race," "I think it is more of the situation that you meet someone in [what you think of them], than what race they are," "I can tell more about someone based on what they have on, more than what race they are". White participants made

these statements. By doing so, race was devalued and no longer seen as an important aspect of the conversation.

It stands to reason that, if no one has a race, then no one can be racist. This then may be the tacit reasoning behind Whites' avoidance of racial categorization. This pattern of avoidance would have been developed by participants to lessen the concern of being labeled racist. To test this proposed relationship, the observation of video recorded race dialogues was conducted. The use and avoidance of racial categorization was coded and noted for examples. Gender and race were coded to determine the correlation.

Methods

For this research we obtained data from group conversations focusing on race and race relations. The Race Relations Project at The Pennsylvania State University conducted these conversations. The Race Relations Project is a group that facilitates conversations with undergraduate students and various organizations on the Penn State campus. Undergraduate students who have been trained through course work and supervised conversations direct the discussion. The facilitators use a Socratic style of questioning when conducting the groups. The groups lasted ninety-minutes. Each group was video and audio recorded. The participants were undergraduate students all above the age of eighteen who signed and agreed to a waiver releasing videotapes for research. The sessions included groups of six to ten members including two trained facilitators who were also undergraduate students at The Pennsylvania State University. Students participated in each session to fulfill a course requirement.

Two research assistants observed each RRP session to improve inter-rator reliability and decrease observer bias. The observers noted comments related to racial categorization and coded for: race of the person making the comment (White, Black, or Other), gender of the person (Male, Female), role of the person (Participant, Facilitator), and time (time quote was made in seconds), and for actual quote made related to racial categorization. These codes included: Was there hesitation when asked "What are you or what do you classify yourself as," Any Explicit Denial?, Do the use Symbolic Ethnicity?, Do they use Alternative Social Classification?, Superordinate (Everyone is the same), Do they state that talking about the issue makes it worse?, Do they state that they are uncomfortable categorizing people?, Do they say something negative about categorizing people?, Yes or No, Do they State: Because I am [RACE] I am stereotyped, How many times does this person say something related to categorizing?, Is this person overall shy or outspoken (Scale from 1-3, 1 being shy and 3 being outspoken). The data collected was entered into an excel spreadsheet. The excel spreadsheet was converted into SPSS format for data analysis.

The proposed relationship for this research was that mainly White participants in the group dialogues would avoid racial categorization the most in an effort not to be seen as racist. The hypotheses of the present research were that Whites would avoid racial categorization more than other groups, avoidance of racial categorization would lead to the devaluation of race in racial dialogue, rather than race used as a way of categorization there would be more emphasis placed on way of dress, personality, social interaction, and

other non-verbal cues, and avoidance of racial categorization will have been developed as a method to avoid being labeled a racist.

Results

It was hypothesized that White participants would make more categorization comments in groups where the concern of being labeled racist was greater. It was hypothesized that White participants would do so in an attempt to avoid being seen as racist. Data was analyzed using a statistical analysis of comments coded in all 28 sessions observed. The average comment made for each category coded was found. There was a statistically significant difference in the amount a comment was made when Blacks were not present in a group, and when Blacks were present in a group. The categories that had a significant difference were explicit denial comment, symbolic ethnicity, alternative social classification, stating discomfort with categorization, and mentions of categorization. The "explicit denial" comments were comments made by participants that explicitly denied being racist. The "symbolic ethnicity" comments were comments made by participants that affiliated them with their culture in an attempt to avoid their affiliation with their race. The "alternative social classification" comment made affiliated participants with a group such as "jock", or "nerd" in an attempt to avoid affiliation with their race. The comments made by participants "stating discomfort with categorization", were noted as having discomfort with the act of categorization. The "mentions of categorizations" comments made by participants were noted when a participant mentioned the act of categorization. The category explicit denial of racism had the results: with no Blacks present there was an average of 0 comments made per session, with Blacks present in the group there was an average of 1.05 comments made per session, t (26) = 2.27, $p < .05$. The category symbolic ethnicity had the results: with no Blacks present there were 0.75 comments made per session, with Blacks present there were 2.2 comments made per session, t (26) = 2.17, $p < .05$. The category alternative social classification had the results: with no Blacks present in there were 0.25 comments made per session, with Blacks present there were 1.3 comments made per session, t (26) = 2.21, $p < .05$. The category "stating discomfort with categorization" had the results: with no Blacks present there were 0 comments made per session, with Blacks present there were 1.15 comments made per session, t (26) = 2.39, $p < .05$. The category "mentions of categorization" had the results: with no Blacks present there were 5.38 comments made per session, with Blacks present there were 9.4 comments made per session, t (26) = 2.39, $p < .05$.

Limitations

The limitations of this research can be seen as the non-proportional sample of participants used. There were a disproportional number of White participants compared to Black participants. A sample that was more proportionally even throughout races may have produced different results. It was only hypothesized that participants avoided racial categorization in an attempt not to be seen as racist. It was not examined or supported that this avoidance actually does reduce the concern of being labeled racist. Also, the understanding of how this avoidance allows for the concern of being labeled racist was

not examined. All of these limitations are future areas of interest that should be researched.

Conclusion

Issues of history and power such as the historical enslavements of Blacks, historical racism, and continued prejudiced towards out-groups are all issues that weigh on White participants within racial dialogues. In an effort to avoid the negative stigma that has been placed on Whites because of these things, White participants often attempt to avoid them. This avoidance occurs in the devaluation of race. Through the avoidance of racial categorization, White participants erase important issues of history and power from the dialogue and remove the threat of racism. White participants do this through an individualization of others in the group. Participants are separated from their social group such as race by placing a greater emphasis on descriptors such as gender, culture, and personality. Doing so, the race of an individual is erased from the conversation. If all participants are seen as "race-less" or equal, there is no responsibility that can be placed on any participant for issues of history and power on the lives of social groups. The threat of racism is also erased, because all participants are equal, and any statement or opinion cannot be seen as a racist. A major implication found from this research is that what may make White participants comfortable in racial dialogue, may not be what makes everyone comfortable.

References

Devine, P.G., Plant, E.A., Amodio, D.M., Harmon-Jones, E., & Vance, S.L., (2002). The regulation of explicit and implicit race bias: the role of motivations to respond without prejudice. *Journal of Personality and Social Psychology, 82 (5),* 835-848.

Fazio, R.H., & Dunton, B.C. (1997). Categorization by race: the impact of automatic and controlled components of racial prejudice. *Journal of Experimental Social Psychology, 33 (5),* 451-470.

Gaetner, S.L., & Dovidio, J.F., (2004). Understanding and addressing contemporary racism: from aversive racism to the common ingroup identity model.

Goff, P.A., Steele, & Davies (Under review). The space between us: Stereotype threat and avoidance in interracial contexts.

Miller, J., Donner, S., & Fraser, E., (2004). Talking when talking is tough: taking on conversations about race, sexual orientation, gender, class and other aspects of social identity. *Smith College Studies in Social Work, 74 (2),* 377-393.

Plant, E.A., & Devine, P.G., (1998). Internal and external motivation to respond without prejudice. *Journal of Personality and Social Psychology, 75 (3),* 811-832.

Richeson, J.A., & Ambady, N., (2003). Effects of situational power on automatic racial prejudice. *Journal of Experimental Social Psychology, 39,* 177-183.

Sellers, R.M., & Shelton, J.N., (2003). The role of racial identity in perceived racial discrimination. *Journal of Personality and Social Psychology, 84 (5),* 1079-1092.

Shelton, J.N., & Richeson, J.A., (2005). Intergroup contact and pluralistic ignorance. *Journal of Personality and Social Psychology, 88 (1),* 91-107.

Shelton, J.N., Richeson, J.A., & Salvatore, J., (2005). Expecting to be the target of prejudice: implications of interethnic interactions. *Personality and Social Psychology Bulletin, 31 (9),* 1189-1202.

Stephan, W.G., Stephan, C.W., & Gudykunst, W.B., (1999). Anxiety in intergroup relations: a comparison of anxiety/uncertainty management theory and integrated threat theory. *International Journal Intercultural Relations, 23 (4),* 613-628.