

Do Biological Measures Add Predictive Value in Screening for Stable Aggression in Children?

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Abstract

The consequences associated with early onset aggression illustrate the importance of early intervention. In order to maximize the cost effectiveness of intervention, screening procedures must predict which children need intervention and which children do not. A staged screening may improve current procedures which maximize sensitivity and thus, risk over-inclusion of healthy children. Electroencephalogram (EEG) research has shown patterns in frontal brain activity related to individual characteristics and emotion experience. EEG data will be examined to determine if biological markers of neural function prospectively differentiate between children at risk for stable aggressive behavior and those whose aggression is temporary.

Introduction

Aggression is a major societal and individual health concern. Aggression encompasses behaviors that have the potential to inflict physical or emotional harm on others (Loeber & Hay, 1997). In children, these behaviors often include direct physical aggression toward other children and adults. Early onset direct aggression can persist into adolescence and adulthood, leading to future maladjustment (Brennan, Hall, Bor, Najman, & Williams, 2003). In fact, as children age, the likelihood of continued aggressive behavior increases (Connor, 2002; Farrington, 1991). Even though half of aggressive males ages 8 to 10 decrease in aggression by the age of 32 (Farrington, 1991), adult aggression is almost always preceded by a history of childhood and adolescent aggression (Sampson & Laub, 1993). Additionally, as problems related to aggression accumulate, older children are less responsive to treatment (Kazdin, 1995; Ruma, Burke, & Thompson, 1996). Some even suggest that antisocial behavior present in middle childhood may not be reversible (Mash & Wolfe, 2010). This stated, early intervention is necessary to maximize the possibility of preventing lifelong aggression and antisocial behavior.

Because early onset aggression is strongly correlated with stable lifelong antisocial behavior, the expression of aggression at a young age is a relatively overt and observable indicator of risk. Therefore, interventions that aim to prevent lifelong antisocial behavior use the presence of early onset aggression as a criterion for entry. However, the fact that half of individuals desist from aggression by adulthood presents a challenge in effective screening. Over-inclusion of individuals incorrectly labeled as “at risk” for lifelong aggression may present

risks and costs. This study explores the predictive value of a staged screening process that utilizes physiological measures in addition to a behavioral screen.

The Consequences of Aggressive Behavior

Early onset aggression is strongly linked to future externalizing problems, such as more serious violence, delinquency, conduct disorder, and substance abuse (Broidy et al., 2003; Card, Stucky, Sawalani, & Little, 2008). These externalizing problems are also associated with potential difficulties in academic and job settings (Kaplow, Curran, Dodge, & Conduct Problems Prevention Research Group, 2002). Furthermore, early onset aggression is associated with peer rejection, which can lead to internalizing problems, such as depression and anxiety (Card et al., 2008; Tremblay et al., 2004; DeRosier, Kupersmidt, & Patterson, 1994). The accumulation of these problems over time further constrains personal growth by reducing opportunities for positive, prosocial influences from adults and peers.

In addition, aggressive behavior presents social and financial consequences for the community. For example, violence damages individuals' perception of safety. It is also associated with significant costs related to medical and psychological treatment, property repair, legal proceedings, incarceration and rehabilitation (Frick, 2001). By the time individuals are involved in the legal system (as juvenile or adult offenders), rehabilitation is notoriously ineffective. A cycle of illegal behavior and poor rehabilitation can yield limited social and occupational opportunities for positive life trajectories and reinforce a pattern of antisocial behavior. Therefore, intervening in the process before aggressive behavior becomes a self-sustaining strategy is both financially and socially beneficial.

Intervention and Screening Procedures

The accumulation of adverse outcomes associated with early onset aggression highlights the importance of effective preventative childhood interventions. Aggression present at age 4 can predict 51% of the variance in aggression at middle adolescence (Connor, 2002). Because aggression by adolescence is more strongly related to adult aggression; early interventions must address young children before aggressive behavior continues and increases in severity (Brennan et al., 2003).

Universal interventions, aimed at every child in a classroom, can decrease individual aggression (Payton et al., 2008). However, these programs are costly in terms of supplying program materials and taking time out of the school day from children who are not aggressive or who will desist from aggression naturally over time (Farrington, 1991). Indicated programs, on the other hand, are cost effective because they only target children who already display aggressive behavior and are at risk for chronic aggression. They are also more intensive and tailored to the individual child's behavioral patterns.

The problem with indicated interventions arises in determining which children should be included in the program. Because indicated programs only attend to a subset of children, selection into the program introduces a labeling process by which children could be stigmatized. Disclosure of the results of behavioral screens permits and reinforces a frame of mind in which parents and teachers will view a child for years to come. Peer suspicions of a child's participation in an intervention will also affect a child's present and future interactions. The stigma and expectation of aggression from others can provoke aggressive responses, a phenomenon commonly referred to as self-fulfilling prophecy. Thus, screening strategies that routinely include children who are not in need of intervention risk stigmatization, which could

adversely alter the child's development. Screening procedures should be as precise in predictive validity as possible.

Unfortunately, it is difficult to know in early childhood which children will demonstrate stable and continuous aggression over the ensuing decades of their lives, and which children will naturally desist from aggression. Therefore, intervention is likely to be most effective at a time when accurately identifying those in need is most difficult. Because early onset aggression is strongly related to later aggressive behavior, children on a trajectory of lifetime aggression will be highly likely to be identified through this screening strategy. These children would be considered "true positives". Furthermore, children who do not show aggressive behavior and who continue this trajectory are considered "true negatives". However because early onset aggression does not predict lifelong aggression with 100% accuracy, both "false positives" and "false negatives" will also exist. False positives are those children showing early aggression but who will naturally desist from aggression in the future. False negatives are those children displaying no aggressive behavior, but who develop future aggression, however, this phenomenon is relatively rare.

True positives are the most likely to benefit from the indicated intervention. Similarly there is a financial benefit to excluding true negatives from intervention. While the aforementioned group distinctions indicate effective program implementation, the existence of false positives and false negatives introduces disadvantages. False negatives can bring about social and financial costs associated with unrecognized aggression. However, the consequences associated with false positives are more likely to occur because screening for early onset aggression implies that as many as 50% of identified children are not true positives. The disadvantages of this group membership include both the financial cost of providing the program unnecessarily, and the risk of contributing to stigma and self-fulfilling prophecy (see above; Frick, 2001).

Qualities of Assessments

Two qualities of assessments influence the proportion of children that comprise each group: sensitivity and specificity. Sensitivity refers to the proportion of true positives accurately identified from the total number of individuals with lifelong aggression. Similarly, specificity refers to the proportion of true negatives accurately identified from the total number of individuals who eventually desist from aggression. In changing the thresholds of these attributes, the proportions of individuals comprising the four groups change. However, because sensitivity and specificity are inversely related, an increase in one domain compromises the other. An ideal screening procedure would maximize the number of true positives and true negatives while minimizing the number of false positives and false negatives. This requires a challenging balance of sensitivity and specificity.

Limitations and Biases of Behavioral Assessment

Screening procedures utilize a number of behavioral assessments ranging from trained observer assessments and parent or teacher reports to self-reported behavior questionnaires. In the case of childhood aggression, a commonly used assessment is the teacher report, often a questionnaire solely about classroom behavior. These reports are advantageously inexpensive and concise, but can be complicated by limitations and subjective factors. Behavioral screening may identify and provide many healthy children with a costly and unnecessary intervention. Many children entering kindergarten may have difficulty adapting to the new environment,

experience anxiety, and react aggressively to the situation. A screening for early onset aggression may indicate that these children are aggressive. However, the same screening procedure, given at the end of the school year might reveal normative aggression levels, indicating no need for intervention. As for all single time-point screenings, the information collected can be an effect of confounding and changing circumstances. Aggression at the time of screening cannot always predict lifelong aggression.

In addition to the timing confound, teacher-report assessments can also be affected by observer biases. Different teachers define aggressive behaviors differently, and are more likely to recognize aggressive behaviors in children of whom they already have a negative impression.

While behavioral measures attempt to measure objectively, subjectivity is always a concern. Even though behavioral assessments are cost effective and easily administered, they can be ineffective due to the aforementioned limitations and subjective complications.

Staged Screening

In an effort to identify many children with lifelong aggression and exclude children with temporary aggression, interventions can use a staged screening procedure. A highly sensitive first stage of screening can ensure inclusion of many children with aggressive behavior. A short teacher-reported questionnaire can serve as this sensitive screener because it is time and cost effective. This first screener can produce two subsets of children in a classroom, those who are currently perceived as aggressive and those who are not. In an attempt to limit the indicated intervention group to only children at risk for lifelong aggression, the second phase of screening can be much more specific. This study attempts to test the value of psychophysiological measures as the second phase of screening for chronic aggressive behavior in children.

Electroencephalography

The use of psychophysiological assessments may add specificity to behavioral assessments. One form of psychophysiological assessment that has been used to study the physiological correlates of individual differences in behavioral tendencies is electroencephalography (EEG). EEG is a measure of surface brain activity through amplification of electrical signals. These signals are recorded from electrodes placed on the scalp above different areas of the brain. Waveforms in the electrodes indicate activity in specific cortical regions: the frontal, parietal, occipital, and temporal lobes. Because EEG records this activity and demonstrates millisecond resolution, it is appropriate for examining responses to emotional stimuli. Much of the literature shows distinct brain responses to different types of emotion. Considering that lifelong aggression may be related to emotion experience and emotion regulation in certain situations, there may be a relationship between brain activity during emotion-inducing situations and aggressive behavior. Differences in this psychophysiological measure during emotion induction may contribute to the differentiation between children displaying persistent and transient aggression.

Frontal EEG asymmetry is a quantification of brain activity that is frequently studied in relation to emotional experiences. It is defined as the magnitude of difference in activation between the frontal regions of the right and left hemisphere. Activation is measured as the inverse of EEG-recorded alpha band power. Alpha power refers to the brain activity oscillating within a specific frequency band, typically 6 – 9 Hz in preschool aged children (Marshall et al., 2002). Brain activity at this frequency is correlated with drowsiness or less cognitive engagement. Accordingly, the hemisphere with lower alpha power is considered higher in

activation. Thus, greater left alpha power indicates right asymmetrical frontal activation, while greater right alpha power indicates left asymmetrical frontal activation.

This asymmetrical activation can be studied in two ways; through lateralization of asymmetry, and magnitude of asymmetry. Lateralization is a categorization of either more prominent left or right activation. Magnitude is the degree of difference between left and right hemispheric activation. As Davidson (1988) highlighted, magnitude can reveal group differences in asymmetry due to the degree of greater or lesser activation of a hemisphere, whereas laterality cannot.

Emotion Experience and EEG Asymmetry. Research indicates that frontal asymmetry is associated with both affective experience (Davidson, 1992) and the motivational direction driving behavior (Harmon-Jones, 2004). A review by Davidson (2004) suggests that right frontal activation is associated with emotions that accompany withdrawal behaviors in many participants. These emotional states include negative valences such as sadness, fear or disgust (Jones & Fox, 1992). On the other hand, left frontal asymmetry is associated with experiencing affective states that accompany approach behaviors (Davidson, 2004). Originally, left frontal asymmetry patterns were considered to exclusively reflect positive emotions (Jones & Fox, 1992; Fox, 1991). Many studies have now shown that anger-inducing stimuli may also generate left asymmetries despite its negative valence (Harmon-Jones & Allen, 1998; Sutton & Davidson, 1997; Rybak, Crayton, Young, Herba, Konopka, 2006; Harmon-Jones & Sigelman, 2001). This is thought to result from the approach motivation that generates behavioral responses aimed at resolving the anger-inducing situation (Harmon-Jones, 2004; Harmon-Jones & Allen, 1998; Davidson, 2004). While the causal direction of EEG asymmetry and emotion response remains unknown, frontal asymmetry may be a potential screening tool. Because previous research indicates right and left asymmetries are associated with withdrawal and approach motivations, abnormal asymmetrical activation may indicate atypical responses to emotional stimuli. Coan and Allen (2004) have also suggested that asymmetry facilitates the experience of the emotion. Thus, absence of the standard pattern of reactivity may affect emotional response (Coan & Allen, 2004). Emotion conditions such as sadness and fear are advantageous in examining brain asymmetry patterns of individuals with aggression, because they are consistently associated with right activation and withdrawal motivation in normal individuals (Fox, 1991). Therefore, deviation from this pattern may indicate atypical emotional response.

Resting State EEG Asymmetry. Interest in the difference behavioral motivation related to brain asymmetrical activation prompted research into emotion predisposition and resting brain activity. Resting right frontal laterality is associated with more withdrawal and inhibitory tendencies (Sutton & Davidson, 1997). Interestingly, right asymmetry is significantly more common among individuals with depression, and even among those whose depression has been in remission for a year (Henriques & Davidson, 1990). On the other hand, studies have found a strong correlation between resting left activation and stable positive disposition as well as higher approach tendencies (Sutton & Davidson, 1997; Tomarken, Davidson, Wheeler, & Doss, 1992). Harmon-Jones and Allen (1998) have also shown that more frequent aggressive behavior is associated with resting left frontal laterality. The association of left activation with both positive disposition and trait aggression show additional support for the relationship between left activation and approach motivation. While EEG measures are emotion-state specific they are also trait specific and may represent an underlying vulnerability to certain reactions to emotional stimuli. This vulnerability may be a risk factor for prolonged aggression.

Based on this research, EEG is a candidate for physiologically specific screeners. EEG is an objective measure that can produce consistent results and, unlike behavioral assessments, it is not skewed by observer bias. Also, EEG provides information that behavioral assessments cannot. Whereas behavioral assessments are a measure of outwardly visible behavior, EEG is a measure of internal, unobservable functioning during specific psychological experiences.

However, despite its objectivity and insight into underlying biological functioning, EEG alone cannot be a screening procedure. EEG is currently used as a research tool because there is no definitive data linking patterns of brain waves and early onset aggression. Although it is a useful noninvasive psychophysiological measure in studying children, it is time and cost intensive and thus not appropriate as the first stage of screening.

The Current Study

The current study compares the frontal asymmetries of a cohort of kindergarten children identified as ‘high risk’ for aggression based on standard teacher-report screening procedures. Children whose aggression remained stable or increased over the year, determined by teacher report at two time points, were categorized as displaying persistent aggression. All children’s EEG asymmetries were measured during resting state and while viewing fear and sad emotion-inducing movie clips. Laterality and magnitude of asymmetry were analyzed, in addition to a behavioral teacher-report and demographic variables, for their added predictive value in identifying persistent aggression over the course of a year. No hypotheses were made regarding the direction of the relationship between resting brain asymmetries and persistent aggression, given the tentative and conflicting literature on individual differences and EEG resting patterns and the lack of research linking brain asymmetries and persistent aggression. However, during the fear and sad clips, when the average person would exhibit more right asymmetry and withdrawal motivation, we expect an abnormal pattern of more frequent and greater left activation in children with persistent aggression. If these hypotheses are supported, it will prompt further investigation into staged screening utilizing physiological measures.

Methods

Participants

Kindergarten children attending a high-poverty urban school district in Pennsylvania were examined in this study as part of a larger longitudinal study on the development of aggression. However, only data from the first year of participation will be presented here. A brief survey about aggressive classroom behavior (see Appendix A) was distributed to teachers of all kindergarten classes in the Fall of 2008 and 2009. Children in the top 20% of ratings in each classroom were identified for recruitment into the study. Research staff contacted parents, explained the study, and scheduled an initial home visit.

During the home visit, parents were provided with consent forms and those who were interested enrolled in the study. Families received a \$75 Visa gift card for each year of participation. Participation consisted of a home visit (in which parents and children were individually and jointly assessed), teacher-rated questionnaires, and two child assessments (at separate times during the regular school day). Children were assessed for cognitive performance and physiological functioning. To participate in the study, children were asked to assent verbally. Those who refused were returned to their classroom and approached again on a

different day. Children who refused twice were not included in the study. 207 children assented to the physiological assessment.

Half the sample was randomly assigned to a comprehensive socioemotional intervention program. However, the intervention was not completed in the time frame of the study and analyses affirmed no differences in proposed measures between the two groups at the time of testing. Thus, intervention status is not considered here and all children were included in analyses.

These procedures resulted in a sample of 207 kindergarten children. Table 1 describes the demographics of the sample. At least 52% of participating families were below the US Census Bureau federal poverty guidelines, based on family size and total income, consistent with region-specific trends. Also, consistent with epidemiological data males were over represented in this high aggression sample.

Table 1
Demographic Characteristics of the Sample

Ethnicity	%
African American	73.2
Caucasian	7.7
Hispanic	18.7
Asian	0.5
Sex	
Male	66.5
Female	33.5

Note. Participant demographics are similar to those of the region. $n = 207$

Procedure

Child Behavioral Assessment. After children were enrolled into the study, teachers filled out a more comprehensive behavioral report (Appendix B). This report is a compilation and modification of items from the Teacher Observation of Classroom Adaptation - Revised (Werthamer-Larsson, Kellam, & Wheeler, 1991), the Social Competence Scale (Conduct Problems Prevention Research Group, 1990), and children's internalizing and withdrawn behavior questions for the Head Start REDI Project (<http://headstartredi.ssri.psu.edu>). Data were collected at the beginning of 2009 and 2010, allowing teachers to become familiar with the children. Teachers completed the report again at the end of the school year. Children with missing teacher reports at either time point were excluded from the sample, resulting in an adjusted sample of 150 participants.

The questionnaire is composed of five constructs: Emotion Regulation, Prosocial Behavior, Social Competence, Aggressive/Oppositional Behavior, and Internalizing/Withdrawn Behavior. The Social Competence Scale encompasses the emotion regulation and prosocial behavior constructs and therefore, was not included in any analyses. Each item on the report is rated on a 6 point scale ("Almost Never" to "Almost Always"; see Appendix B). Items measuring the constructs were averaged to produce a score between 1 and 6 for each construct independently. The 7 item Aggressive/Oppositional Behavior construct was used to study the change in aggression. These include items such as "breaks things on purpose", "hits, pushes, or shoves," and "fights with other children." Scores closer to 6 indicate the presence of many aggressive behaviors.

Change in aggression was calculated for each child by subtracting the first Aggression/Oppositional Behavior score from the second Aggression/Oppositional Behavior score. Negative change scores reflect a decrease in aggression between testing, whereas positive or zero scores indicate an increase in or stability of aggression. Using these raw change scores dichotomous groups were created for further analysis. Children with negative scores were grouped as “transient” in aggression, and those with a score greater than or equal to zero were grouped as “persistent” in aggression. Children with transient aggression are thought to represent those screened into the intervention as highly aggressive but for whom aggression normalized over time without assistance (false positives). Consistent with epidemiological research, about half (48%) of the sample naturally decreased in aggression over time.

Child Physiological Assessment. In order to reduce anxiety in children, this study adopted a space travel theme. Physiological measures took place in a Recreational Vehicle (RV) outfitted to resemble a spaceship. This theme appropriately disguised electrode use in physiological testing of heart rate, skin conductance, and EEG. To increase child comfort, teachers and their classrooms were invited to tour the RV prior to the study.

Physiological measures were taken of each child individually during the school day. Research assistants (RAs) measured the circumference of the skull and placed the correct cap size on the scalp. Measurements were taken to ensure the midline of the cap aligned with the midline of the skull. After each electrode holder on the cap was filled with Signa Gel, RAs checked that impedances were below 100 ohms, and re-gelled and repositioned as necessary. RAs then attached electrodes to their corresponding holders and electrooculogram (EOG) electrodes to the face. EOG electrodes were placed on the cheeks under the pupils and parallel to the pupils a centimeter from the outer edge of each eye. These ensure accurate EEG readings by accounting for EEG recording artifact due to eye movement.

Each child was prompted to relax and remain still and quiet while watching a computer monitor in front of them. The EEG task began once RAs initiated recording in the ActiView program. To induce a resting baseline state, each child was directed to watch a star-field computer screen for 2 minutes as they ‘traveled through space’. Children then played a game to measure inhibitory control, followed by a second 2 minute baseline. The inhibitory control task was not included in this study. Children then watched 4 clips from the Lion King movie evoking 4 types of emotion: 2 withdrawal emotions (sad and fear) and 2 approach emotions (happy and angry). The emotion inducing clips were presented consistently in the following order: fear, sad, happy, and angry. Clips maintained their chronological position within the movie. Each clip lasted two to three minutes (dependent on the duration of one consistent emotion) and was followed by a 30 second neutral clip. Neutral clips, containing no obvious emotional quality, were selected from film in between the neighboring emotion scenes. To prevent continuation of emotions, the neutral clip also depicted resolution of the previous emotion clip. The neutral clip was then followed by 30 seconds of a fixation stimulus (a red plus sign on a white screen) in order to establish a baseline for the following emotion. The testing sessions lasted from 1 – 1.5 hours.

EEG Analysis. Continuous EEG measures were taken using Biosemi elastic head caps and the Active Two BioSemi system (BioSemi, Amsterdam, Netherlands). ActiView enabled data recording at 512 Hz from 32 scalp electrodes using the 10/20 International system, (see Figure 1; Jasper, 1958). E-Prime allowed simultaneous presentation of stimulus and signaled timed synchronized markers of the start and completion of each emotion and fixation block to the computer recording EEG (Psychological Software Tools, Inc., 2004).

After recording, the EEG data were analyzed using Brain Vision Analyzer 2.0 (Brain Products, Gilching, Germany). Data were filtered for high and low pass frequency of 0.1 Hz and 30 Hz, respectively. Artifacts were identified as any voltage step greater than 100 $\mu\text{V}/\text{ms}$ between sampling points, a voltage difference greater than 300.0 μV within an interval, or a maximum voltage difference less than 0.50 μV within 100ms intervals. Applying transformations, including correcting to a baseline of 200 ms, (Gratton, Coles, and Donchin, 1983) and manually removing data from electrodes affected by gross movement or poor connection reduced number of artifacts. The data were averaged in 30-second epochs within each emotional clip. Only the last 30 seconds of the fear and sad emotion clips were analyzed under the assumption that they are the points at which the emotion has accumulated and is the strongest.

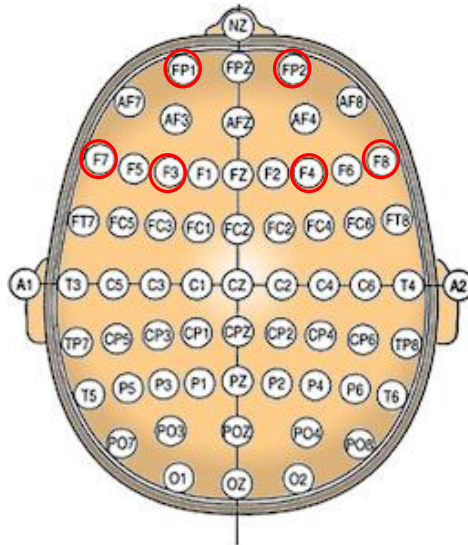


Figure 1. International 10-20 system. This map depicts electrode placement with nose and ears displayed for reference. The electrodes circled are those analyzed in this study. Electrodes on opposite hemispheres the same distance from the midline correspond to each other.

Electrodes studied include frontal F3/F4 and F7/F8 and prefrontal FP1/FP2 (see Figure 1). We recorded alpha band power at 7 – 12 Hz through a Fast Fourier Transform; an algorithm that analyses the distribution of power within frequency bands. Asymmetry scores were calculated by subtracting left hemisphere electrodes (FP1, F3, F7) from their corresponding right hemisphere electrodes (FP2, F4, F8). The three asymmetry scores were used in analysis of the magnitude of asymmetrical activation. Asymmetry scores were also converted into categories of laterality. Because alpha power is inversely related to activation, positive asymmetry scores indicate left activation whereas negative asymmetry values indicate right activation. This laterality enables the study of qualitative rather than quantitative group differences.

Analytical Procedures

Chi-square tests were used to examine relationships between aggression grouping and categorical demographic variables, as well as lateralized EEG activation of frontal electrodes. A chi square test determined that the socioemotional intervention was not significantly associated with persistent or transient aggression group status ($X^2 = .00$, n.s.). Therefore, all subsequent analyses include all 150 participants with complete teacher-reported and physiological data.

Although 11 children were on medication at some point during kindergarten, a chi-square test verified no significant difference in group status due to medication ($X^2 = .00$, n.s.). These 11 children were kept in the study.

Sex was also tested with a chi-square and found to have a marginally significant effect on the differentiation of children with persistent and transient aggression ($X^2 = 3.84$, $p = .06$). This test showed that males were more likely to exhibit transient aggression and females were more likely to exhibit persistent aggression. This prompted our inclusion of sex as a covariate in further analyses.

Nine chi-square tests were used to examine the relationships between aggression group status and lateral activation of frontal electrodes F3/4, F 7/8, and prefrontal electrodes Fp1/2 during baseline, fear clip, and sad clip. The group status variable was compared to laterality in each electrode during each condition.

Step-wise regressions, models developed using ordinary least square regression with forced-entry in two blocks, were used to examine the predictive value of teacher-report constructs, cognitive ability variables, and EEG asymmetry. Step-wise regressions were chosen to compare the explained variance of multiple models with potential predictor variables. A step-wise regression was used to determine the predictive value of the first teacher-report and child sex on the degree of change in aggression over time. Block 1 included the first Aggressive/Oppositional Behavior score and sex because these variables showed potential in significantly predicting the change in aggression. Block 2 tested the additional predictive value of the other constructs from the teacher report: Prosocial Behavior, Emotion Regulation, and Internalizing/Withdrawn Behavior.

Step-wise regression analysis was also used to examine any effects of cognitive ability on degree of change in aggression. The first block of the regression included sex and first Aggressive/Oppositional Behavior score. The second block included Letter-Word Identification, Applied Problems, Block Design, and the EOWPVT.

To examine the predictive value of EEG asymmetry in addition to other teacher-report measures, 3 regression models attempted to predict the degree of change in teacher-reported Aggressive/Oppositional Behavior. Block 1 consistently included sex and the first Aggressive/Oppositional Behavior score. Block 2 introduced asymmetries from F3/4, F 7/8, and Fp1/2, for each condition. The model output describes the predictive value of emotion-related EEG asymmetry in addition to the teacher-rated behavioral report.

Results

Behavioral Assessments

The mean Aggressive/Oppositional Behavior raw scores of the sample were compared to constructs from which this report was composed; the Overt Aggression Construct and Oppositional Construct from the Teacher Observation of Child Adaptation-Revised (TOCA-R). The TOCA-R constructs were recorded for a normative sample (Rains, 2003). This sample scored about three times higher than the normative sample demonstrating that this sample is in fact, highly aggressive.

Shown in Table 2, the regression of teacher-report constructs on the degree of change in children's aggression scores yielded a significant result for the first Aggressive/Oppositional Behavior score, but for no other constructs. Neither sex nor any of the additional behavioral constructs (Prosocial Behavior, Emotion Regulation, and Internalizing Behavior) significantly

predicted the degree of change in aggression better than the first Aggressive/Oppositional Behavior score.

The negative β weight of the first Aggressive/Oppositional Behavior score indicates that higher scores in the first assessment were more likely to decrease by the second test, whereas lower scores were likely to increase. The test concludes that the combination of other behavioral constructs adds very little explanation of variance ($\Delta R^2 = .01$) to the first Aggressive/Oppositional Behavior score.

Table 2
Step-wise Regression Analysis of Teacher-Report Predicting Degree of Change in Aggression Over Kindergarten

Variable	Model 1			Model 2		
	β	<i>SE B</i>	<i>Sig.</i>	β	<i>SE B</i>	<i>Sig.</i>
Sex	-.05	.13	.54	-.04	.14	.61
1st Aggressive/Oppositional Behavior Score	-.37	.06	.00	-.40	.10	.00
Prosocial Behavior				-.17	.11	.20
Emotion Regulation				.10	.10	.40
Internalizing Behavior				-.05	.09	.65
R^2		.14			.15	

Note: $\Delta R^2 = .01$

Shown in

Table 3, the cognitive ability scores of this sample were not significant predictors of the degree of change in aggression when forced into a step-wise regression. The cognitive ability tasks add very little explanation of variance ($\Delta R^2 = .01$) to the first Aggressive/Oppositional Behavior Scale.

Table 3
Step-wise Regression Analysis of Cognitive Ability Predicting Degree of Change in Aggression Over Kindergarten

Variable	Model 1			Model 2		
	β	SE B	Sig.	β	SE B	Sig.
Sex	-.04	.14	.58	-.06	.15	.49
1st Aggressive/Oppositional Behavior Score	-.36	.06	.00	-.36	.06	.00
EOWPVT				.09	.01	.38
Letter-Word Identification Score				-.02	.01	.89
Applied Problems				-.08	.01	.49
Block Design				.05	.03	.58
R^2		.14			.15	

Note: $\Delta R^2 = .01$

EEG Analysis

Laterality. Chi-square tests found a significant relationship between aggression group status and prefrontal laterality at the Fp1/2 electrode site only during the sad clip, $X^2(1, 85) = 4.14, p < .05$). Children with transient aggression more frequently displayed left activation while children with persistent aggression more frequently displayed right activation. Figure 2 shows the trend in average alpha power for the Fp1 and Fp2 electrodes. The visibly greater change in electrode activation for children with transient aggression reflects the group's difference in frontal activation, yielding more frequent left activation.

The remaining eight chi-square tests comparing laterality in each electrode pair during each emotion yielded no significant results, all *ps* n.s.

Magnitude of Asymmetry. Three step-wise regressions, one for each emotion condition, modeled the predictive value of sex and first Aggressive/Oppositional Behavior score in addition to the magnitude of EEG asymmetry. These regressions yielded no significant relationships, all *ps* n.s.

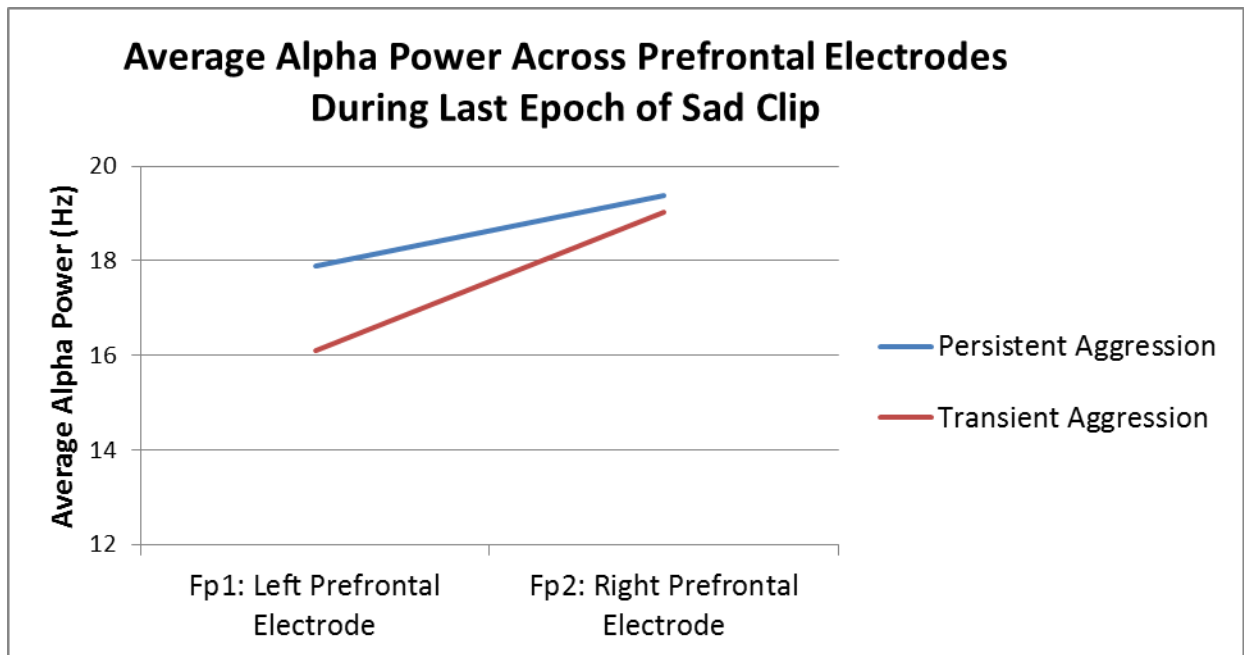


Figure 2. The graph depicts the trend in average alpha power across prefrontal electrodes during the last epoch of the sad clip.

Discussion

Predictive Value of EEG Asymmetry

We aimed to explore resting EEG differences in asymmetry between children with persistent and transient aggression. We also anticipated left laterality and greater left asymmetrical magnitude in children with persistent aggression during fear and sad emotion induction. This study found no difference in resting EEG asymmetries between children displaying persistent aggression and those displaying transient aggression. A significant difference was found in laterality between aggression groups during the last 30 seconds of the sad emotion inducing clip. No other laterality analysis or magnitude asymmetry analysis yielded significant results.

The laterality difference in children with persistent aggression and those with transient aggression emerged in a direction contrary to the original hypothesis. Children with transient aggression were more likely to display left activation during the most emotionally charged epoch of the sad clip, whereas children with persistent aggression were more likely to display right activation. Although this is an unexpected finding, this study demonstrated that prefrontal EEG asymmetry is related to transient versus persistent aggression group status over a kindergarten year. Although not statistically significant, as seen in Figure 2, there seems to be a magnitude difference in alpha power at the prefrontal electrodes during the last 30 seconds of the sad clip. This laterality finding and trend in magnitude lends some support for further investigation into staged screening procedures with biological measures.

More frequent left activation among children with transient aggression may be a reflection of the relationship between left activation and the ability to cope with emotional stimuli (Jackson et al., 2003). Because this study only analyzed the last 30 seconds of the sad emotion clip, we have no information on the brain activity during the progression of the clip. It

is possible that children who naturally decreased in aggression over time were better able to employ coping skills over the course of the emotion clip and thus demonstrated more left activation by the end of the clip. Coping ability may have been enhanced by the likely familiarity with the Lion King movie, allowing children with higher coping skills to recall the positive ensuing outcome. Future research could employ novel emotion-inducing stimuli to reduce individual variability and directly assess children's coping skills to examine this hypothesis.

Predictive Value of Demographic and Behavioral Screening

This study also discovered other notable findings. There was a marginally significant relationship between sex and aggression group status. While the number of girls with aggressive behavior in the sample is consistent with the literature on childhood aggression (Connor, 2002), we found that girls were slightly more likely than boys to exhibit persistent aggression over kindergarten. Although this trend is only marginally significant, and sex was not found to be a significant covariate in our predictive models, sex differences in stability of aggression should be further examined.

With regard to the behavioral measures, only Aggressive/Oppositional Behavior, predicted change in aggression over kindergarten. While it may be expected that children with the highest levels of aggression in the first assessment are also those who maintain aggression over time, the step-wise regression between these variables shows that this is not the case. The direction of the relationship between first Aggressive/Oppositional Behavior scores and stability of aggression may be a function of regression to the mean, in which children scoring at the extremes of the scales, upon second assessment are more likely to score closer to the mean. This finding, in addition to the lack of predictive value in the other teacher-report constructs, is evidence that behavioral measures alone cannot accurately distinguish between children who are temporarily aggressive and those who will show chronic aggressive behavior

Limitations

Several methodological limitations hinder the conclusions that can be drawn from this study. It is possible that the lack of significant findings may be attributed to the nature of the emotions studied. In particular, fear may be too powerful of an emotion to detect subtle individual differences, inducing a ceiling effect of right frontal activation in almost all children and revealing no group differences in laterality and magnitude of asymmetry. A more moderate emotion, of the same intensity as the sad clip, may be more likely to uncover EEG asymmetry differences between the persistent and transient aggression groups.

Moreover, EEG measurement in children is frequently challenging given the sensitivity of EEG measures to gross motor movement, eye movement, and/or talking. Data loss due to movement artifact reduced the sample size for each EEG analysis and thus, may have compromised detectable differences. Movement related to the experience of intense emotions could have created a selective influence on data loss.

Finally, the reliance on teacher reports to determine aggression stability is less than ideal. Because the same teacher is asked to report on aggression at both time points, initial reports of aggression may have influenced teacher's perceptions and subsequent interactions with some children. Future research should consider assessing consistency of aggression across grades, or include observational behavioral assessments over a longer period of time in order to reduce the incidence of incorrectly identified children.

The Future of Staged Screening Procedures

Further research must be conducted to retest the predictive value of EEG frontal asymmetry and test other potential biological assessments in screening procedures. Conducting a longitudinal study from childhood into mid-adulthood, although challenging, would provide groupings of adult aggressors and those who desisted from aggression. Comparing childhood frontal activation differences between these groups sheds more light on the relationship between EEG asymmetries and persistent aggression.

In conclusion, the results of this study did not support our hypotheses, but EEG asymmetries during a sad emotion-induction condition did add predictive value to behavioral teacher reports in distinguishing between persistent and transient aggression over children's kindergarten year. Further research into the biological characteristics of aggression can greatly reduce the problem of stigma and self-fulfilling prophecy arising from screening for early interventions.

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Appendix A

Paths to Success: Screening Instrument

		Almos t never	Rarely	Some- times	Often	Very often	Almos t always
1	Friendly	1	2	3	4	5	6
2	Is liked by others	1	2	3	4	5	6
3	Cries a lot	1	2	3	4	5	6
4	Feels unloved	1	2	3	4	5	6
5	Feels persecuted	1	2	3	4	5	6
6	Worries	1	2	3	4	5	6
7	Feels worthless	1	2	3	4	5	6
8	Doesn't seem to feel guilty after misbehaving	1	2	3	4	5	6
9	Cruelty, bullying, or meanness to others	1	2	3	4	5	6
10	Gets in many fights	1	2	3	4	5	6
11	Temper tantrums or hot temper	1	2	3	4	5	6
12	Physically attacks people	1	2	3	4	5	6
13	Destroys property belonging to others	1	2	3	4	5	6
14	Doesn't get along with other pupils	1	2	3	4	5	6
15	Breaks rules	1	2	3	4	5	6
16	Harms others	1	2	3	4	5	6
17	Trouble accepting authority, disobedient	1	2	3	4	5	6

Appendix B

Child Behavior Questionnaire

	Almost Never	Rarely	Some- times	Often	Very Often	Almost Always
1. Invites others to play	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2. Copes well with disappointment or frustration	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3. Low energy, lethargic, or inactive	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4. Shares with others	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5. Breaks things on purpose	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6. Accepts things not going his or her way	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
7. Keeps to him or herself, tends to withdraw	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
8. Is helpful to others	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
9. Feelings are easily hurt	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
10. Stubborn	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
11. Resolves problems with other children on his or her own	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
12. Listens to other people's point of view	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
13. Whines or complains	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
14. Controls temper when there is a disagreement	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
15. Acts younger than his or her age	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
16. Yells at others	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
17. Cooperates	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
18. Knowingly breaks rules	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
19. Understands other people's feelings	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
20. Sad, unhappy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
21. Fights with other children	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
22. Expresses needs and feelings appropriately	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
23. Ignores or refuses to obey adults	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
24. Avoids playing with other children	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
25. Hits, pushes, or shoves	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
26. Stops and calms down when frustrated or upset	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>