The Relation between Executive Functioning and Emotion Regulation in Young Children

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Abstract

To examine whether executive functioning (EF) in preschool age is a multidimensional set of processes and how these relate to aspects of children's emotion regulation (ER). Sample consisted of 119 48-month-old children. Relations between EF and specific indices of ER (e.g., latency to first bout of anger, duration of attempts at distraction) were examined. Support was found for the hypothesis that EF is a multidimensional rather than unitary construct. Also, accuracy on Less is More was related to the overall amount of anger children displayed, the frequency of anger bouts, and the average duration of periods of calm. Accuracy on DCCS task was related to the duration of the longest bout of distraction. Future directions for research in this area are included in the discussion.

Introduction

Over the last few decades there has been increasing interest in children's neurodevelopment. In particular, developmental scientists seek to understand the neurodevelopmental foundations of the maturation of social-emotional competence before children enter formal schooling (Dalton & Bergenn, 2007). One area within this broad topic that has received considerable recent interest is executive functioning. This subject has its origins in clinical research; adults with frontal lobe damage were found to have difficulties with self-regulation and emotional reactivity (Hughes & Graham, 2002). This early work helped to specify the role of the frontal lobes in executive processes that regulate behavior according to environmental demands and constraints (Zelazo & Muller, 2002). In recent years interest has extended to the development of executive functions (EF), particularly in preschool age children (Hughes & Graham, 2002), an age period during which the brain (particularly the frontal lobes) and EF are rapidly developing. It is believed that executive functioning may underlie the early development of self-regulation that is crucial for a child's healthy development, including the ability to regulate emotional reactions.

A challenge, however, for assessing executive functioning and its relation to self-regulation and emotional functioning in young children, is that it is unknown as to whether EF is a unitary or multidimensional construct (Garon, Bryson, & Smith, 2008). A number of scientists have tried to reveal the precise nature of executive functioning (Carlson, Davis, & Leach, 2005; Kochanska, Murray, Jacques, Koenig, & Vandegeest, 1996; Frye, Zelazo, & Palfai, 1995). One related challenge is the need to develop valid measures for assessing EF during periods when it is rapidly developing (Carlson, et al., 2005; Carlson, Moses, & Berton, 2002; Hughes & Graham, 2002).

Because one of the most important aspects of self-regulation is emotion regulation, in short the ability of a child to initiate effective efforts to adjust emotional reactions to social and situational constraints, a natural area of study is developmental relations between executive functioning and emotion regulation. The aim of the present study was to examine EF in children at age 48 months, an age that appears to be pivotal in the early development of EF (Zelazo, Carter, Reznick, & Frye, 1997; Gordon & Olson, 1998; Zelazo, Frye, & Rapus, 1996) and to examine whether measures of EF can predict aspects of child self-regulation of emotion. However, in order to understand the relation between executive function and emotion regulation we must first question what EF is and what it is composed of.

Construct of Executive Function

Executive function is defined as the ability to initiate goal-directed behaviors when one has to override established thoughts and responses that are more automatic in nature (Garon et al., 2008). This general definition however does not specify the process by which these behaviors are possible and whether it is best to conceptualize EF as a single process or as a multidimensional process that calls upon a number of cognitive functions. Some researchers have considered EF as a single unit (e.g., Duncan, Burgess, & Emslie, 1996), while most others (e.g., Miyake, Friedman, Emerson, Witzki, Howerter, & Wager, 2000; Baddeley, 1996; Diamond, 2001; 2002) have taken a multidimensional approach to EF. Diamond (2001, 2002) argues that there are two separate components to EF, working memory and inhibition. Working memory is the ability to hold a rule in mind during a period of delay. Inhibition is the ability to stop acting upon automatic urges. Because there is evidence to suggest that each has a different developmental path (Diamond, 2001; 2002) working memory and inhibition are said to be two different components. To support this theory, differences are shown in the developmental timing of various EF abilities (Carlson, 2005; Murray & Kochanska, 2002).

Set shifting is often cited as a third component (Lehto, Juujarvi, Kooistra, & Pulkkinen, 2003; Huizinga, Dolan, & van der Molen, 2006; Garon et al., 2008), although Diamond and colleagues regard set-shifting as the product of the combination of working memory and inhibition (e.g., Davidson, Amso, Anderson, & Diamond, 2006). Set shifting is the ability to switch between frames of references, such as rules. Neuroimaging research has confirmed that task-switching activates the neural system associated with EF (Brass, Derrfuss, Forstmann, & von Cramon, 2005) thus making it plausible that EF and set shifting are related. Still, there has also been evidence to suggest set shifting as a third component of EF (Miyake et al., 2000; Lehto et al., 2003). In a recent study by Lehto et al. (2003), performance on different EF tasks by 8-to 13-year-olds were found to cluster into three categories: working memory, inhibition and set shifting. Similarly, Garon and

colleagues (2008) listed working memory, inhibition, and set shifting as the three components that make up EF. This is similar to the multidimensional model we have followed.

The present study takes the view that EF is most likely multidimensional in nature and therefore selected tasks that, to differing degrees, assessed working memory, inhibition, and set shifting. Each component is arguably pertinent to emotion regulation. Children must keep social rules in mind even when they have urges to act in ways that violate those rules (for example, mother told me I have to wait to get the gift). They must also be able to inhibit action when they need to apply those rules (for example, avoiding opening, touching or even looking at a desired gift). Finally, set shifting should facilitate a child's ability to switch to a different frame of reference (e.g., distract oneself with other activities while tolerating a wait for a desired gift). Therefore, we tested whether our executive function tasks were correlated highly or, as we expect, related but not highly, and we then tested how each related to measures of emotion and regulatory strategy use.

There are a variety of tests of executive functioning for children and no clear evidence of which are the best. In the present study, three tasks were used: Peg Tapping (Luria, 1966), Dimensional Change Card Sort (DCCS) (Frye et al., 1995) and Less is More (Carlson et al., 2005). Each of these has been shown to tap certain components of EF (Carlson et al., 2005; Frye et al., 1995; Luria, 1966; Garon et al., 2008). For instance, Blair, Peters, and Granger (2004) used Peg Tapping as a measure of inhibitory control and cognitive set-shifting ability. In our study Peg Tapping was used as a measure of complex response inhibition that also calls upon working memory. In other words, in order to successfully complete the task the child must be able to hold a rule in mind and inhibit prepotent urges in order to respond correctly (i.e., NOT imitate the action of the experimenter). We also used the DCCS task, which according to Garon and colleagues (2008) assesses set shifting. Specifically, DCCS requires the ability to shift attention focus from a dominant sorting dimension (color) to a less dominant aspect (shape). The third task we selected was Less is More, which is classified as a test of complex response inhibition (Garon et al., 2008). Similar to the Peg Tapping task, it requires a child to hold a rule in mind (the monkey will take the plate of treats that I select) and inhibit prepotent response (to select the plate with more treats) in order to successfully complete the task.

Emotion regulation in preschoolers

Cognitive processes, such as the executive functions described, are believed to support the ability to self-regulate emotion (Kopp, 1982; 1989). Executive functions are known to develop slowly between infancy and early adulthood, although they develop rapidly in certain periods, including the preschool years (Carlson & Wang, 2007). The cognitive processes that are included in the term "executive function" are arguably the most important for the development of emotion regulation.

Emotion has been defined as preparation to create, maintain, or alter one's relation to one's environment when the situation is of significance to one's well-being (Saarni, Mumme, & Campos, 1998). Emotion regulation (ER) has been defined as the processes that are responsible for the monitoring, evaluating, and modifying of emotional reactions in the service of achieving goals for well-being (Thompson, 1994). Most often the terms refers to patterns of emotion regulation that lead to behavior that is socially

acceptable (Kopp & Neufeld, 2003). According to Eisenberg and colleagues (Eisenberg et al., 2007), emotion related regulation consist of processes that change one's emotional state, prevents or initiates emotional reactions, and modulate the behavioral expression of one's emotions. ER relies on intrinsic and extrinsic regulatory processes, including awareness of social norms and the ability to apply them to expressive behavior (Carlson & Wang, 2007). Children who efficiently execute emotional regulation are less likely to develop maladjusted behavior (Eisenberg et al., 2007).

In the first months of life, infant emotional expressions elicit social assistance from adults who then regulate the child's emotions through care giving and interaction with the infant (Eisenberg et al., 2007). But, when adult assistance is not available, infants have limited ways of reducing discomfort. When a baby encounters a novel situation the infant may try to look away in order to relieve discomfort. This is truly a case of "out of sight, out of mind." The infant looks away and distress is temporarily reduced (Stifter & Braungart, 1995). Infants engage in basic forms of ER such as gaze aversion, sucking, and proximity seeking (Buss & Goldsmith, 1998). Between ages 2 and 4 years, the need for external support declines somewhat, particularly in familiar problematic situations, and is increasingly replaced by socially acceptable strategies of self-regulation (Eisenberg et al., 2007). Between the ages of 2-5; cognitive, socio-cognitive, motor, and language development rapidly occurs (Kopp, 1989; Kopp & Neufeld, 2003). By preschool age children are capable of behaving in socially acceptable ways, even when an external entity is not there to monitor the child's behavior (Kopp, 1982). This rapid growth allows for more sophisticated and diverse forms of self-regulation to develop. (Eisenberg et al., 2007)

During the preschool years a child's ability to regulate emotions improves by way of monitoring the manner in which behavior is expressed (Carlson & Wang, 2007). By the age of 4, motor inhibition is established (Eisenberg et al., 2007). Regulating emotion involves the ability to engage in effortful control (EC), which is believed to be part of executive function. EC is defined as the capability to undergo executive attention, including the ability to inhibit an automatic behavior and to activate a secondary response, to plan, and to detect error (Rothbart & Bates, 2006). EC involves the inhibition of an action and the initiation of another, especially when the child prefers not to do so but must in order to adapt to social expectations or to achieve a goal (Eisenberg et al., 2007).

In the case of emotion regulation, an emotional reaction is a fairly automatic, well-established response to perceived challenges to an individual's well-being (Barrett & Campos, 1987). It is a reaction that is not consciously controlled in early childhood and that can lead to behavior that is socially undesirable, such as temper tantrums. In the course of early childhood, parents socialize children to control these automatic emotional responses (Saarni et al., 1998). For the child to behave in socially appropriate ways when emotionally aroused, inhibitory control must be practiced. Preschoolers who have difficulty are often identified as either having psychopathology or being at risk for it (Hughes & Graham, 2002). For example, when a child cannot have a toy that the child desires, the child must learn to inhibit angry demanding and aggressive action to get the toy. Executive processes may provide the means by which children can delay and reorient their behavior under circumstances that elicit automatic emotional responses such that they override the action tendency associated with the emotion and behave in socially

acceptable ways. According to Hughes and Ensor (2007), children's ability to understand internal states and interpersonal relations, rely on executive function. Studies have shown that as children age, their scores on EF tasks increase (Kochanska, Murray, Jacques, Koenig, & Vandegeest, 1996; Kopp, 1989). A child's ability to regulate their actions also increases during this time (Kochanska et al., 1996; Kopp, 1989). If EF and self regulation are developing during the same time period they may be interrelated. For this reason, the present study tested the prediction that EF processes would relate to specific aspects of emotion expression and regulatory strategy use. Using anger eliciting tasks that were previously coded by others, the present study related variables derived from coded emotion regulation strategies and anger expressions and related these to children's accuracy on a set of tests of executive function.

Executive Function and Emotion Regulation

In sum, theory and evidence support the prediction that executive function processes and emotion regulation are related (Hoesksma, Oosterlaan, & Schipper, 2004; Kieras, Tobin, Graziano, & Rothbart, 2005), but the precise nature of the relation requires specification (Carlson & Wang, 2007). If a child's performance is lower in one domain (EF or ER) than performance in the other domain is likely to be low as well, supporting the idea that EF and ER may be related (Frye et al., 1995). There are three possible ways that executive function and emotion regulation might relate (Carlson & Wang, 2007):

1. EF➔ER: The first possibility is that general inhibitory processes are necessary for successful emotional regulation. In this model we would expect ER to rely on the development of inhibitory control and the growth of ER.

2. ER➔EF: The second possibility states that ER is required for the successful initiation of inhibitory control. Having more efficient coping skills (self-regulation) opens up cognitive resources for more effective problem solving.

3. **EF⬅➔ER**: The third possibility combines the previous two into an integrative model. Deliberate self-regulation of emotion is achieved via conscious cognitive processes. When the primary goal is to regulate emotion EF and ER are undistinguishable. When modulating emotion is secondary and it occurs in conjunction with another problem, EF is said to involve ER.

The role EF plays in social interactions is very important from early on in development (Carlson, Moses, & Breton, 2002). In terms of the relation to emotion regulation specifically, there is evidence from Balaraman's (2003) study that children with weak inhibitory control are involved in more negative exchanges with peers than children with well developed inhibitory control. However, the specifics on how they relate are unknown (Carlson & Wang, 2007), in part because there remains uncertainty as to the best ways to measure EF (Carlson & Moses, 2001) and ER (Cole, Martin, & Dennis, 2004). Our study focuses on several experimental tasks that have emerged to assess EF in preschool age children and observational procedures that capture the temporal dynamics of children's emotional responses and strategic behaviors to assess emotion regulation.

Because toddlers have not yet fully developed their ability to convey internal feelings verbally, observational methods have been commonly used to infer emotional

episodes (Zeman, Klimes-Dougan, Cassano, & Adrian, 2007). Facial expressions and body gestures relay crucial information about the emotion being felt internally (Zeman et al., 2007). Self-regulation, behavior regulation, and self-control have been used to describe behaviors that aid individuals dealing with stressful situations (Bridges & Grolnick, 1995). Such constructs have been indexed in various ways such as latency to behavior during waiting (Mischel, 1974). Mischel and colleagues (1974) examined several behaviors thought to be relevant in emotion regulations, specifically those that seem to influence delayed gratification.

In this study we used a task that requires a child to wait for an extended period (Vaughn, Kopp, & Krakow, 1984) to observe two specific strategies thought to regulate emotion; self distraction or shifting of attention (Derrberry & Rothbart, 1988; Fox, 1989) and support seeking. For this study self distraction ranged from looking away (Fox, 1989) to sustained use of a toy (Braungart & Stifter, 1991). Support seeking, one of the strategies used most frequently in situations requiring delay of gratification (Grolnick, Bridges, & Connell, 1996), was characterized by a child distracting the mother during the Wait task and asking her about the surprise on the table.

Gaze aversion as a strategy has been shown to reduce feelings of distress following a delay in gratification among infants (Buss & Goldsmith, 1998). Distraction with a toy has predicted decreased anger in toddlers (Calkins & Johnson, 1998; Grolnick et al., 1996). For our study support seeking was regarded as an unwanted strategy because distracting the mother would theoretically cause her to take long on her task and longer for the child to receive the surprise. In our study we predicted that if a child has higher EF skill they would be less likely to support seek and more likely to self distract in order to alleviate distress. If stress is alleviated there should be less and shorter periods (bouts) of anger and longer bouts of calm or neutral states.

Present Study

The focus of this project was to examine the relations between two constructs—executive function and emotion regulation in children 48 month of age. To do this, we related four purported measures of executive function with children's behavior during three tasks that challenged them emotionally. These tasks were designed to tap into EF in a multidimensional manner. This is to say that we believe EF is not a unitary construct but rather a construct composed of different components. Our EF tasks evaluated: working memory, inhibition, and set shifting. Measures such as: Less is More (Carlson, Davis, & Leach, 2005), Dimensional Change Card Sort (Frye et al., 1995), and Peg Tapping (Luria, 1966); were used to operationalize EF. More specifically, these tasks tested for response inhibition, set shifting, and working memory. Less Is More tapped into complex response inhibition. Complex response inhibition involves the ability to inhibit while being able to hold a rule in mind. Dimensional Change Card Sort was used as a test for set shifting in which the child was required to have the ability to shift mind sets. Finally, Peg Tapping was used to evaluate simple working memory and complex response inhibition. The Children were required to keep the rule of the task in mind while inhibiting automatic responses.

It is also challenging to assess emotion regulation (Cole et al., 2004). In early childhood, the most common method is to observe the young child during a laboratory task in which emotion is likely to be elicited. For example, anger or frustration is studied

by blocking children from getting or doing something they desire. In the present study, we used Wait Task (Vaughn, Kopp, & Krakow, 1984) to assess ER. The session was videotaped and later coded for the types of strategies used during the task by the child and the emotions being expressed. These tasks were used to answer the following questions:

1. Is executive function unitary or multidimensional?

2. Do specific components of EF relate to parts of ER?

Based on the available literature, we made the following hypotheses: 1. Executive function is made of multiple components, such that each test would be related to the other but would not be so highly related as to be redundant, as would be the case in a unitary model. 2. The more correct responses a child makes (accuracy) in EF tasks, the less often, less long, and less intense the child's anger will be during a frustration task, and the more often and longer the child will maintain a calm (neutral) demeanor. Moreover, if EF is multidimensional, then the complex response inhibition tasks (Peg Tapping and Less is More) will be more related to the emotion regulation indices than the DCCS. 3. The more correct responses on EF tasks the child makes, the more often the child will be able to use distraction as a strategy during a long boring wait and the less likely the child will rely on the less mature strategy of support-seeking. The DCCS, an index of set-shifting ability, should relate specifically to distraction. 4. Finally, the more correct responses on the DCCS a child makes, the more likely the child will be to use the most optimal regulatory strategy for the specific frustrating task, that is, focused distraction.

Method

Participants

For the larger project, families were recruited who met two criteria: (1) the family had a child who would be 18 months of age at the first (home) visit and (2) the annual household income had to be above the government-defined poverty threshold but at or below the national median income. Of the 128 families recruited, 3 were income-ineligible, and 5 missed two or more visits of the 8 possible visits (4 home and 4 lab visits over 30 months of the child's life). As a result, the sample that will be studied for the present study includes 119 children at the age of 48 months (63 males; 56 female). .

Procedures

For the larger study, children were observed and tested every six months from the age of 18 months to that of 48 months and then a year later at 5 years. For half of the visits, naturalistic home observations were conducted at four ages (18, 30, 36, and 42 month visits) and standardized laboratory tasks, assessing emotion regulation, emotion knowledge, cognitive and language functioning, and parent-child interaction were administered in a lab playroom setting (18, 24, 36, 48 months, and 5 years). The aim of the larger study was to understand the early development of emotion regulation, the child and parenting characteristics that predict its development, and the role of stress in interfering with its development. A variety of measures were used including; self-report questionnaires, interviews, and behavioral observations. The current study focuses only on laboratory data from the 48 month lab visit and tasks that assessed executive function and emotion regulation.

Each child was brought into the lab by one or both parents. Upon arrival, there was an introduction period used as time to allow the child to get used to the experimenter. The session was videotaped through a two-way mirror. The lab visit lasted approximately three hours. Among the procedures administered at the 48 month visit, there were three tasks that were used to assess EF processes: these tasks were: Peg Tapping, Dimensional Change Card Sort, and Less Is More.

Peg Tapping (Luria, 1966). This task was used as a measure of working memory and complex response inhibition. The child is seated across the table facing the experimenter. The Experimenter (E) first explained the rules to the child and made sure the child understood the basic steps. The test itself requires the child to tap twice when the E taps once, and to tap once when the E taps twice. Hence the child must remember the rule and inhibit the prepotent tendency to imitate the E. There were 16 items, randomly presented to the child. The number of correct responses was the variable used in analyses.

Dimensional Change Card Sort (Frye et al., 1995). The DCCS assesses set-shifting. For the DCCS the child was seated facing two card trays, across from the E. One tray had a card of a red rabbit while the other had a card with a blue boat printed on it. The child was told they were going to play a game with these cards. The first game was one dimension (e.g. color) for half the sample and the other dimension (e.g. shape) for the other half of the sample. The E showed the child two standard cards: a red triangle and a blue ship. For example the child was told, "We are going to play a game. This is the color game. The color game is different from the shape game. All the red ones go in this box, and all the blue ones go in that box. We don't put any red ones in that box. No way. We put all the red ones over here and only blue ones go over there. This is the color game." Then after two correct trials the game was switched to the other type of task (either the color or shape game). For each card the E stated the relevant rules for the game and asked the child where the card went. The E than showed the child five cards that were drawn at random. The limit for drawing the same card was twice. Once six trials were administered, the task switches to the game that the child initially started with. Six trials were administered per game regardless of how many they get right or wrong. The number of correct trials was the variable used in analyses.

Less Is More (Carlson et al., 2005). Less is More tests complex response inhibition. It was a task in which children were given two choices of which treat they would use during the task. They were allowed to eat the sample treats in order to aid them in their decision (e.g. jellybeans). Once the child made a decision the experimenter (E) recorded the choice and grabbed a large bag with the designated treat inside it. The experimenter adjusted the plates on the table, and placed a stuffed animal monkey on the right side of the child. The E began to explain the rules to the child. The E asked which amount the child preferred (a little or a lot of the selected treat). The child was told that the plate in which s/he selected was the plate the naughty monkey would receive. The task was repeated for a total of 8 trials, and then the monkey was transferred to the child's left side. Eight more trials were done with the same rules still in place. Throughout the task the child was reminded of who received the treats on the plate he chose (the monkey) and each child was given 16 trials total. The number of correct trials was the variable used in analyses.

In addition to the tests of executive functioning, standard laboratory tasks were use to assess children's emotion regulation. For this study a wait task (Vaughn et al., 1984) was used to assess emotion regulation and to elicit anger from children by blocking their goal of immediately getting a desired object.

Wait task. Before the task began, the mother of the child was brought into the room and asked to fill out a questionnaire. The E gave the child a broken toy and placed an attractively wrapped gift on a table in the middle of the room. As previously instructed, the mother told the child "This is a surprise for you but you must wait until I finish my work to open it." After eight minutes, the E returned and the mother allowed the child to open the surprise. The child was then allowed to play with the gift (magnetic marbles). The task was videotaped and later emotion expressions (e.g. angry and neutral) and regulating strategies (distraction and bids to mother, or support-seeking) were coded by independent coding teams.

All of the data analyzed in the present study was drawn from a previously collected data set that was part of a larger, longitudinal study at the Pennsylvania State University. The larger project, called the Development of Toddlers Study (DOTS; Cole, Crnic, Nelson, & Blair, 2000) was supported by the NIMH (RO1-MH 63188) and conducted with the approval of the Penn State University Office of Research Protections (Protocol 18993). The data were collected by graduate students and coded by undergraduate students. The present project involved the analyses of variables that those students generated.

Data Coding and Reduction

Child emotion expressions and regulatory strategies were coded by separate teams of coders. Coding was time synchronized so that each coder was making judgments in the same 15 second epochs. For each epoch, a coder on each team classified which emotions or strategic behaviors occurred.

Variables. Based on the coding, several variables could be generated. For example, for anger expressions, the variables were total number of epochs, number of bouts, average bout duration, maximum bout duration, and latency to first bout. Number of bouts was the number of epochs in which an emotion (i.e. anger) was continuously displayed. A "bout" was counted when the child was coded as (e.g. angry) during continuous epochs; a bout ended when there was an epoch in which the child was not angry. Average bout duration was calculated by adding up the lengths of all the bouts (i.e. anger) and dividing it by the number of bouts. Maximum bout duration was the length of the longest bout in which the emotion was felt (e.g. anger). Latency to first bout was the amount of time it took to initially express a certain emotion (e.g. anger). There were a total of 32 epochs.

Emotion Expressions. Expressions of anger and were coded based on facial, vocal, or postural cues. Neutrality was coded when no other emotion was being expressed. Expressions were coded if one or more cues were present. Anger facial cues included: furrowed brow, lips pressed, and a clenched jaw. Anger vocal cues included: harsh toned vocals conveying protest, loud, and deep pitch. Anger postural cues included: finger wagging or jabbing and fists placed on hips.

Regulatory Strategy Use. Once emotions were expressed regulating strategies were coded. Specifically, support seeking and distraction were coded. Support seeking

consisted of: asking mom for or about the demand item, bring the surprise to mom, and asking when mom would be done with the questionnaire. Distraction is defined by child-initiated attention shifting from a source of distress or the demand of a task. Coding for distraction included: attention shifting from the source, playing with the boring toy, attention absorbed (looking at something outside of the task intently), etc.

Summary of Hypotheses

In sum, we predict that EF is a multidimensional construct and that specific variables generated by EF tasks will predict a child's ability to delay and abbreviate anger in a frustrating task, a boring wait. The predictions are: 1. Executive function is made of multiple components, such that each test will be related to the other but will not be so highly related as to suggest a unitary construct. 2. The more correct responses a child makes (accuracy) in EF tasks, the less a child will express anger during a frustration task, and the more often and longer the child will maintain a calm (neutral) demeanor. Moreover, if EF is multidimensional, then the complex response inhibition tasks (Peg Tapping and Less is More) will be closer related to the emotion regulation indices than the DCCS. 3. The more accuracy on EF tasks, the more often the child will be able to use distraction as a strategy during a long boring wait and the less likely the child will rely on the less mature strategy of support-seeking. The DCCS, an index of set-shifting ability, should relate specifically to distraction. 4. Finally, the more correct responses on the DCCS a child makes, the more likely the child will be to use the most optimal regulatory strategy for the specific frustrating task, that is, focused distraction.

Results

Data Preparation

Upon inspection of the data, one child's data was removed due to the child's lack of cooperation during all three EF tasks. Another child's scores were adjusted due to experimenter error. The error occurred during the Less is More task in which the E administered the test incorrectly during the second phase of the test. Scores from the first part showed that the child received a perfect score and thus we gave the child the same score on the second part of the task. The E also committed an error also occurred during DCCS. The E only administered 4 trials when they were supposed to administer 6. The child received 3 out of 4 correct during the task, thus we altered the score to 5 correct. Statistical outcomes were not affected by the alterations. Pearson correlations, before and after the change showed that there was no change in how significantly the tasks related to each other. All correlations remained the same (see Table 1).

As is common, several variables were skewed. Logarithmic transformations were used to improve skewed data for these variables (see Table 1). These transformations improved the distributions such that parametric analyses could be conducted, as skew was reduced to acceptable limits for nearly all variables. This therefore reduces the risk of spurious results due to outlying values.

Executive Function Construct

One-tailed Pearson correlations were used to assess the relations among the accuracy scores (number of correct responses) for each of the three EF tasks. If EF is a unitary construct, a correlation close to 1.00 is expected. Results support the prediction

that EF is a multidimensional, rather than unitary, construct. As shown in Table 2, there were several significant relations among the EF scores, but the magnitude of the relations was quite modest (average r = .24). Moreover, the range (.11 to .31) indicates varying degrees of relatedness among the three EF tests. Peg Tapping number correct was significantly related to DCCS number correct, r (107) = .31, p < .01, and to Less is More number correct, r (112) = .30, p < .01. However, DCCS number correct was not significantly associated with Less is More (r (112) = .11, p = .13). The fact that all of the variables were not equally related and that even the significant relations were modest in magnitude suggests that EF is more accurately conceptualized as a multidimensional, and not unitary, construct. .

Relations among Executive Functioning and Aspects of Emotion Regulation
Emotional Expression
        As predicted, some modest relations were found between EF and measures of child emotion. Specifically, the number of correct responses in Less Is More was inversely related to the number of bouts of anger, r (112) = -.20, p < .05, average bout length (duration) of anger, r (112) = -.17, p < .05, and maximum bout duration, r (112) = -.18, p < .05. That is, the more times the child remembered to point to the plate with *fewer* treats, the less angry the child appeared during the wait task.
        Similarly, accuracy on Less Is More was modestly related to the child's neutral epochs, both the total number of neutral periods, r (112) = .16, p < .05 and their average bout length, r (112) = .16, p < .05. That is, the better the child's performance at this task, the more frequent and longer the child's periods of calm demeanor.
        Contrary to expectation, accuracy on Peg Tapping and the DCCS was not related to anger variables. Furthermore, accuracy on these tasks was not related to any of the calm emotion variables (see Table 2).

Emotion Regulation Strategy Use
        Though the number correct in Less Is More was related to the expression of anger it was not related to strategy use (see Table 3). Similarly, Less Is More was not related to the use of distraction (see Table 3).
        However, accuracy on the Peg Tapping task was modestly related to strategy use. Specifically, the more accurate the child was on Peg Tapping, the longer the longest bout of support seeking during the wait, r (106) = .18, p < .05. Accuracy on the DCCS was also related to support seeking, but to a different measure of supporting seeking. That is, the more correct responses the child had on the DCCS, the longer into the task it was before the child first sought support from the mother, r (107) = .21, p < .05. Contrary to expectation, accuracy on DCCS was inversely related to maximum bout duration of distraction, r (107) = -.19, p < .05. That is, the more accurate a child was on the DCCS, the *shorter* the child's periods of self-distraction were.

Discussion
        The questions that led to the present study were two: (1) is executive function a unitary or multidimensional process and (2) do aspects of executive function relate systematically to emotion regulation. Partial support was found for a multidimensional model and for relations between at least one purported measure of executive function and

children's anger. The discussion develops interpretations of the findings and addresses limitations and possible future research topics.

Executive Function: Unitary or Multidimensional?

As predicted, our results support Garon and colleagues' (2008) view of executive functioning as a multidimensional process. The fact that the different measures of executive functioning, drawn from the contemporary research literature on EF in early childhood, did not correlate suggests that they may tap different aspects of EF. Peg Tapping was moderately correlated with both Dimensional Change Card Sort and Less is More. Perhaps this is due to the nature of peg tapping. Peg tapping taps into: working memory, response inhibition and may tap into set shifting; all of which are part of either DCCS or Less is More. However, DCCS and Less is More are weakly associated and do not have a significant relation. Maybe the weak association is due to the difference in what each task tests for. Less Is More is a better measure of response inhibition, while DCCS is used to measure set shifting. Perhaps set shifting and response inhibition are two very different components of executive function. Because there was not a perfect correlation ($r = 1.00$, $p < .01$) among any of the tasks, interpretation of the correlations suggest that EF is not unitary.

Executive Function and Emotion Regulation Relations
Emotion Expression

Is accuracy of EF tasks related to the expression of emotion? According to our findings, accuracy on Less Is More is associated with the expression of emotion (see Table 3). More specifically, Less Is More was related to the expression of anger and the maintenance of neutrality. Less Is More was the only task that proved to be moderately correlated with the expression of emotion.

Perhaps Less Is More taps into "hot" EF processes, requiring children to inhibit strong affective reactions (Metcalfe & Mischel, 1999) Hot EF processes are different from cool EF processes in that hot EF processes involve affective motivation. If the child is emotionally invested (affectively motivated) in the task it is considered to tap into hot EF processes. Because Less Is More is a task that involves attainment of a physical object (treats) the child is more likely to be emotionally invested in this task than in the other EF tasks. Thus, Less Is More may measure children's ability to inhibit pre-potent actions that are not only automatic but also affectively motivated. Likewise, Wait task involves a tangible reward (the surprise) which may explain the child's emotional investment and expression within that task. In comparison, Peg Tapping does not involve a tangible reward (the treats) and thus may not require the "hot" EF processes that are involved in the Less Is More and Wait tasks. The DCCS task is considered a cool EF task (Hongwanishkul, Happaney, Lee, & Zelazo, 2005) because it is also does not involve appetite or emotional investment. This may explain why the emotion measures were not related to either of these tasks.

Another reason that Less is More was the only task that was related to the expression of emotion may be that Less is More is a better measure of complex response inhibition. Because Less is More was inversely related to indices of expression of anger this indicates that the higher the accuracy on the EF was related to less expression and shorter expression of anger. This in turn may be due to the child's ability to employ

response inhibition. Because Less is More was the only task significantly related to expression of emotion this suggests that Less is More was the best measure of response inhibition. Though Peg Tapping is thought to tap into response inhibition (Blair et al., 2004) accuracy on the EF task was not significantly related to reduced anger or frustration. This finding further supports the idea that Less is More is a better measure of response inhibition. Because DCCS is not a measure of response inhibition but rather of set shifting, we did not predict a relation between accuracy on DCCS and expression of emotion. Results did not indicate any relation between number correct on the DCCS task and the expression of emotion. Thus, it seems that set shifting (measured by DCCS) is not related to the expression of emotion.

Emotion Regulating Strategy Use

Is accuracy on EF tasks related to the use of emotion regulating strategies, particularly more distraction and less support seeking? Our results suggested the number correct on Peg Tapping was related to the maximum bout length (duration) of support seeking. In other words, as accuracy increased on Peg Tapping, the duration of support seeking during the wait also increased. This result may be due to the ability to use working memory. Perhaps the child's ability to remember how many times to tap also allows the child to remember the surprise for a longer period of time. It may be that it becomes harder to stop seeking support from "mom" when the child is continuously thinking about the surprise. Furthermore, accuracy on the DCCS task related to latency to first bout of support seeking. A reason for this outcome may be that the child may have other means of regulating anger (e.g. self distraction). DCCS requires the ability to shift mindsets and attention (Frye et al., 1995). Perhaps, if a child is able to shift attention they may shift away from the frustrating situation (not being able to open the surprise) and regulate using self distraction rather than distracting the mother from her work and causing her to take longer on the questionnaire. Number correct on Less is More was not related to the use of support seeking. Maybe this result is due to the nature of the task. Perhaps, Less is More taps mainly into complex response inhibition when used to regulate affect. If this is the case, then the employment of support seeking is not related to affectively activated response inhibition or to accuracy on Less is More.

Accuracy on DCCS inversely related to average maximum duration of bout for focused distraction. At first the inverse relationship between DCCS number correct and maximum duration of bout was surprising. Because DCCS tests for set shifting we thought indices of focused distraction would be positively related. However, accuracy on DCCS is thought to be governed by the ability to set shift. This in turn allows a child to be able to shift from one mind set to another. Perhaps, if a child can set shift they may be able to shift away from the initial distraction back to the surprise or to another distracting object more readily. That is to say that as a child's ability to set shift increases so does their ability to shift out of distractions more quickly, thus making duration to the maximum bout shorter. Accuracy on Peg Tapping and Less is More tasks did not relate to the emotion regulating strategy distraction. Perhaps the lack of relation is due to the nature of these EF tasks. Peg Tapping requires inhibition and working memory but it has not been proven to involve set shifting. Less is More requires complex response inhibition but does not require set shifting either. The DCCS task is the only task that

requires set shifting and is the only task that related to distraction it appears that set shifting is related to the use of distraction as an emotion regulating task.

Ultimately relations among EF tasks supported our hypothesis of EF as a multidimensional construct. Accuracy on Less is More was related to the expression of anger and the maintenance of a neutral state. Accuracy on Peg Tapping was related to the maximum bout length (duration) of support seeking. The number correct on DCCS was related to latency to first bout of support seeking and inversely related to average maximum duration of bout for focused distraction.

Limitations

Even though we found significant correlations among some of our variables that supported our hypotheses, the data was based on correlations. Because correlations do not necessarily indicate causation we can not be certain of which variables are affecting the others. We do not know if it is executive function that is assisting in emotion regulation or the ability to regulate emotion that affects EF development. Furthermore, working memory is believed to underpin most executive skills (Roberts & Pennington, 1996). Because working memory may influence most executive skills we can not know for certain which components of EF are being measured with the tasks previously described. Finally, sample consisted of one social economic status (SES). Participants were from low income rural families. Because of this, the sample might not be reflective of the entire population.

Future Directions

In summary, the present study suggested a weak to moderate relation among EF tasks. Results also suggested a link between accuracy on Less Is More, expression of anger and maintenance of emotion. The number correct Peg Tapping was related to the maximum bout length (duration) of support seeking as a strategy. Lastly, accuracy on the task DCCS was related to latency to first bout of support seeking and maximum duration of bout for focused distraction. Future research should focus on finding further evidence to support executive function as a multidimensional construct. Future studies should also focus on finding ways to test for emotion regulation behavior (e.g. strategy use) that will be able to be analyzed by multiple means (e.g. correlation, linear regression, etc.). Such findings have implications for the understanding of the role of emotion regulation in adjustment and maladjustment of children and the development of future intervention techniques as well as the development of better teaching techniques.

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References

Balaraman, G. R. (2003, April). Children's self-regulation and peer interaction at 36 and 54 months: Concurrent and longitudinal relations. Paper presented at the Biennial Meeting of the Society for Research in Child Development, Tampa, Florida

Barrett, K. C., & Campos, J. J. (1987). Perspectives on emotional development II: A functionalist approach to emotions. In J. D. Osofsky (Ed.), *Handbook of infant development* (2nd ed., pp. 555-578). Oxford, England: John Wiley & Sons.

Blair, C., Peters, R., & Granger, D. (2004). Physiological and neuropsychological correlates of Approach/Withdrawal tendencies in preschool: Further examination of the behavioral inhibition System/Behavioral activation system scales for young children. *Developmental Psychobiology, 45*, 113-124.

Brass, M., Derrfuss, J., Forstmann, B., & von Cramon, D. Y. (2005). The role of the inferior frontal junction area in cognitive control. *Trends in Cognitive Sciences, 9*, 314-316.

Braungart, J. M., & Stifter, C. A. (1991). Regulation of negative reactivity during the strange situation: Temperament and attachment in 12-month-old infants. *Infant Behavior & Development, 14*, 349-364.

Bridges, L. J., & Grolnick, W. S. (1995). *The development of emotional self-regulation in infancy and early childhood*. Thousand Oaks, CA, US: Sage Publications, Inc.

Buss, K. A., & Goldsmith, H. H. (1998). Fear and anger regulation in infancy: Effects on the temporal dynamics of affective expression. *Child Development, 69,* 359-374.

Calkins, S. D., & Johnson, M. C. (1998). Toddler regulation of distress to frustrating events: Temperamental and maternal correlates. *Infant Behavior & Development, 21*, 379-395.

Carlson, S. M., & Moses, L. J. (2001). Individual differences in inhibitory control and children's theory of mind. *Child Development, 72*, 1032-1053.

Carlson, S. M., Moses, L. J., & Berton, C. (2002). How specific is the relation between executive function and theory of mind? Contributions of inhibitory control and working memory. *Infant and Child Development, 11*, 73-92.

Carlson, S. M. (2005). Developmentally sensitive measures of executive function in preschool children. *Developmental Neuropsychology, 28*, 595-616.

Carlson, S. M., Davis, A. C., & Leach, J. G. (2005). Less is more: Executive function and symbolic representation in preschool children. *Psychological Science, 16*, 609-616.

Carlson, S. M. & Wang, T. S. (2007). Inhibitory control and emotion regulation in preschool children. *Cognitive Development, 22*, 489-510.

Carlton, M. P., & Winsler, A. (1999). School readiness: The need for a paradigm shift. *School Psychology Review. Special Issue: Beginning School Ready to Learn: Parental Involvement and Effective Educational Programs, 28*, 338-352.

Ciairano, S., Visu-Petra, L., & Settanni, M. (2007). Executive inhibitory control and cooperative behavior during early school years: A follow-up study. *Journal of Abnormal Child Psychology, 35,* 335-345.

Cole, P. M., Usher, B. A., & Cargo, A. P. (1993). Cognitive risk and its association with risk for disruptive behavior disorders in preschoolers. *Journal of Clinical Psychology, 22,* 154-164.

Cole, P. M., Martin, S. E., & Dennis, T. A. (2004). Emotion regulation as a scientific construct: Methodological challenges and directions for child development research. *Child Development, 75,* 317-333.

Dalton, T. C., & Bergenn, V. W. (2007). *Early experience, the brain, and consciousness: An historical and interdisciplinary synthesis*. Mahwah, NJ, US: Lawrence Erlbaum Associates Publishers.

Davidson, M. C., Amso, D., Anderson, L. C., & Diamond, A. (2006). Development of cognitive control and executive functions from 4 to 13 years: Evidence from manipulations of memory, inhibition, and task switching. *Neuropsychologia: Special Issue: Advances in Developmental Cognitive Neuroscience, 44*, 2037-2078.

Denham, S. A., Blair, K. A., DeMulder, E., Levitas, J., Sawyer, K., Auerbach-Major, S., et al. (2003). Preschool emotional competence: Pathway to social competence? *Child Development, 74,* 238-256.

Derryberry, D., & Rothbart, M. K. (1988). Arousal, affect, and attention as components of temperament. *Journal of Personality and Social Psychology, 55*, 958-966.

Diamond, A. (2001). A model system for studying the role of dopamine in the prefrontal cortex during early development in humans: Early and continuously treated phenylketonuria. In C. Nelson & M. Luciana (Eds.), *Handbook of development cognitive neuroscience* (pp 433-472). Cambridge, MA: MIT Press.

Diamond, A. (2002). Normal development of prefrontal cortex from birth to young adulthood: Cognitive functions, anatomy, and biochemistry. In D. Stuss & R. Knight (Eds.), *Principles of frontal lobe function* (pp. 466-503). New York: Oxford University Press.

Eisenberg, N., Hofer, C., & Vaughan, J. (2007). Effortful control and its socioemotional consequences. In J. Gross (Ed.), *Handbook of emotion regulation* (pp. 287-306). New York: Guilford.

Ekman, P., & Friesen, W. (1969). The repertoire of nonverbal behavior: Categories, origins, usage, and coding. *Semiotica, 1,* 49-98.

Fox, N. (1989). Psychophysiological correlates of emotional reactivity in the first year of life. *Developmental Psychology,* 25, 364-372.

Frye, D., Zelazo, P. D., & Palfai, T. (1995). Theory of mind and rule-based reasoning. *Cognitive Development, 10*, 483-527.

Garon, N., Bryson, S. E., & Smith, I. M. (2008). Executive function in preschoolers: A review using an integrative framework. *Psychological Bulletin, 134*, 31-60.

Grolnick, W. S., Bridges, L. J., & Connell, J. P. (1996). Emotion regulation in two-year-olds: Strategies and emotional expression in four contexts. *Child Development, 67*, 928-941.

Green, V. A., & Rechis, R. (2006). Children's cooperative and competitive interactions in limited resource situations: A literature review. *Applied Developmental Psychology, 27,* 42-59.

Hoeksma, J. B., Oosterlaan, J., & Schipper, E. M. (2004). Emotion regulation and the dynamics of feelings: A conceptual and methodological framework. *Child Development, 75*, 354-360.

Hongwanishkul, D., Happaney, K. R., Lee, W. S. C., & Zelazo, P. D. (2005). Assessment of hot and cool executive function in young children: Age-related changes and individual differences. *Developmental Neuropsychology, 28*, 617-644.

Hughes, C., & Graham, A. (2002). Measuring executive functions in childhood:
Problems and solutions? *Child and Adolescent Mental Health, 3,* 131-142.

Hughes, C., & Ensor, R. (2007). Executive function and theory of mind: Predictive
relations from ages 2 to 4. *Developmental Psychology, 43,* 1447-1459.

Huizinga, M., Dolan, C. V., & van der Molen,Maurits W. (2006). Age-related change in
executive function: Developmental trends and a latent variable analysis.
*Neuropsychologia. Special Issue: Advances in Developmental Cognitive
Neuroscience, 44*, 2017-2036.

Jahromi, L. B., & Stifter, C. A. (2007). Individual differences in the contribution of
maternal soothing to infant distress reduction. *Infancy, 11*, 255-269.

Kochanska, G., Murray, K., Jacques, T. Y., Koenig, A. L., & Vandegeest, K. A. (1996).
Inhibitory control in young children and its role in emerging internalization. *Child
Development, 67*, 490-507.

Kieras, J. E., Tobin, R. M., Graziano, W. G., & Rothbart, M. K. (2005). You can't always
get what you want: Effortful control and children's responses to undesirable gifts.
Psychological Science, 16, 391-396.

Kopp, C. B. (1982). Antecedents of self-regulation: A developmental perspective.
Developmental Psychology, 18, 199-214.

Kopp, C. B. (1989). Regulation of distress and negative emotions: A developmental
view. *Developmental Psychology, 25*, 343-354.

Kopp C. B. & Neufeld, S. J. (2003). Emotional development during infancy. In R.
Davidson, K. R. Scherer, & H. H. Goldsmith (Eds.), *Handbook of affective sciences*
(pp. 347-374). Oxford, UK: Oxford University Press.

Leadbeater, B. J., Ohan, J. L., & Hoglund, W. L. (2006). How children's justifications of
the "best thing to do" in peer conflicts relate to their emotional and behavioral
problems in early elementary school. *Merrill-Palmer Quarterly, 52*, 721-754.

Lehto, J., Juujarvi, P., Kooistra, L., & Pulkkinen, L. (2003). Dimensions of executive
functioning: Evidence from children. *British Journal of Developmental Psychology,
21,* 59-80.

Luria, A. R. (1966). High cortical functions in man. *Oxford England: Basic Books.*

Metcalfe, J., & Mischel, W. (1999). A hot/cool-system analysis of delay of gratification:
Dynamics of willpower. *Psychological Review, 106*, 3-19.

Mischel, W. (1974). Processes in delay of gratification. In L. Berkowitz (Ed.), *Progress
in experimental personality research* (pp. 249-292). New York: Academic.

Miyake, A., Friedman, N., Emerson, M., Witzki, A., Howerter, A. & Wager, T. D.
(2000). The unity and diversity of executive functions and their contributions to
complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology,* 41,
49–100.

Murray, K., & Kochanska, G. (2002). Effortful control: Factor structure and relation to
externalizing and internalizing behaviors. *Journal of Abnormal Child Psychology, 30,*
503-514.

Roberts, R. J., & Pennington B. F. (1996). An interactive framework for examining
prefrontal cognitive processes. *Developmental Neuropsychology, 12,* 105-126.

Rothbart, M. K., & Posner, M. I. (1985). Temperament and the development of self-
regulation. In L. Hartlage & C. F. Telzrow (Eds.), *The neuropsychology of individual
differences: A developmental perspective* (pp. 93-123). New York: Plenum.

Rothbart, M. K., & Bates, J. E. (2006). Temperament. In W. Damon (Series Ed.) & N. Eisenberg (Vol. Ed.), *Handbook of child psychology: Vol. 3. Social, emotional, and personality development* (6th ed., pp. 99-166). New York: Wiley.

Rueda, M. R., Acosta, A., & Santonja, M. (2007). *Attention and motivation interdependence in self-regulation: A neurocognitive approach.* Hauppauge, NY: Nova Science Publishers.

Saarni, C., Mumme, D. L., & Campos, J. J. (1998). Emotional development: Action, communication, and understanding. In W. Damon (Series Ed.) & N. Eisenberg (Vol. Ed.), *Handbook of child psychology: Vol. 3. Social, emotional, and personality development* (5th ed., pp. 237-309). New York: Wiley.

Stifter, C. A., & Braungart, J. M. (1995). The regulation of negative reactivity in infancy: Fucntion and development. *Developmental Psychology, 31,* 448-455.

Thompson, R. A. (1994). Emotion regulation: A theme in search of definition. In N. A. Fox (Ed.), *The development of emotion regulation: Biological and behavioral considerations. Monographs of the Society for Research in Child Development* (pp. 250-283).

Vaughn, B. E., Kopp, C. B., & Krakow, J. B. (1984). The emergence and consolidation of self-control from eighteen to thirty months of age: Normative trends and individual differences. *Child Development, 55*, 990-1004.

Zelazo, P. D., & Muller, U. (2002). Executive functions in typical and atypical development. In U. Goswami (Ed.), *Handbook of childhood cognitive development* (pp. 445-469). Oxford: Blackwell.

Zeman, J., Klimes-Dougan, B., Cassano, M., & Adrian, M. (2007). Measurement issues in emotion research with children and adolescents. *Clinical Psychology: Science and Practice, 14*, 377-401.

Table 1

Correlations among three Executive Function Measures

	DCCS	Less is More
Peg Tapping	0.31**	0.30**
DCCS	-	0.11

**p < .01.

Table 2

Correlations between EF Accuracy Scores and Indices of Emotion Expression

	Peg Tapping	DCCS	Less is More
Anger			
No. of epochs	-0.11	0.10	-0.14
Average No. of bouts	-0.04	-0.06	-0.20*
Average bout length	-0.07	-0.07	-0.17*
Maximum bout length	-0.08	-0.04	-0.18*
Latency to first bout	0.02	0.14	0.14
Neutral			
No. of epochs	-0.09	-0.15	-0.11
Average No. of bouts	0.14	-0.01	0.16*
Average bout length	0.12	-0.90	0.18*
Maximum bout length	0.05	0.07	0.05
Latency to first bout	0.06	-0.12	0.14

*p < .05.

Table 3

Correlations between EF Accuracy Scores and Indices of ER Strategy Use

	Peg Tapping	DCCS	Less is More
Support Seeking			
Average No. of bouts	0.02	-0.03	-0.09
Average bout length	0.14	-0.06	-0.04
Maximum bout length	0.18*	-0.03	-0.09
Latency to first bout	0.10	0.21*	-0.03
Focused Self Distraction			
Average No. of bouts	0.06	-0.14	0.10
Average bout length	0.03	-0.13	0.10
Maximum bout length	0.03	-0.19*	0.12
Latency to first bout	-0.12	0.04	-0.10

*p < .05.