The Impact of Fearfulness on Childhood Memory:

Attention, Effortful Control, and Visual Recognition Memory

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ABSTRACT

Fear is an integral and adaptive aspect of emotion related development (Gullone, 1999) and is one of the earliest regulatory systems influencing the control of behaviors (Rueda, Posner & Rothbart, 2004). This study examined the potential role of child fearfulness on the relation between attention, effortful control and visual recognition memory. Behavioral and physiological measurements of fear as well as measures of attention and recognition memory were examined. Behavioral tendencies of fearfulness rather than discrete behavioral acts were associated with right frontal asymmetry. VRM performance was also associated with more right frontal functioning. Fearfulness regulated the relation between attention and VRM as well as moderated the relation between effortful control and VRM. This study provided some evidence for the influencing role of normal variations of fear (i.e., non-clinical levels of fear) on the cognitive processes of developing children.

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Contents

List of Tables

List of Figures

Chapter 1

Introduction

The following dissertation proposes a framework for considering the potential impact of normal variations of fear on child cognition .The study of fear is vital as emotions develop to enhance an individual's response and engagement to the environment (Robinson & Acevedo, 2001). However, little attention has been paid to how early appearing; perhaps relatively stable, normal variations in fear-related behaviors have implications for later child development (Eisenberg, Fabes, Murphy, Maszk, Smith & Karbon, 1995). Few studies have approached the study of normal variations in fearfulness as an early developing self-regulatory system that having inhibitory influence and control over child behaviors, even though the notion that fear and other negative emotions are regulatory has been proposed in temperament literature (Rueda, Posner & Rothbart, 2004; Rothbart, Ellis & Posner, 2004; Rothbart & Bates, 1998; however, see Kagan, Reznick & Snidman (1985) and Fox, Henderson, Marshall, Nichols & Ghera (2005) for a discussion of the impact of pathological levels of fear, or behavioral inhibition, on child outcomes). This dissertation tried to provide a conceptual framework for the regulating role of normal variations in fearfulness (i.e., non-clinical levels of fear) on the cognitive processes of normally developing children and empirically investigated the impact of individual differences in fearfulness and attention on visual recognition memory.

1.1 Child Fearfulness

Goldsmith and Rothbart (1999) have suggested that fear is one of several basic emotions that can be differentiated from other emotions and exhibited in children as early as 6 months of age. Regarded as one of the most salient temperamental characteristics (Bates, 1989), fear is moderately stable, easily quantifiable, and present in almost every species studied (Fox, Henderson, Marshall, Nichols & Ghera, 2005). In humans, it behaviorally manifests as distressed facial expressions, vocalizations and even physical display of bodily fear such as escape or freezing behaviors. Fearfulness emerges with the expectation and the anticipation of distress, or potential threat (Kochanska, 1991), and serves as a major survival mechanism mobilizing a child's resources in the face of threat or imaginary threat. It develops gradually, with infants becoming fearful of stimuli in their immediate environment that display loud noises or from a loss of support (Scarr & Salapatek, 1970) to later childhood fear reactivity towards anticipatory events and stimuli of an imaginary or abstract nature (Campbell, 1986).

Marks (1987) has described the development of fear as an ''ontogenetic parade'', which refers to the rise and disappearance of certain fears in a predictable sequence during a child's development. That is, in their preschool years, children are afraid of imaginary creatures (ghosts, monsters), animals, and the natural environment (darkness, thunderstorms). Then late in middle childhood, fears of physical danger, bodily injury, and school performance become more prominent (Muris, Merckelbach, Ollendick, King, Meesters, & Van Kessel, 2000). Fearfulness demonstrates a clear developmental pattern with most children experiencing some degree of fear during their development. It is no surprise then that fear is considered one of the more integral and adaptive aspects of emotion-related development (Gullone, 1999).

It is important to note at this point that both reactive and regulatory behaviors associated with emotion, such as fear, are intimately linked to individual differences in biological processes. Fearfulness includes the arousability and excitability of not only behavioral but also physiological systems. Children with fearful temperaments show greater relative right frontal EEG activity at baseline (Perez-Edgar & Fox, 2005) and during stressful tasks (Schmidt, Fox, Schulkin, & Gold, 1999). In his model of differential activation of the left and right frontal cortices, Fox (1994) postulates that differential frontal EEG asymmetry patterns are indices of individual differences in emotion reactivity and regulation, with negative emotions and active withdrawal associated with right frontal cortex functioning and positive emotions and active approach with left frontal functioning. Patterns of prefrontal EEG asymmetry may serve as a marker of an underlining disposition, as well as an indication of a current emotional state. One of the major functions of the frontal lobe is to deal with new or surprising situations effectively. It exerts control over emotions, modulating the degree to which the amygdala's output produces emotional responses in different context (Kolb & Taylor, 1990). Because of the role of the frontal cortex in emotion reactivity and regulation, fearfulness' self-regulating role with development may be associated with maturation of the frontal lobes.

Because reactive and self-regulatory processes are interdependent at neural, functional, and behavioral levels, emotions are rarely generated in the absence of the recruitment of self-regulatory processes that influence how emotions are experienced and then expressed (Gross, 2002). Fearfulness is a reactive dimension that also contains regulatory components (such as withdrawal from threatening stimulation) that develop later than approach responses (Rothbart, 2007). Previous work on self-regulation has found that infants who show higher levels of distress at younger ages continue to employ physical self-soothing methods when most infants begin to adopt looking away as a control strategy (Rothbart et al. , 1992). Fearful infants may be more likely to use both physical soothing and show cautious reaching. Supporting this idea, latency to approach a novel toy is positively related to duration of distress and self-soothing to the novel stimuli (Rothbart et al. , 1992). These relations would be congruent with fearfulness having self-regulatory associations. Furthermore, fearfulness is thought of as the first major control system over approach behaviors (Gray, 1987). Latency to approach novel objects early in development predicts higher levels of self-regulation at 7 years of age (Rothbart, Derryberry, & Hershey, 2000) and fearfulness in 8 year olds has also been related to a greater occurrence of self-regulation (Prins, 1985).

Thus, fearfulness is not only a reactive system but it also is a part of a system of self-regulation (Rueda, Posner & Rothbart, 2002). The ability to modify emotions by actively controlling them but most importantly, the ability to self-regulate oneself, allows children to curtail inappropriate or extreme emotions or utilize emotions appropriate for specific situations. However, not every child easily develops the ability to adjust fear to attain a specific goal or discern what would be more appropriate or even adaptable in similar situations. In the development of regulatory processes, children progress from almost total dependence on their caregivers for the regulation of their emotions to later independence, with some purposeful regulation evident by the end of their first year (Calkins & Bell, 2010; Kopp, 1989). As children grow they develop early capabilities to inhibit, strengthen and weaken emotions. Children even eventually learn to experience emotions without sharing them with others. This may be more evident with fearfulness, as the frequency and degree of the behavioral manifestation of fears seem to decrease in middle childhood (Burnham & Gullone, 1997). Knowing when and where to exhibit a specific emotion like fear is crucial in situations when a child is confronted with the unfamiliar. Fear in childhood is typically directed towards novel animals, supernatural phenomena and darkness (Gullone & King, 1993). It is reasonable to assume that physiological maturation may contribute to these more abstract sources of fear. Even though children are less likely to display fearfulness as overtly as they did in infancy, physiological measures of fearfulness could demonstrate that it is not an indication of a decrease of fear displays in developmental processes but an increase in fearfulness' self-regulating abilities. However, few studies have involved the direct and indirect observations of fear behavior or its physiological associations in middle childhood (Gullone, 1999). Frontal EEG may reflect an individual's bias to respond with negative affect to certain stressful situations though they might not be overtly expressing fearfulness or other negative affect behaviors (Fox, Henderson, Rubin, Calkin, & Schmidt, 2001). Though children may not exhibit fear behaviors in the laboratory, children's physiology during may reveal an underlining emotional trait.

Parental measures of emotions have been consistently used in literature (Gartstein & Marmion 2008). Parent-reports are beneficial because parents are able to observe their children in a variety of situations and during different times of the day. However, some view maternal ratings of fearfulness as viable measures until 6 years of age. After 6 years of age, maternal and child reports have shown poor reliability with parents underestimating children's fear (Gunner, Leighton & Peleaux, 1984). Underestimation on behalf of caregivers might be due to the difficulties for an outsider to see anticipatory and abstract fears. Middle childhood is both a stage and a pathway to future development with increased capabilities in cognitive and affective domains. During middle childhood, most children dramatically improve in their memory capacities as well their ability to sustain and control attention (Santrock, 2012). Furthermore, this developmental period is also marked with improvements in the conscious control of thoughts, emotions, and actions that coincide with neurophysiological changes. Not to mention, children begin to develop the ability to verbally express their fears but mask them in particular situations (Gullone, 1999). From 6 years of age, self-reports of fearfulness may show a better representation of physiological fear. **Therefore, hypothesis 1 is that fearfulness measures will be correlated with frontal EEG asymmetry scores, with higher fearfulness associated with more right frontal activation.** Right frontal EEG asymmetry is thought to influence behavioral expression of fearfulness, anxiety, or shyness (Fox et al. 2001). Fox and Davidson (1987; 1988) found that when children exhibited behaviors reflecting approach (reaching with hands, positive vocalization, facial expressions of joy), there was greater relative left-frontal activation (i.e., left frontal asymmetry) during those behaviors. When displayed behaviors reflected active withdrawal (distress, gaze aversion), there was greater relative right-frontal activation. Furthermore, Diaz and colleague (2011) have reported baseline frontal EEG asymmetry, as well as fear task frontal EEG asymmetry, uniquely accounting for variance in infant normal fear behaviors. Depending on the contexts, greater right frontal asymmetry at baseline and during fear tasks was associated with greater fearful behaviors. This study brings up the potential utility of frontal EEG asymmetry as a predictor of fearfulness. Baseline and fear task frontal EEG asymmetry should also predict children's fearfulness. Specifically, maternal and self ratings of fearfulness will be associated with greater right frontal activation at baseline and during fear task. Buss and colleagues (2003) also reported greater right frontal EEG asymmetry when children demonstrated fearfulness and sadness. Thus, in addition to serving as a marking of underlying disposition toward positive or negative responsivity, frontal EEG asymmetry is also correlated with patterns of emotion behavior reactivity during an emotion-eliciting situation.

1.2 Visual Recognition Memory

Visual recognition memory (VRM) is the cognitive process involved when we remember familiar visual stimuli and recognize that new visual stimuli are indeed novel. It plays a substantial role in the skills involved in novelty detection as well as discriminatory abilities. Events and stimuli that are novel have been associated with greater attention, greater orienting responses, and better recognition than those events that have been categorized as familiar (Reynolds, Courage & Richards, 2006; Bornstein, 1985; Fantz, 1961). Indeed, if familiarization time is sufficient, visual attention to the novel stimulus should predominate when given a choice between looking at either novel or familiar stimuli (Rose, Feldman & Jankowski, 2003). VRM plays a substantial role in early development as a child needs the capability to recognize aspects of the surrounding environment. This can include the recognition of faces of family and friends, as well as favorite objects. The recognition of locations also emerges during this time period, as well as the ability to orient oneself within a given setting (Campos, Kermoian, & Bertenthal, 1992).

Infants with better recognition memory (i. e., greater novelty detection) are considered to have better memory and are quicker at retrieving information from memory in later childhood (Rose, Feldman, Futterweit, & Jankowski, 1997). In addition, Rose and colleagues (2003) have documented improvements in the speed of information processing that corresponds to increases in novelty detection. Better recognition memory of visual stimuli in infancy has also been associated with higher IQ scores at later ages (Rose, Feldman & Jankowski, 2003). The development of novelty preference may serve as a biologically driven survival mechanism for the recognition of novelty in one’s environment. Specifically, the recognition of visual discrepancies may lead to better discrimination of threat in the environment that may be associated with harm.

Novelty preference measured using looking time is taken as a measure of VRM only in infancy. As a child matures, there are quantitative differences in the ease of retrieval and accessibility of target memories (Hockley & Murdock, 1987) as well as communication abilities. Researchers can ask children to state whether they recognize a stimulus or whether it is novel. Developmental studies of VRM have shown consistent improvement in discrimination abilities across development, with mature performance during adolescence (Carroll, Byrne, & Kirsner, 1985; Cycowicz, Friedman, Snodgrass& Duff, 2001; Mandler & Robinson, 1978; Newcombe, Rogoff, & Kagan, 1977; Parkin & Streete, 1988). Dirks and Neisser (1977) examined recognition memory performance of 1st, 3rd, and 6th graders, as well as college students and found a clear developmental improvement on multiple aspects of recognition memory. Rose and Feldman (1995) found that VRM, assessed with a paired-comparison task at 7 months, correlated with visual recognition memory from a span task at 11 years. To emphasize, this is an association over a span of more than 10 years. The association remained significant even when controlling for other general measures of memory.

With respect to brain-behavior functioning, novelty detection is associated with net increases in neurological activity as neurons are coding specific stimuli features and properties when confronted with new information (Colombo, 2010). Children respond faster and perform significantly higher when presented with new items (Czernochowski, Mecklinger, Johansson & Brinkmann, 2005; Czernochowski, Mecklinger & Johansson 2009). Perhaps this is due because of an interest in novelty but also because uncertainly provides a motive for psychological growth that continues throughout development. This claim is substantiated with physiological evidence, which suggests that the frontal central regions demonstrate greater Nc amplitude (an ERP indicator of novelty detection) as well as a faster latency to peak to novel than to familiar stimuli (DeBoer, Scott, & Nelson, 2004).

There is also evidence that different anatomical or functional circuitry may be involved in the processing of novelty for adults as compared to children (Thomas & Nelson, 1996). Eight year olds display a frontal negativity to novel stimuli which is absent in adults (Thomas & Nelson, 1996). Detection of novel events is associated with mismatch negativity (MMN), which is thought to reflect an automatic response to stimulus deviance. This is not surprising as frontal lobe maturation in middle childhood is marked with an increase in logical, flexible, and organized thought as well as better strategies to store and retain information processing information more skillfully in novel situations. **Therefore, hypothesis 2 proposes that the prefrontal cortex aids in discriminating and recognizing objects and frontal EEG asymmetry will predict VRM performance.** Indeed the relation between the regulating role of fearfulness and VRM performance might overlap in the frontal cortex. Furthermore, fearfulness and the ability to discriminate novelty from familiarity may share developmental trajectories, especially since the detection of discrepancies is significant for everyday information processing. However, VRM associations with fearfulness may not be a direct relationship but one that influences the strength between attention and VRM.

1.3 Attention

Attention can be viewed as a state of engagement that involves orienting, selecting, and sustaining focus on objects and events. It is a fundamental cognitive process and underlies learning and memory as early as infancy (Ruff & Rothbart, 1996). Children show increasing flexibility and control of attention, one aspect of which is the ability to concentrate for longer durations on a wider variety of targets (Ruff & Lawson, 1990) and to adapt attention to contextual demands and goals (Kopp, 1982).

There is a clear positive association between a child's attentional capabilities and VRM (Rose, Feldman & Jankowski, 2003). VRM undergoes considerable change in early development (Fagan, 1979) as the ability to disengage and inhibit attention is rapidly developing in infancy (Rose, Feldman & Jankowski, 2003). Moreover, object recognition involves the ability to selectively deploy attentional processes and correctly parse an object from its environmental context (Coldren & Haaf, 1999; Haaf, Lundy, & Coldren, 1996). Thus, it is reasonable to hypothesize that cognitive development is fostered by the abilities to focus attention (Eisenberg, Smith, Sadovsky & Spinard, 2004). Focusing one's attention is an ability that improves with age as shown by older children encoding visual information differently from adults (Sloutsky & Fisher, 2004). Children are inclined to attend to perceptual details during information induction while adults use a much broader level of category information processing (Hayes & Heit, 2004; Sloutsky & Fisher, 2004). Children also tend to attend and process stimuli longer, feasibly influencing their recognition accuracy (Sloutsky & Fisher, 2004).

1.4 Potential Impact of Fearfulness on Cognition

Fear serves as a protective factor against later developing aggression (Rothbart & Bates, 1998), as well as a predictor of behavior responses like higher empathy (Rothbart, Ahadi, & Hershey, 1994) and lower impulsivity in later childhood (Rothbart, Ahadi & Evans, 2000). Fearfulness is also positively correlated with, and an important control system for, the development of a conscience (Caspi & Silva, 1995; Kochanska, 1995; 1997). Nevertheless, there is plenty of clinical research that points to fear (anxiety) exacerbating or mitigating the expression of anger and aggression (Ollendick, Seligman & Butcher, 1999) as well as a predisposition for later internalizing and externalizing disorders (Rothbart & Bates, 1998). Not to mention, studies that suggest that distress states are incompatible with attentional (Ruff & Rothbart, 1996), memory (Lewis, 1993), and information encoding and retention (Fagan, Ohr, Fleckenstein & Ribner, 1985; Fagan & Prigot, 1993). This study is interested in normal developing fearfulness and Bauer (1976; 1980) believes that there is a relation between the developmental changes in the content of children's fears and the cognitive shift from concrete to more abstract representations. A longitudinal study examining fear reactivity in infancy demonstrated that fearful infants had higher IQ later in childhood (Karass & Baungart-Ricker, 2004). Muris and colleagues (2002) revealed that with increasing levels of cognitive skills, children are more capable of developing worrisome thoughts. There is also evidence of associations between negative affect and better future-oriented decision making skills in preschoolers (Garon & Moore, 2006). This evidence may suggest that fearfulness is involved in the regulation of multiple behavior tendencies (Gray, 1987). Although fearfulness may serve to regulate and inhibit approach behaviors, it may also capture attention (Gross, 2007). Both adults and children have shown a significantly stronger attentional bias toward fear-related pictures than toward pleasant pictures. This finding reflects that objectively threatening stimuli selectively capture the attention of adults and children in a sample of children not selected for high fearfulness. Empirical visual search studies have also demonstrated that faster detection of fear-relevant compared to fear-irrelevant stimuli is present in 3 to 5 year old children (Lobue & DeLoache, 2008). This conforms to cognitive models that propose that individuals show a bias toward stimuli depicting higher levels of objective threat (Mathews & Mackintosh, 2000; Mogg

& Bradley, 1998), suggesting that such a bias reflects a specific fearful response rather than a general bias toward emotionally salient stimuli.

Furthermore, researchers suggest that fearfulness may serve as an early self-regulating system by inhibiting responses and ongoing motor programs as well as preparing response systems when confronted with novelty (Rothbart, Ellis & Posner, 2004; Banfield, Wyland, Macrae, Munte & Heartherton, 2004). Fearful reactivity is sometimes viewed as serving a relatively automatic regulatory function in a variety of theoretical frameworks (Calkins & Fox, 2002; Derryberry & Rothbart, 1997; Eisenberg & Fabes, 1992; Newman & Wallace, 1993). Developmentalists discuss such regulatory functions in terms of the effects of fearful arousal on attentional systems (Derryberry & Rothbart, 1997; Eisenberg & Fabes, 1998). Appraisals of novelty or threat cues activate attentional resources in ways to maximize search for safety and to minimize risk to physical or psychological self. Such examples rest on the known situational effects of fearful arousal on reactive or posterior attentional systems and the consequent deployment of higher executive reasoning capacities (Aksan & Kochanska, 2004).

Thus, fearfulness may strengthen the relation between attention and VRM. Self-regulation is responsible for the planning and the execution of not only emotional responses but executive processes that allow a child greater control over his/her responses. With evidence suggesting self-regulation plays a role in novelty detection (Banfield, et al., 2004), fearfulness in childhood may be regulating the ability to attend and then discriminate stimuli or event features. Since, fearfulness' adaptive function is to increase vigilance and orienting to environmental cues that could be indicative of threat (LeDoux, 2000), perhaps heightened arousal can aid children's discrimination abilities, giving them an advantage to better attend and distinguish novelty from the familiar than non-fearful children.

1.5 Brain Systems

The neural circuitry of fear is able to process relevant external signals extremely fast and perceptual processes are automatically activated to effectively detect discrepancies in the environment. An increase in extrastriate visual cortex activation is indicative of fear arousal and a top-down process involving the amygdala and the orbitofrontal cortex (Tabbert, Stark, Kirsch &Vaitl, 2006). Furthermore, preschoolers who were observed to engage in fearful behaviors showed not only right frontal EEG activity but relatively low levels of cortical power across all scalp regions (Henderson, Marshall, Fox & Rubin, 2004). Given the inverse association between power and activation in the alpha band, this finding suggests that these children have elevated levels of cortical activity indicative of a very attentive state in which these fearful children are closely monitoring the unfamiliar environment for any signs of threat (Kapp, Supple, & Whalen, 1994). Because fearfulness is linked to enhanced attention to threats (Derryberry & Reed, 1994), fearfulness may be regulating the attention to potential negative or unfamiliar stimuli allowing a child to avoid potentially threatening situations. Viewing fearfulness as part of the larger construct of self-regulation, modulating behavior according to demands of the situations, children who are at first hesitant when confronted with the unfamiliar may do so because they have greater attentional skills and thus may be able to differentiate subtle differences between stimuli.

Although the anterior cingulated cortex (ACC) is best viewed as an executive attention system, it is also needed whenever a task requires the resolution of conflict or when it involves novel and/or dangerous stimuli (Norman & Shallice, 1986). The ACC has major subdivisions to process cognitive and emotional information (Bush, Luu, & Posner, 2000). The cognitive subdivision has interconnections with the prefrontal cortex, parietal cortex, and premotor and supplementary motor areas. The affective subdivision has interconnections with the orbitofrontal cortex, amygdala, and hippocampus, among other brain areas. Empirical data show the development of the executive attention system is implicated in prefrontal regulation of both cognitive and emotional processes with advances in attention control (Ruff& Rothbart, 1996), cognitive control (Diamond, Prevor, Callender, & Drum, 1997), and regulation (Calkins, Dedmon, Gill, Lomax & Johnson, 2002). Executive attention shows substantial development between 2 and 7 years of age (Rueda et al. , 2002). Excitability of the amygdala and maturation of the prefrontal cortex may aid in discrimination and recognition memory abilities during middle childhood (Zentner & Bates, 2008).

The modulating role of fearfulness on attention and VRM might overlap at the frontal cortex. Lesions to the prefrontal cortex have demonstrated disruption in attention of novel stimuli. The evaluation of stimuli is associated with P3a response (a frontally oriented positive ERP component) which is thought to reflect the engagement of the frontal lobes in response to deviant events (Schroeger, Giard &Wolff, 2000). Lesions to the PFC result in a reduction in P3a response and a reduction in time spent viewing the novel stimuli. It is difficult to deal with new or surprising situations and regulate behaviors accordingly if one is not aware that events are novel or unexpected. VRM may be severely disrupted when allocation of attention and fearfulness to novel events or stimuli is either severely diminished or exaggerated. **Therefore, hypothesis 3.1 is that behavioral indicators of fearfulness may serve as a moderator of the association between attention and recognition memory.** Specifically, children who have higher normal levels of fearfulness will show greater attentional and VRM capabilities as the relation between attention and VRM would intensify. Children who are low in regulating fearfulness will have a weaker relation between attention and VRM. **It is also hypothesized, hypothesis 3.2, that physiological indices of fearfulness may also serve as a moderator of the association between attention and recognition memory.**

1.6 Effortful Control

Effortful control is a temperament construct associated with the voluntary deployment of attention. It reflects the efficiency with which a child's executive attention network develops and operates in naturalistic settings (Rueda, Posner & Rothabrt, 2002). It is a fundamental capacity associated with the ability to regulate and control thoughts and behaviors. Specifically, effortful control is central in a child's ability to withhold a dominant response in order to perform a non-dominant response. It contributes to a number of important developmental processes, including the ability to delay gratification and the development of a conscience (Eisenberg, et al., 1995; Kochanske, 1991). Effortful control is attentional in nature as individual differences in attentional efficiency in children foreshadow the degree of successful effortful control. Effortful control is also connected to the development of the ACC (Posner & Rothbart, 2000) and subsequently is strongly associated with the executive attention system (Rothbart & Bates, 1998).

Effortful control goes beyond attention, however, to be a mechanism of self-regulation. The growth of self-regulatory mechanisms is the cornerstone of childhood development (Schokoff & Phillps, 2000) and effortful control plays a part in that regulation by means of inhibitory control and attentional focusing. Differences among children in the degree to which they can exercise effortful control have a dramatic influence on behavior because of the ability to willfully or voluntary inhibit, activate, and change attention control as appropriate. There is mounting evidence that individual differences in effortful control are linked to a variety of important developmental outcomes (Eisenberg, Smith, Sadovsky & Spinard, 2004).

Not only is effortful control associated with the control of higher and lower order cognitive processes, it is also integral to the control of affect, drive and motivation (Rothbart & Ahadi, 1994). The development of fear control is followed by effortful inhibitory control emerging late in the first year and continues to develop across childhood (Rothbart & Ahadi, 1994). Extensive reciprocal connections between the amygdala and the prefrontal cortex, particularly the medial and orbital regions of PFC, suggest that the PFC provides important inhibitory inputs into the amygdala (Davidson, 2000). Additional cortical development in children is believed to increase a child's capacity for effortful control allowing a child to anticipate future states of the self plus the world, to evaluate the consequences of potential actions, and access information necessary for strategic voluntary control (Derryberry & Rothbart, 1984). This anticipatory and evaluative activity may work along with one's fear system to help suppress approach responses that might lead to harm.

Children's increased ability to control emotions has important ramifications for the development and managing of interpersonal relationships, as well as individual problem solving abilities. A recent functional magnetic resonance imaging (fMRI) study with adults demonstrated that the engagement of the right prefrontal cortex during the cognitive evaluation of angry and fearful facial expressions was associated with attenuation of the response of the amygdala, providing evidence for a functional neural network for emotion and regulation in addition to cognitive assessment (Hariri, Mattay, Tessitore, Fera, & Weinberger, 2003). Self-regulation emerges when the affective subdivision of the ACC involved in assessing the salience of emotional and motivational information and the regulation of emotional responses is beginning to stabilize around 3 or 4 years of age (Kopp, 1989; Bush et al. , 2000). As the child matures, emotion regulation strategies are forming which include reappraisal, distraction, avoidance, escape, suppression, and the use of information to enhance or blunt emotional experience some of which coincide with typical fearful behaviors.

Children with a normal bias toward fearfulness are challenged to learn to control their attention at several different levels, including the shifting of visual attention as well as cognitively reappraising stimuli and/or situations that elicit distress. As such, an increase in sensitivity to aversive stimulation in children has been shown to be associated with higher concurrent levels of cognitive control and executive attention (Blair, Peters & Granger, 2004). Effortful control allows one to resist immediate influences of affect and either approach the situation or resist actions in a flexible way. Individual differences in effortful control allow the child to go beyond fearfully reactive self-regulation in order to inhibit dominant responses and perform subdominant responses. However, fearfulness may be necessary for the initial efficiency of effortful control. Evidence suggests that early emotional control systems, such as fearfulness, contribute to the development of control systems that develop later and are more cognitive in nature. In fact, child fearfulness at 2 to 3-years of age has been shown to predict higher levels of effortful control later in childhood (Aksan & Kochanska, 2004).

The gradual development of the neural circuitry underlying effortful control, and therefore the executive cognitive functions associated with emerging self-regulatory skills, suggests a particularly exciting area of research in the study of fearfulness and cognition in childhood. Inhibitory aspects of fearfulness may serve to make children better able to practice and perform behaviors associated with executive attention and with effortful self-regulation (Aksan & Kochanska, 2004). As children mature into middle childhood, effortful control provides a basis for self-regulation that goes beyond the earlier inhibitory influences of fearfulness but may not completely replace it. Differences in fearfulness may play both indirect and direct roles in fostering inhibitory control (Aksan & Kochanska, 2004). Fearfulness and inhibitory control have often been discussed as having a regulatory influence on a variety of approach responses (Calkins & Fox, 2002; Derryberry & Rothbart, 1997; Eisenberg & Fabes, 1992; Rothbart & Bates, 1998). Since self-regulatory processes are fundamental and an essential part of emotion-related development, individual differences in fearfulness could also be regulating a child's effortful control and visual recognition memory relation. **Hypothesis 4.1 proposes that fearfulness may serve as a moderator of the association between effortful control and recognition memory.** As with the previous hypothesis focused specifically on attention, the effects of effortful control on recognition memory will be different for children with different levels of fearfulness. Specifically, children who have higher normal levels of fearfulness will show greater effortful control and VRM capabilities as the relation between effortful attention and VRM would intensify. Children who are low in regulating fearfulness will have a weaker relation between effortful control and VRM**. It is hypothesized, hypothesis 4. 2, that physiological indicators of fearfulness will also serve as a moderator of the association between effortful control and recognition memory.**

1.7 Hypotheses

In this dissertation project, I describe a framework for considering the potential impact of fearfulness on growing cognition abilities observed in middle childhood. The following hypotheses tested the regulating role of normal variations in fearfulness (i. e. , non-clinical levels of fear) on the cognitive processes of normally developing children:

Hypothesis 1 -Fearfulness measures will be correlated with frontal EEG asymmetry scores with higher fear associated with more right frontal activation. Baseline and fear task frontal EEG asymmetry will predict maternal ratings of fearfulness.

Hypothesis 2 - Frontal EEG asymmetry will predict VRM performance.

Hypothesis 3.1 - Fearfulness serve as a moderator of the association between attention and VRM.

Hypothesis 3.2 – Physiological fearfulness serves as a moderator of the association between attention and VRM.

Hypothesis 4.1 - Fearfulness serves as a moderator of the association between effortful control and recognition memory.

Hypothesis 4 2 - Physiological fearfulness serves as a moderator of the association between effortful control and recognition memory.

Chapter 2

Method

2.1 Participants

Participants included 105 six (mean age 73.4 months, SD 3.16; 12 boys, 22 girls), seven (mean age 85 months, SD 2.24; 14 boys, 21 girls), and eight (mean age 96.6 months, SD 4.31; 20 boys, 16 girls) year olds, from the New River Valley area of southwest Virginia (46 boys, 59 girls; 98 Caucasian, 4 African American, 2 Asian American, 2 Hispanic). Children were full term, born within 3 weeks of their expected due dates, and experienced no prenatal or birth complications. Children were seen in the research lab within four months after their birth date. All children were born to parents with a high school diploma and college degrees or higher were held by 90% of the mothers and 82% of the fathers. Mothers were approximately 38 years of age at the child's birth (range 26–50) and fathers were approximately 40 years old (range 29–53). Children were healthy at the time of the visit and had no developmental delays or cognitive disabilities.

2.2 Procedures

Children were recruited through the Developmental Sciences Database in the Department of Psychology, advertisements on the Virginia Tech website, and e-mails to the Working Moms list serve. After the research lab appointment was scheduled, parents were mailed three questionnaires; Children's Behavior Questionnaire short form, the attention control section of the Temperament in Middle Childhood Questionnaire, and the Fear Survey Schedule for Children-Revised (parent report) along with a Parent Consent Form (appendix A) and a Child Assent Form (Appendices B). Parents were asked to complete the questionnaires prior to coming to the lab. They were also asked to read the consent and assent forms and contact us with any questions. All questionnaires were returned at the lab visit. When participants arrived for their appointment, verbal explanation of the consent form was given and they were shown the electroencephalography (EEG) equipment. Another copy of the consent and accent forms was provided to be signed and dated for that day and completed temperament questionnaires collected.

On the day of the visit, an EEG Electro-cap was situated on the child's head. Electrodes remained on the scalp during the entire procedure and the EEG record was event marked by a research assistant in an adjacent room. The session was digitally recorded for later coding purposes. Children sat in front of a table where baseline, fearful and neutral movie clips were counterbalanced and played on a television screen 1.5m way from the child. After the fear video, a rollaway desk with a touch screen computer replaced the table. The child sat in the desk while familiarization and test phases of the VRM task and an attention control task were administered. After recognition memory tasks, a visual search task followed. At the end of the visit and after the child returned to a baseline state, children were ask to join the experimenter on the floor to self report on their fear, attention and effortful control using the Temperament in Middle Childhood Self Report Questionnaire. Due to children's age, each statement on the questionnaire was read out load. The research lab procedures described below lasted approximately 75 minutes.

2.2.1 EEG Recordings

Upon arrival to the research laboratory, the EEG electrodes were placed on the child's head using a 32-electrode cap (Electro-Cap International, Inc.) Recordings were made from 24 left and right scalp sites [frontal pole (Fp1, Fp2), medial frontal (F3, F4), lateral frontal (F7, F8), central (C3, C4), central frontal (FC1, FC2, FC5 FC6), temporal (T7, T8), lateral parietal (P7, P8), medial parietal (P3, P4), central parietal (CP1, CP2, CP5, CP6) and occipital (O1, O2).]. All electrode sites were referenced to Cz during recordings. Baseline EEG was recorded while children watched a video clip of slowly turning shapes in different colors (mandalas) for four minutes. Mothers were asked not talk to children during the EEG recordings as well as tasks until asked otherwise.

After the EEG cap was placed on the head, the recommended procedures regarding EEG data collecting with children was followed (Pivik et al., 1993). Specifically, a small amount of abrasive gel was placed into each recording site and the scalp gently rubbed. Next, conductive gel was placed in each site and the scalp gently rubbed. Electrode impedances were measured and accepted if they were below 10K Ohms. The electrical activity from each lead was amplified using separate SA Instrumentation Bioamps and bandpassed from 1 to 100 Hz. Activity for each lead was displayed on the monitor of an acquisition computer. The EEG signal was digitized on-line at 512 samples per second for each channel so that the data will not be affected by aliasing. The acquisition software is Snapshot-Snapstream (HEM Data Corp.) and the raw data was stored for later analyses. EEG data was examined and analyzed using EEG Analysis System software developed by James Long Company. First, the data were re-referenced via software to an average reference configuration. Average referencing, in effect, weighed all the electrode sites equally and eliminated the need for a noncephalic reference. Active (Fp1, Fp2, F3, F4, F7, F8 etc.) to reference (Cz) electrode distances vary across the scalp. Without the re-referencing, power values at each active site may reflect interelectrode distance as much as electrical potential.

The average reference EEG data were artifact scored for eye movements using a peak-to-peak criterion of 100 uV or greater. Artifact associated with gross motor movements over 200 uV peak-to-peak were also scored. These artifacts scored epochs were eliminated from all subsequent analyses. Missing EEG data was due to high impedances as well excessive artifact in specific EEG electrode sites. The data was then analyzed with a discrete Fourier transform (DFT) using a Hanning window of 1-second width and 50% overlap. Power was computed for the 8 to 10 Hz frequency and expressed as mean square microvolts. Infants have a dominant frequency between 6 and 9 Hz (Bell & Fox, 1994; Marshall, Bar-Haim, & Fox, 2002) and adults have a dominant frequency between 8 and 13 Hz (Lindsley, 1939.). Both adult and infant EEG frequency bands are clearly defined and accepted in literature. However, the same cannot be said for children's EEG frequency bands. Due to the studies interest in middle childhood, an alpha frequency between infant and adults, "low alpha", was utilized (Klimesch, 1998). Data was then transformed using the natural log (ln) to normalize the distribution.

F3 and F4 asymmetry has been utilized to provide evidence of the associations between frontal scalp regions and observed cognitive and emotion behaviors (Fox, 1994). However, Buss and collogues (2004) have provided evidence of the associations between not only F3 and F4 asymmetric regions but Fp1 & Fp2 and F7 & F8. In their study, greater frequency of withdrawal-related behaviors and right frontal activation was strongest for the most anterior site of Fp1 and Fp2 and not medial frontal sites F3 and F4. Therefore, asymmetry scores at each pair of frontal electrodes (e.g., Fp1 & Fp2, F3 & F4, F7 & F8) were assessed by subtracting ln left frontal power from ln right frontal power (ln right – ln left = frontal asymmetry). In the affective neuroscience literature, brain activation is indicated by lower EEG power values (Bell & Fox, 1994). Thus, negative asymmetry scores reflect greater activation in the right hemisphere compared to the left, whereas positive asymmetry scores reflect greater activation in the left hemisphere relative to the right. Asymmetric labels refer to scalp, not brain, locations. Utilizing more than one asymmetric region can provide more information of localization in the absence of source localization methods that permit topographic localization of the intracerebral sources of brain electrical signals (Buss et. al, 2003).

2.2.2 Fear task - Fear Video

Because the frequency and degree of behavioral fears decrease with age (Burnham & Gullone, 1997), it is difficult to find a fear task in middle childhood that elicits fear due to children's growing capabilities to mask and hide emotions. Though behavior fear was predicted, no overt fear behavior was demonstrated. However, physiological measures of fear could demonstrate an increase in fear's self-regulating abilities.

Each child was presented with four film clips. The children watched a baseline clip that would be followed by either a neutral or fear film clip. After this, a baseline fragment was shown again (to decrease possible arousal) and end with either a fear or a neutral clip (Gilissen et al., 2007). The order of the film presentation was counterbalanced for the fear-neutral condition. The baseline clip lasted 1.5-minutes and showed slowly turning circles and colors. The fear video clip was a 1.5-minutes fragment of the film “Dinosaur”, an animation production of Walt Disney. These images, in combination with the accompanying intense music, are likely to arouse fear in 6 to 8 year old children. Gilissen and colleagues (2007) demonstrated the children in this age range had greater increases in skin conductance and greater decreases in heart rate variability during the fear inducing film clip compared to a neutral film clip. The duration of the neutral film clip, a sesame street clip of colorful objects moving in a slow rhythm, was 1.5-minutes long.

2.2.3 Recognition Memory Task

Children viewed pictures of common objects considered to be familiar, perceptually simple, and easy to label. Each individual image was presented on a color touch screen computer monitor. Children were told that they are about to watch some colorful pictures on a computer screen and that there will be quite a lot of pictures, and each picture will go by rather quickly. They were asked to sit quietly and to pay attention to each picture that was presented and to try to remember the pictures, because at a later time they will be asked whether a picture was seen before or new. The pictures belonged to categories such as toys (e.g., dice, kite), transportation (e.g., car, boat), food (e.g., pizza, apple), and instruments (e.g., pianos, guitar). These stimuli were divided into two blocks of 74 pictures; Object1 Block and Object2 Block. Blocks were counter balanced to prevent any ordering effects. Each block consisted of familiarization (memory encoding) and test (memory retrieval) phases. Each familiarization phase was comprised of 37 pictures. Each image was displayed for 2-seconds with an interstimulus interval of 2-seconds. A 5 minute delay occurred between familiarization and test phases and 15 minutes between blocks.

The test phase comprised of a 74 picture block, which included the 37 pictures displayed at the familiarization phase and an additional set of 37 new pictures. Three practice trials were given to teach the child the rules of the game. Children were told that the game was to remember whether they had seen the image on the screen before or if it is a picture that was never shown to them before as quickly as possible. When they have decided whether the image was old or new, they had to touch the correct answer on the screen, and then return their hands back to his/her lap. The test phase continued in the same fashion with children being presented with a screen that showed a single image and asked to discriminate between presentations of new and old pictures by touching either the word “new” or “old” on the screen. Marshall, Drummey, Fox & Newcombe (2002) have previously used this task with four-year olds as well as adults with a non-touch screen monitor. Seven children failed the practice trials on the first block and thirteen children failed the practice trials on the second block. Four computer malfunctions also occurred during the second block and those data were excluded from the study. Table 2.2 provides summary scores for each VRM variable. Reaction time as well as old/new discrimination was recorded and the following variables measured (Marshall et al, 2001):

1) Correct old recognition: The number of correct recognitions of previously viewed images.

2) Correct new recognition: The number of correct recognitions of novel images.

3) False Positive: The number of incorrect recognitions of previously seen images as new.

4) False Negative: The number of incorrect recognitions of previously never seen images as old.

5) Correctly Identified: Total number correct.

2.2.4 Attentional Control Task

During the 5 minute delay between the first block familiarization and test phases of the recognition memory task, the child was instructed to find items that match a target stimulus (tacks) on an 11' x 18' page containing both targets and distracters (NEPSY: Korkman, Kirk, & Kemp, 1998). This visual attention task is analogous to the game of i-SPY and is a classic visual search task requiring selective attention as well as attentional control in the continual selective processing of differentially relevant stimuli features (Espy & Bull, 2005). This attentional ability has been shown to mature quite early in development, but with great variability among same-age children (Welsh et al., 1991). Children were given 2 minutes to find as many targets as possible. The following variables were assessed (Espy and Bull, 2005) and Table 2.3 provides summary scores for each attention variable.

1) Efficiency Scores 1 - Unique Identified (the number of correctly identified target objects) over Total Response (the number of total responses made)

2) Efficiency Scores 2 - Total Identified (the number of correctly identified targets) over Total Response (the number of total responses made).

2.2.5 Fear Task - Visual Search

Snakes are among the most common targets of fear (Lobue & Deloache, 2008). In visual search tasks, adults detect the presence of snakes more rapidly than the presence of other kinds of visual stimuli (Ohman & Mineka, 2001; Lipp, Derakshan,Waters, & Logies, 2004). There is evidence that very young children share this attention bias (Lobue & Deloache, 2008). Lobue and Deloache's (2008) take a developmental approach to the topic of threat detection, with a task that examines the visual detection of relevant threat stimuli, snakes. Their research shows that 3 to 5 year old children respond equally fast to the detection of snakes when non-threatening stimuli like flowers and caterpillars are present.

This visual search task also took place on a touch screen monitor and began with four practice trials. On the first two trials, the display consisted of 1 target and 1 distractor picture, and the child was asked to touch only the target picture. Stimulus categories included snakes, flowers, and caterpillars. On the final two practice trials, 3 x 3 matrices were displayed and the child told that the task was to find the ‘‘X’’ (target) among ‘‘Ys’’ (distractors) as quickly as possible, touch it on the screen, and then return their hands back to his/her lap. Test trials would follow in the same fashion. All children passed the practice trials. However, computer malfunction occurred during two visits during phase two and three visits during phase three.

In phase 1, children were asked to locate either a single snake target among eight flower distracters or the lone flower target among eight snakes. Snake images were all depicted coiled on the ground or in trees. None of the stimuli were depicted in a threatening pose. Phase 2 was an even more stringent test of the existence of threat-detection, as caterpillars were used as the nonthreat-relevant stimulus category instead of flowers. Like the snake stimuli, the caterpillar stimuli shares one of the most salient physical characteristics of snakes—their elongated shape. In phase 3, children were asked to locate either a single caterpillar target among eight flower distracters or the lone flower target among eight caterpillars. Each experiment consisted of 24 test trials with a different picture matrix containing one target and eight distractors. Between trials, a large smiley face appeared on the screen. The experimenter pressed the face when it was judged that the child was looking at it, causing the next matrix to appear ensuring that the child’s full attention was on the task before moving forward. Latency to touch (i.e., reaction time) was automatically recorded from the onset of the matrix to when the child touches one of the pictures on the screen as well the total number of correctly indentified pictures (Table 2.4).

2.2.6 Fear Questionnaire - Parent reports

The Children Behavior Questionnaire short form (CBQ-SF) was utilized to measure parent observations of child fear temperament outside of a laboratory setting on a seven-point Likert scale. This 95-item questionnaire assessed the child's emotional and behavioral responses across a number of situations. This instrument measures 15 domains of child temperament. The focus however is on the temperamental fear score.

The Fear Survey Schedule for Children-Revised parent version (FSSC-R/P) was also collected as it is a widely used measure of children and adolescents' fears (Ollendick, 1983). This instrument contains 80 items that are each rated on a three-point scale (none, some, a lot) and is a normative instrument for selecting fearful children for prevention and treatment trials. This measure was used to rule out high levels of fear in the current sample. A total fearfulness score was obtained and the average FSSC-R/P score for this sample (M= 123.14; SD= 22.08) was below that clinical mean reported for fearful populations (Ollendick & Horsch, 2006; Weems, et. al, 1999).

Table 2.1 provides summary scores for each behavioral fear variable. The sample means demonstrate that this group of children showed relatively low levels of fear. The sample range, however, shows that there was variability in the intensity of fear behaviors.

2.2.7Attention and Effortful Control - Parent reports

Subscales from the CBQ-SF were also used to assess parental rating of their child's attention capabilities and effortful control. Individual scale scores for each child was calculated based upon prior factor analytic work (Rothbart et al., 2001). Parental ratings on the attentional focusing scale was used to assess children's tendency to maintain attentional focus upon task-related channels and a composite score for children's effortful control was created by averaging the subscale scores of Attention Focusing, Inhibitory Control, Low Intensity Pleasure and Perceptual Sensitivity (Putnam & Rothbart, 2006).

Mother's were also asked to fill out part of Temperament in Middle Childhood Questionnaire using a seven-point likert scale. The portion given to mothers contained 15 items believed to access conceptual levels of effortful control. The Activation Control scale contains the statements found below to measure children's capacity to perform an action when there is a strong tendency to avoid it. Scale score for each child was calculated based upon prior factor analytic work (Simonds & Rothbart, 2004) and summary scores can be found in Table 2.3.

1. Can make him/herself do homework, even when s/he wants to play.

2. Can say hello to a new child in class, even when feeling shy.

3. Has a hard time speaking when scared to answer a question.

4. Can take a band-aid off when needed, even when painful.

5. Can make him/herself run fast, even when tired.

6. Has a hard time making him/herself clean own room.

7. When a child is left out, can ask that child to play.

8. Has a hard time working on an assignment s/he finds boring.

9. Does a fun activity when s/he is supposed to do homework instead.

10. Can make him/herself get out of bed, even when tired.

11. Can apologize or shake hands after a fight.

12. Can make him/herself take medicine or eat food that s/he knows tastes bad.

13. Can make him/herself pick up something dirty in order to throw it away.

14. Has a hard time getting going(moving) when tired.

15. Can make him/herself smile at someone, even when s/he dislikes them.

2.2.8 Fear Questionnaire - Self report

The Temperament in Middle Childhood Questionnaire Self-Report (TMCQ-Self) was utilized to measure self reported observations of fear temperament across a number of situations. This 157-item questionnaire assessed the child's emotional and behavioral responses across a number of situations. This instrument measures 17 domains of child temperament. The focus of this study however was on the self-rated temperament fear score. Children were told they were about to be ask a few things about themselves and it was really important that they answer as truthfully as possible and then with a colorful stamp mark their answers on a sheet that contained a 5-point likert scale (no, a little, sometimes, mostly and a lot). The experimenter would read out a statement; I like candy. Then follow with, do you not like candy? Do you like candy a little bit?

Do you like candy sometimes? Do you like candy most of the time? Or do you like candy a lot? Then children were told to stamp their answers on the sheet in front of them with whichever stamp they liked. All statements were asked in this matter. Three practice statements were given in order to access if the child comprehended the instructions. All children understood the rules of the game. Table 2.1 provides summary scores self reported fear. The sample means demonstrate that this group of children showed relatively low levels of fear. The sample range, however, shows that there was moderate variability in the intensity of fear behaviors.

2.2.9Attention and Effortful Control - Self report

The TMCQ-Self fear procedures were also utilized to measure attention and effortful control. Subscales from the TMCQ-Self report were used to assess children’s own ratings of their attention, effortful control and activation control abilities. Individual scale scores and effortful control composite for each child was calculated based upon prior factor analytic work (Rothbart et al., 2001; Simonds & Rothbart, 2004; Putnam & Rothbart, 2006). Summery scores of attention, effortful control and activation control can be found in Table 2.3.

Chapter 3

Results

3.1 Initial Analyses

No age differences were found in ratings of fear, attention or during the first VRM task. However, one-way ANOVAs revealed age differences in reaction time in the second VRM task and in the visual search tasks with 6-year-olds taking significantly longer to make a decision (Table 3.1). Thus, age was used as a covariate when examining these variables.

3.1.1 Maternal Report Fear Correlations with Frontal EEG Asymmetries

Hypothesis 1 - Fear measures will be correlated with frontal EEG asymmetry, with higher fear associated with more right frontal activation. Maternal ratings of CBQ-SF($r(105) = .30$, $p < .002$) and FSSC-R/P fear ($r(105) = .48$, $p < .000$) were positively correlated with child self reported fear. Pearson correlations were used to examine associations among parent and child rated fear, and frontal EEG asymmetries (Table 3.2). Frontal asymmetry scores were calculated by subtracting left EEG power from right EEG power during baseline, as well as during the film and visual search fear tasks. Negative EEG asymmetry scores reflect greater relative right frontal activation. Positive scores reflect greater relative left frontal activation. Higher maternal reports of fear were related to left frontal Fp1/Fp2 and F3/F4 activation during baseline, fear video and visual search task. However, self reported fear was associated with more right frontal F7/F8 activation at baseline and during the fear video. CBQ-SF maternal ratings were correlated with left frontal activation during the visual search task at FP1/Fp2 and approached significance at F7/F8 (see Table 3.2).

3.1.2 Visual Search Reaction Time Correlations with Visual Search Task Frontal EEG Asymmetries

Pearson correlations were used to examine associations among visual search reaction times and frontal EEG asymmetries during the fear visual search task. Due to significant age differences in reaction time, correlations were performed across all ages as well as within each individual age (Table 3.3). Longer reaction times were associated with more right frontal F3/F4 and F7/F8 activation during the visual search task at 7 years of age. Correlations were also used to examine associations among visual search reaction time and frontal EEG asymmetries during baseline and fear video. Six-year-olds reaction time was associated with right frontal F3/F4 asymmetry. Reaction time at 7-years approached a significant correlation with F7/F8 right frontal activation at Baseline. However, at 7-years of age longer reaction times was associated with more left frontal Fp1/Fp2 and F3/F4 activation during the fear video.

3.1.3 Reported Fear Relations with Frontal EEG Asymmetries

A median split was used to determine higher and lower levels of reported CBQ-SF, FSSC-R/P and Self Report fear as well as shorter and longer reaction times during the visual search task. Fear groups (high and low CBQ-SF, FSSC-R/P and Self Report fear as well Visual

Search reaction times) were compared on baseline and task-related frontal EEG asymmetries. Only an independent-samples t-tests comparing frontal F7/F8 asymmetry in high and low self rated fear reveled significant differences. Right frontal children at baseline rated themselves as more fearful (M=1.91, SD=.95) and left frontal children themselves as less fearful (M=1.55, SD=0.86); t (95) = 1.94, p = 0.55. Right frontal children during the fear video also rated themselves as more fearful (M=2.00, SD=.98) and left frontal children reported less fear (M=1.52, SD=0.81); t (98) =2.52, p = 0.01. No asymmetry group differences were associated with the visual search task.

3.1.4 Predicting Reported Fear Behaviors

A series of hierarchal regression analyses were conducted with child frontal EEG asymmetry (baseline, video fear task) as predictors of latencies on the search task, parent-rated fear and self-rated fear. Regressions were done separately for each fear measure. Fox (1994) has proposed that patterns of resting frontal EEG asymmetry may serve as a marker of an underlining disposition. Therefore, baseline frontal asymmetry was entered in Step 1. Task-related frontal EEG asymmetry may be indicative of current emotional state (Davidson & Fox, 1989; Dawson et al, 1992). Thus, frontal asymmetry during the fear video task was entered in Step 2. Results of these regression analyses are presented in Table 3.4.

Baseline frontal F7/F8 EEG asymmetry revealed a marginally significant contribution in predicting self reported fear accounting for 3.2% of the variance, F(2, 95) = 3.15, p = .07 (see Table 3.4). The addition of video fear frontal F7/F8 EEG asymmetry to the final model did not change the amount of variance accounted for by the regression equation. The negative beta values for baseline indicates however that as the children were more right frontal in their EEG asymmetry (i.e., the asymmetry index becomes more negative in value), the level of self reported fear also increased.

To determine the utility of baseline frontal EEG asymmetry and video fear frontal EEG asymmetry in predicting maternal ratings of fear, similar hierarchal regressions were performed with predictors entered in the same order as in the previous analysis. The results of these analyses are shown in Table 3.4 (middle) and reveal a significant contribution of baseline frontal F7/F8 EEG asymmetry and video fear frontal F7/F8 asymmetry accounting for 6% of the variance in FSSC-R/P fear, $F(2, 95) = 3.06$, $p = .05$. Further analyses revealed a significant contribution of baseline frontal Fp1/Fp2 EEG asymmetry and video fear frontal Fp1/Fp2 asymmetry in predicting CBQ-SF fear accounting for 6.2% of the variance, $F(2, 100) = 4.40$, $p = .02$ (Table 3.4, bottom). A similar pattern was observed with video fear frontal F3/F4asymmetry accounting for 12.1% of the variance in CBQ-SF fear, $F(2, 100) = 6.81$, $p = .002$. The positive beta values, however, suggest that as the children were more left frontal in their EEG asymmetry (i.e., the asymmetry index becomes more positive in value), the level of maternal reported fear also increased. No significant findings were found for the visual search task. No significant findings were found using visual search task asymmetry scores or reaction time.

3.1.5 Predicting VRM Performance

Hypothesis 2 - Frontal EEG asymmetry predicts VRM performance A series of hierarchal regression analyses were used to examine whether EEG asymmetry during familiarization and/or test could be used to predict performance during the first VRM task. Regressions were done separately for each VRM variable (correct old recognition; correct new recognition; false positive; false negative; correctly identified, reaction time). Results of these regression analyses are presented in Table 3.5. Only individual models of frontal F3/F4 asymmetry during VRM familiarization and test contributed to the prediction of correctly identified old images. Both right frontal F3/F4 asymmetry during familiarization, $F(1, 93) = 2.86$, $p = .09$, and test, $F(1, 93) = 4.11$, $p = .05$, accounted for 3% of the variance.

Hierarchal regression analyses were then used to examine whether EEG asymmetry during familiarization and/or test could be used to predict performance during the second VRM tasks. Results of these regression analyses are presented in Table 3.5. Right frontal Fp1/Fp2 EEG asymmetry during Test contributed to the prediction correct identification of new images as new $F(1, 79) = 3.11$, $p = .09$ accounting for 4% of the variance. VRM test right frontal Fp1/Fp2 asymmetry also revealed a significant contribution towards the prediction of correctly identified images accounting for 8.2% of the variance, $F(2, 78) = 3.51$, $p = .04$. Due to the age differences in reaction time during the second VRM task, age was used as part of the regression analyses between reaction time and VRM EEG (Table 3.5, bottom). Approaching significance, VRM familiarization left frontal F7/F8 asymmetry and VRM test right frontal F7/F8 asymmetry accounted for 11.8% of the variance in reaction time, $F(2, 73) = 3.26$, $p = .03$.

3.1.6 Summary

Hypothesis 1 was partially substantiated. Maternal ratings of fear were significantly correlated with left frontal asymmetry at baseline, video fear and visual search task. Only self-fear ratings were correlated with greater right frontal asymmetry. Sparse and inconsistent relations between visual search reaction time and frontals asymmetry were found. Children who demonstrated right frontal asymmetry at baseline and fear video rated themselves as more fearful. Right frontal asymmetry at baseline also predicted children's self reported fear.

However, left frontal asymmetry predicted higher maternal ratings of fear. Hypothesis 2 was supported. Frontal EEG asymmetry predicts VRM performance.

3.2 Main Analyses

3.2.1 VRM Correlations with Attention

Pearson correlations were used to examine associations among attention variables and the first VRM task (see table 3.6). VRM was correlated with attention measures

3.2.2 Attention (IV) & VRM (DV) Moderated by Fear

Hypothesis 3.1 – Reported fear may serve as a moderator of the association between attention and visual recognition memory. Continuous variables were centered prior to conducting the regression analyses. Centering was accomplished by subtracting the sample mean from all individual scores on the variable; this produced a revised sample mean of 0. This procedure reduced the multicollinearity between predictors and any interaction terms among them and facilitated the testing of simple slopes (Holmbeck, 2002). Guidelines from Holmbeck (1997) were used in the moderation analyses. In step one, the predictor (attention) and moderator (reported fear, visual search latency) main effects were entered into a regression equation predicting recognition memory performance. Next, the interaction term of predictor and moderator (attention X fear) was entered. A significant interaction between attention and fear were interpreted by plotting simple regression lines for high and low values of fear (Holmbeck 1997, 2002).

Multiple regression models were tested and an association between attention efficiency score 1 and the number of correctly identified images during the second VRM task was found to depend on the degree of reported self fear (see Table 3.7). The model approached significance, $F(3, 82) = 2.29$, $p = .085$, and the interaction between self fear and attention was acceptable Cohen, Cohen, West, and Aiken, 2003) (Figure 3.1). Simple slopes for this association and all significant moderations were tested for low (-1 SD below the mean), moderate (mean), and high (+1 SD above the mean) levels of fear and revealed that only the higher self fear group significantly differed from zero ($\beta_{SD+1} = 14.29$, SE = 7.28, $t(78) = 1.96$, $p = .05$).

Replacing self reported fear with maternal reported CBQ-SF fear also revealed a significant model, $F(3, 82) = 3.77$, $p = .01$, and a significant interaction between CBQ-SF fear and attention (Figure 3.2). Simple slopes for the association between attention and CBQ-SF fear were tested and revealed that the higher self fear group significantly differenced from zero ($\beta_{SD+1} = 18.92$, SE = 7.07, $t(78) = 2.68$, $p = .009$). An association between attention efficiency score 1 and the number of correctly identified images as old during the second VRM task also depended on the degree of maternal reported CBQ-SF fear (Table 3.7, bottom). The model approached significance, $F(3, 82) = 2.54$, $p = .06$, with an interaction between CBQ-SF fear and attention (Figure 3.3). Simple slopes for the association between attention and CBQ-SF fear were tested and revealed that the higher self fear group significantly differenced from zero ($\beta_{SD+1} = 12.6$, SE = 6.21 $t(78) = 2.19$, $p = .03$).

3.2.3 Attention (IV) & VRM (DV) Moderated by Fear Video Physiology

Hypothesis 3.2 - Physiological fear moderates the association between attention and visual recognition memory. The analysis of this hypothesis utilized attention and VRM and fear EEG in the moderation analyses similar to the one describe above. The use of fear psychophysiology allowed for testing of potential moderation effect of fear in the absence of behavioral manifestations of fear.

A regression reveled an association between attention efficiency score 1 and the number of correctly identified images as old moderated by fear video Fp1/Fp2 frontal asymmetry (Table 3.8, top). The model was significance, $F(3, 92) = 5.18$, $p = .002$ and revealed a significant interaction between fear asymmetry and attention (Figure 3.4). Simple slopes for the association between attention and fear asymmetry were tested and revealed that left frontal asymmetry significantly differenced from zero ($\beta_{SD+1} = 16.92$, SE = 4.44 $t(91) = 1.49$, $p = .0003$).

Association between attention efficiency score 2 and reaction time were also found depending on fear video F7/F8 frontal asymmetry (Table 3.8, bottom). The model was significance, $F(3, 83) = 2.88$, $p = .04$ and revealed an interaction between fear asymmetry and attention (Figure 3.5). Simple slopes for the association between attention and fear asymmetry were tested and revealed that left frontal asymmetry significantly differenced from zero ($\beta_{SD+1} = 2.28$, SE = 1.14 $t(82) = 2.00$, $p = .05$).

3.2.4 VRM Correlations with Effortful Control

Pearson correlations were used to examine associations among effortful control variables and the first VRM task (see table 3.6). VRM was associated with better effortful control.

3.2.5 Attention Correlations with Effortful Control

Pearson correlations were used to examine associations among effortful control variables and attention measures (see table 3.9). Effortful control was associated with better attention.

3.2.6 Effortful Control (IV) & VRM (DV) Moderated by Reported Fear

Hypothesis 4.1 –.Reported fear moderates the association between effortful control and visual recognition memory. Regression models were tested and identified an association between CBQ-SF effortful control and the number of correctly identified images during the first VRM task depending on self fear group membership (see Table 3.10). The model was significance, $F(3, 92) = 3.00$, $p = .04$, and an interaction between self fear report and effortful control was found (Figure 3.6). Simple slopes for the association between effortful control and VRM were tested and revealed that the low self fear group significantly differed from zero ($\beta_{SD-1} = 5.15$, $SE = 1.82$ $t(89) = 2.83$, $p =.001$).

Replacing self reported fear with CBQ-SF fear group also revealed a significant model, $F(3, 92) = 6.14$, $p = .001$ and a significant interaction between CBQ-SF fear and effortful control (Figure 3.7). Simple slopes for the association between effortful control and VRM tested also revealed that the low self fear group significantly differed from zero ($\beta_{SD-1} = 7.5$, $SE = 1.79$ $t(89)$

= 4.19, p =.0001). A regression also revealed an association between CBQ-SF effortful control and the number of correctly identified images as old during the first VRM task depending on self fear groups (Table 3.10, middle). The model was significance, $F(3, 92) = 5.1$, $p = .003$ and revealed a significant interaction between self fear and effortful control (Figure 3.8). Simple slopes for the association between attention and self fear demonstrated that the low self fear group differed from zero ($\beta_{SD-1} = 2.9$, SE = .88 $t(91) = 3.28$, $p =.001$).

An association was found between TMCQ activation control and the number of correctly identified images depending on FSSC-R/p group in the supports this studies hypothesis (Table 3.10, bottom). The model was significance, $F(3, 92) = 6.22$, $p = .001$, and revealed a significant interaction between FSSC fear and activation control (Figure 3.9). Simple slopes analyses demonstrated that the high FSSC fear group differed from zero ($\beta_{SD+1} = 7.79$, SE = 2.68 $t(88) = 2.91$, $p =.005$).

3.2.7 Effortful Control (IV) & VRM (DV) Moderated by Fear Video Physiology

Hypothesis 4.2 - Physiological fear moderates the association between effortful control and visual recognition memory. The first analysis of this hypothesis utilized effortful control/activation control and VRM and fear EEG in the moderation analyses similar to the one described before. The use of fear psychophysiology allowed for testing of potential moderation effect of fear in the absence of behavioral manifestations. A regression model identified an association between CBQ-SF effortful control and the number of correctly identified images during the first VRM task that depended on frontal F7/F8 fear video asymmetry (see Table 3.11). The model was significance, $F(3, 92) = 7.95$, $p = .00$, and an interaction between F7/F8 fear video asymmetry and effortful control was significant (Figure 3.10). Simple slopes for the association between attention and fear asymmetry were tested with right frontal asymmetry significantly differing from zero (β_{SD-1} = 10.4, SE = 2.25 t(84) -4.62, p =.00000). Another regression model revealed an association between CBQ-SF effortful control and the number of correctly identified images as new during the first VRM task also depended on fear video F7/F8 frontal asymmetry (Table 3.11, top). The model was significance, F(3, 92) = 5.33, p = .002 and revealed a significant interaction between fear asymmetry and attention (Figure 3.11). Simple slopes for the right frontal asymmetry significantly differed from zero (β_{SD-1} = 7.23, SE = 1.82 t(84) 3.97, p =.0001).

The second VRM task was also examined revealing an association between TMCQ activation control and the number of correctly identified images depending on frontal Fp1/Fp2 fear video asymmetry (see Table 3.11, middle). The model was significance, F(3, 80) = 3.02 p = .03, and an interaction between Fp1/Fp2 fear video asymmetry and effortful control was significant (Figure 3.12). Simple slopes for the association between attention and fear asymmetry were tested and reveled right frontal asymmetry group significantly differing from zero (β_{SD-1} =4,89, SE = 2.48 t(76) 3.97, p =.05). A regression model investigating the association between TMCQ activation control and the number of correctly identified images as old also depended on fear video Fp1/Fp2 frontal asymmetry (Table 3.11, middle). The model was significant, F(3, 80) = 2.91, p = .04 and revealed a significant interaction between fear asymmetry and attention (Figure 3.13). Simple slopes analyses demonstrated more right frontal asymmetry differing from zero (β_{SD-1} =3.5, SE = 2.07 t(76) 1.69, p =.095). Lastly, a regression model investigating the association between CBQ-SF effortful control and the number of correctly identified images as old depended on fear video F7/F8 frontal asymmetry (Table 3.11, bottom). The model approached significance, $F(3, 80) = 2.35$, $p = .079$ and revealed a significant interaction between fear asymmetry and attention (Figure 3.14). Simple slopes were tested and identified right frontal asymmetry differing from zero ($\beta_{SD-1} = 4.01$, SE = 1.9 $t(74)$ 2.11, $p = .04$).

3.2.8 Summary

Hypothesis 3.1 & 3.2 were partially supported. Ratings of fear regulated the association between attention and VRM performance. Physiological fear also moderated the relation between attention and VRM however in the opposite direction than hypothesized.

Hypothesis 4.1 & 4.2 were partially supported. Physiological fear moderated the relation between effortful control and VRM. Ratings of fear regulated the association between attention and VRM performance however in the opposite direction than hypothesized.

Chapter 4

Discussion

The interconnections between emotion and cognition have not been thoroughly explored, despite acknowledgment that integration across these areas of development will likely yield a more complete understanding of development and of successful in home, peer, and school contexts (Bell & Wolfe, 2004; Blair, 2002; Gray, 2004; Leerkes, Paradise, O'Brien & Calkins, 2008). Emotions are thought to be adaptive processes that can organize an individual's functioning (Barrett & Campos, 1987; Campos & Barrett, 1984) as well as redirect and organize components of cognition (Gray, 2001; 2004; Barrett & Campos, 1987; Campos & Barrett, 1984). Indeed, knowing when, where and to what degree to exhibit emotions has been found to play a substantial role in early cognitive performance (Wolfe & Bell, 2004, 2007). Individual differences in fearfulness could shed some insight into the relation of emotion and cognition since it is one of the more integral and adaptive aspects of emotion related development (Gullone, 1999).

Investigating individual differences provides an excellent framework for the study of temperament; constitutionally based individual differences in emotion reactivity and regulation. Fearfulness is crucial to development as we are regularly confronted with different contexts of novelty and unfamiliarity such as novel objects, environments, situations and/or unknown individuals throughout development. Not to mention, higher-order cortical processes are closely involved in fear acquisition in both animals and humans (Delgado, Olsson, & Phelps, 2006; Lovibond, 2004). Fearfulness also inhibits responses and ongoing motor programs as well as prepares response systems when confronted with novelty (Rothbart, Ellis & Posner, 2004; Banfield, Wyland, Macrae, Munte & Heartherton, 2004). However, few studies have approached the study of normal variations in fearfulness as an early developing self-regulatory system that has inhibitory influence and control over behaviors. Though conceptually proposed in literature (Rothbart, 2007; Rueda, Posner & Rothbart, 2002).

Self-regulation is responsible for the planning and the execution of not only emotional responses but executive processes that allow a child greater control over his/her responses. Middle childhood is recognized as a crucial phase in the development of human emotion and cognitive behavior. Middle childhood denotes improvement in emotional understanding and emotional regulation (Raffaelli, Crockett, & Shen, 2005) which includes the emergence of emotion regulation strategies (Pons, Harris, & De Rosnay, 2004) that include distraction, avoidance, escape, suppression, and use of information to enhance or blunt emotional experience some of which coincide with typical fearful behaviors. From the cognitive point of view, this phase is marked by a striking and rapid increase in self-regulation and self-control, focused attention, and strategic planning (known as the '5-to-7 years shift') (Colle & Del Giudice, 2010). Most importantly, middle childhood is also marked by the ability to better classify and distinguish features compared to earlier developmental periods (Santrock, 2012). Visual recognition memory plays a substantial role in novelty detection and discriminatory abilities and is closely related to attentional capabilities. Events and stimuli that are novel have been associated with greater attention, greater orienting responses, and better recognition (Reynolds, Courage & Richards, 2006; Bornstein, 1985; Fantz, 1961). Abilities to attend and discriminate between novel and familiar could be greatly informed by also considering individual differences in fearfulness.

With evidence suggesting self-regulation plays a role in novelty detection (Banfield, et. al., 2004), fearfulness in childhood may be regulating the ability to attend and then discriminate stimuli or event features. Since, fearfulness' adaptive function is to increase vigilance and orienting to environmental cues that could be indicative of threat (LeDoux, 2000), heightened arousal can aid children's discrimination abilities, giving them an advantage to better attend and distinguish novelty from the familiar than non-fearful children. The current study investigated the potential regulating role of child fearfulness on the relation between attention and visual recognition memory. Because middle childhood is characterized by—and still not completely understood—neurobiological processes (Campbell, 2006; Del Giudice, Angeleri, & Manera, 2009), both behavioral and physiological measurements of fearfulness, attention and recognition memory were examined.

4.1 Hypothesis 1 - Fearfulness Measures were Associated with Frontal EEG Asymmetry

Few studies have involved the observations of fearfulness behavior or its physiological associations in middle childhood when the significance of emotion is especially broad in scope (Gullone, 1999). It was predicted that frontal EEG may reflect an individual's bias to respond with negative affect to certain stressful situations though they might not overtly express fear (Fox, Henderson, Rubin, Calkin, & Schmidt, 2001). Specifically, it was predicted that even though children are less likely to display fear as overtly as they did in infancy, physiological measures of fearfulness could demonstrate that it is not an indication of a reduction of fearfulness itself but an increase in fearfulness' self-regulation. Buss and colleagues (2004) have provided evidence of the associations between Fp1 & Fp2 and F7 & F8 asymmetry and fearfulness as well as evidence suggestion the association between F3 & F4 asymmetry with fearful behaviors. Hence, all three locations were examined.

Though initial proposal included behavioral measures of fearfulness during a fear tasks, no overt behaviors were observed during. However, this was not surprising as middle childhood is indicative of more self-awareness and sophisticated emotion regulation strategies. Indeed, normative studies have shown that regulation strategies, such as cognitive reappraisal, first appear in middle childhood (Pons, Harris, & De Rosnay, 2004). Nevertheless, parental and child reports of fearfulness were correlated with frontal EEG asymmetry during baseline and fear video with higher maternal ratings of fearfulness associated with more left frontal activation and children's self reported fearfulness associated with more right frontal activation. Left frontal asymmetry is associated with positive/approach emotions (Bell & Fox, 1994; Fox, Bell, & Jones, 1992). Right frontal asymmetry is typically associated with negative emotions (Fox, 1994) and also has been taken to indicate activation of the motivational system associated with withdrawal behaviors coupled with the experience and expression of moderately high levels of fearfulness (Fox, Henderson, Marshall, Nichols & Ghera, 2005). Maternal reports of their children's fearful behaviors do not correspond to children's physiological characteristics.

Kagan (1998) has criticized the use of parent-report, noting that parents tend to form a consistent opinion of their child. Furthermore, there is some evidence that maternal temperament has a modest but significant contribution to maternal reports of their children's temperament (Matheny, Wilson, & Thoben, 1987). Another limiting factor of parent-report, is that parents unwittingly make comparisons when judging characteristics of their child, which are subject to the influence of prior experiences not related to their child's temperament (Kagan, 1998, Anderson et al.,1989, Crockenberg & Acredolo, 1983). However, in early and middle childhood the combination of increased internal and external knowledge of emotion enables the development of a child's ability to learn and to predict their own emotional reactions and enact regulation accordingly (Stegge & Terwogt, 2007). As children move through middle childhood they develop emotional awareness, or the ability to recognize and reflect on their own emotion experiences, which is integral in the development of emotion regulation. Indeed, Harris, Olthof, and Meerum Terwogt (1981) interviewed seventy-two 6-, 11-, and 15-year olds and found that a marked shift in the child's concept of emotion occurs between 6- and 11- years old. These emerging capabilities allow children to be good judges or their fearful emotions but may not give parents the opportunity to overtly view their children's fearfulness. The current findings give some support for the use self-reports in middle childhood.

It was expected, however, that visual search reaction times would be associated with frontal EEG asymmetries. Findings were not robust and mostly contradicted what was hypothesized. Objectively threatening stimuli was believed to selectively capture attention and so faster detection of fear-relevant compared to fear-irrelevant stimuli would occur (Lobue & DeLoache, 2008). Such a bias would reflect a specific fearfulness response and be associated with right frontal activation. This seemed true for 7 year olds visual search reaction times only during the video fear task. The opposite association was seen at 6 and 7 years of age at rest. Inconsistent findings and greater reaction times associated with right frontal activation begs the question whether children where objectively judging these images as threatening. Snake images were specifically chosen to depict coiled snakes on the ground or in trees. The lack threatening poses may have diminished children's attentional and fearful responses. Perhaps the concept of prepared learning or that humans have an evolved predisposition to associate certain stimuli with fearfulness (Öhman and Mineka, 2001; Öhman, Flykt & Esteves, 2001) should be examined developmentally a bit further. Lobue and Deloache (2008) found that adults recognized snake stimuli much faster than children suggesting that fearfulness of snakes are learned and not as evident early in development. Moreover, a study on adults also found similar results for the detection of spiders (Tipples, Young, Quinlan, Brooks, & Ellis, 2002). It is important to make a distinction between inherent fearfulness and acquired fears in childhood. What determines acquired fears can depend largely on experience and genetics (Stevenson, Batten and Cherner, 1992). These fears are acquired through direct aversive experiences where a stimulus comes to evoke a fear response by association with some traumatic outcome (Davey, 1997), learned through observing others and/or the transmission of negative information (Rachman, 1991). The association seen in prior studies (Öhman and Mineka, 2001; Öhman, Flykt & Esteves, 2001) may have been a consequence of acquired fears of snakes and spiders rather than a predisposition. Overall, little significant finding were found for the visual search task.

Right frontal children at baseline rated themselves as more fearful and left frontal children rated themselves as less fearful. This same pattern was observed during the fear video. Only right frontal baseline asymmetry approached significantly predicting higher child reported fearfulness. Resting right frontal EEG pattern is typically associated with the tendency to display negative emotions (Fox, 1994). It also has been used to indicate activation of the motivational system associated with withdrawal behaviors coupled with the experience and expression of fearfulness (Fox, Henderson, Marshall, Nichols, & Ghera, 2005). Our prediction that children with higher levels of fearfulness would also exhibit right frontal EEG asymmetry during fear tasks was based in part on the behavioral inhibition literature (e.g., Calkins, Fox, & Marshall, 1996; Fox et al, 2001; Fox et al, 2005) that may not pertain to normal fearful behaviors. This hypothesis was partially confirmed and verifies the efficacy of frontal EEG asymmetry as an indicator of fearfulness even when the behavioral fear is quite low.

However, maternal reports were also predicted by child frontal EEG asymmetry scores with higher maternal ratings of fearfulness predicted by greater left frontal asymmetry. Children's self reported fearfulness coincides with their physiological characteristic more closely than their parent's reports on their child's fearfulness. Parental ratings may be the product of not just child behavior but also of parental perceptions of these behaviors (Bates, 1980). For instance, certain behaviors such crying in the sight of novelty may be interpreted as a fearful reaction (Goldsmith & Rothbart, 1999). However, parents may vary in the degree to which they find this behavior fearful. Again, research has indicated that parental ratings of temperament are influenced by antecedent parental behavior patterns (Anderson et al.,1989; Crockenberg & Acredolo, 1983). One viable and interesting next step would be to extend this experimental protocol to investigate mother's perception of her own temperament and examine correlations with her child's fearful behaviors.

Film clips have been utilized before to evoke fear in children (Gilissen, et al., 2007; Cantor, 2002). However, fear video clips in middle childhood are increasingly getting harder to find. The recently completed 3-year National Television Violence Study found that nearly two thirds of all programming contains graphic scenes that may be considered scary or frightening and children's shows contain the most of these scenarios. Perhaps since children are becoming numb to media portrays of fearful events, situations, and persons better tasks can be devised. Indeed, children between the ages of 7- 9 have self-reported more fear as a result of verbal information, compared to information given via video (Field, Argyrus & Knowles, 2001). Other studies have also shown that verbal threat information has a highly significant effect on children's fear of novel animals and social situations (Field 2006; Field & Lawson, 2003) and increases in fear when novel animals are paired with scared faces (Askew and Field, 2007). These methods may provide a better understanding of middle childhood fear both behaviorally and physiologically.

The notion of "constitutional basis" of temperament refers to the relatively enduring biological make-up of the individual (Rothbart & Derryberry, 1981). The basis of this study revolved around fearfulness being one of the earliest regulatory systems influencing the control of behavior (Rueda, Posner & Rothbart, 2004). It is important to take into consideration then that although fear information may change beliefs in a current setting, it might not translate into the same behavioral change that would be expected if this information had a powerful effect outside of a controlled setting and directly relevant to their temperamental fear development. Individual differences in trait characteristics are what lay the foundation from which cognition, emotion and other behaviors develop, thus enabling a better examination of early mechanisms that are important for the development of future self-regulation. Temperamental fear, taps into children's experience of general patterns of fear throughout their development and is concerned with normative fears. Temperament traits, including fearfulness, have been associated with better cognitive outcomes because of their links to more regulatory aspects of temperament (Goldsmith, Lemery, Aksan, & Buss, 2000). The regulatory role of trait fear may be more relevant and critical for the holistic understanding of the interconnections between emotion and cognition than a child's current emotional state.

4.2 Hypothesis 2 -Visual Recognition Memory was Associated with Frontal EEG Asymmetry

Biederman's recognition-by-components theory is based on an assumption that visual recognition reflects the ability to attend to object's feature component parts and to the relation among those components (Biederman, 1987). Novelty detection has been associated with net increases in neurological activity as neurons code specific stimuli features and properties (Colombo, 2010). Frontal central regions have also demonstrate greater Nc amplitude as well as a faster latency to peak to novel than to familiar stimuli (DeBoer, et., 2004). There is also some evidence that children's old-new recognition has a tendency to be stronger over right frontal areas similar to current known physiological associations with fearfulness. Functioning might overlap at the right frontal cortex. Specifically, better item recognition has been associated with better right medial frontal site (F4) activation (Marshall, Drummey, Fox & Newcombe, 2002). Right frontal F3/F4 asymmetry during VRM1 familiration and test predicted children's ability to correctly identified familiar objects. Right frontal Fp1/Fp2 asymmetry during VRM2 test significantly predicted children's ability to correctly identify new images and overall correct picture classification as old or new. These data provide evidence for the role of frontal EEG asymmetry in VRM capabilities with more right frontal asymmetry related to overall better discrimination and recognition of previously never seen and seen images. Though indirect, this also provides some support for the dual role of right frontal activity in both VRM performance and fearful behaviors.

Due to the significant age differences in reaction time during the second VRM task, a composite score was not formed for VRM and each VRM block examined separately. The second block of 74 pictures for the VRM task was given to each child approximately 15-18 minutes after the first block. Marshall and colleagues (2002) have utilized this task before with younger children as well as adults however with a shorter delay between blocks. This was attempted in the current study, however, children began to complain about the length of the task and fail the practice trial. Marshall and colleague originally employed this task with 20 4-year-olds however, stated that 14 were omitted due to failure to engage and low performance. Perhaps this was a carefully selected sample as the 14 omitted children may have been too exhausted to successfully complete the task. The delay was increased in the current study which increased practice trial performance. However, the age differences observed might still be one of fatigue. Examining reaction times further, it is evident that the youngest children; 6 year-olds, took the longest to answer. Seventy-four images to sit and be quiet though as they answer may have been more difficult for younger children than the older children. However, there were no age differences in performance. Due to fatigue, six-years may have needed more time to process information. Nevertheless, controlling for age still revealed a significant association between VRM2 reaction time and frontal asymmetry. Left frontal asymmetry during familiration significantly predicted longer reaction time. Those that perform and attend better have revealed faster reaction times in previous study (Marshall, Drummey, Fox & Newcombe, 2002). Since our study suggest better performance with right frontal asymmetry, left frontal asymmetry children having longer reaction times substantiated.

4.3 Hypothesis 3.1 & 3.2 - Fearfulness Moderates the Relation Between Attention & VRM

The relation between fearfulness, attention and visual recognition memory extending into middle childhood is conceptually driven as there are no empirical studies looking at the regulatory role of fearfulness. However, interest in novelty and uncertainly provides a motive for psychological growth that continues through human development. Positive association between a child's attentional capabilities and VRM have clearly been identified in previous literature (Rose, Feldman & Jankowski, 2003) and found in this investigation a well. However, a main function of emotion is also to direct attention to relevant aspects of the environment (Ekman, 1994; Izard, 1993). Fearfulness' adaptive function is to increase vigilance and orienting to environmental cues that could be indicative of threat (LeDoux, 2000; Karrass & Braugart-Rieker, 2004; Matheny, 1989), heightened normal levels of fearfulness may regulate the amount of attention given to a stimulus thus improving a child's ability to recognize it later compared to have low levels of fearfulness. This study found significant moderation effects to substantiate this claim with fearfulness enhancing the relation between attention and VRM. Both self reported and maternal reports of fearfulness moderated the relation between attention and VRM performance. Children with higher levels of normal fearfulness demonstrated higher attention and better overall correct image identification. Children with lower levels of normal fearfulness demonstrated lower attention and poorer image discrimination. Specifically, fearfulness seemed to enhance the attention needed to recognize familiar images. Fearfulness in childhood may not be associated with a preference for novelty as it did in infancy but an overall better ability to discriminate stimuli or event features improving their recognition of familiar images. However these results were only significant during the second VRM task. Regulatory processes that modulate reactivity include selective attention and processing of cues to reward and punishment, as well as approach and inhibition to novel stimuli (Rothbart et al 1994). These data give some credence to fearfulness' regulating role in cognitive behaviors but perhaps because of fatigue, these children needed to recognize and regulate more their internal and external behaviors in order to "win" the game.

Rose and colleagues (2003b) have reported correlations between attention and recognition memory and Posner has suggested that the vigilance attentional network of the brain, which comprises inputs to the frontal cortex, is involved in maintaining and sustaining ones alertness (Posner & Raichle, 1995). Our study also found a particular association between right frontal asymmetry and VRM performance. The substitution of physiology for fear reports revealed a moderation effect contrary to what was hypothesized. Depending on the child's frontal asymmetry the relation between attention and VRM was altered. Children with left frontal asymmetry exhibited better attention during the attention control task and were better able to recognized previously seen images than right frontal children. Nevertheless, left frontal children, though demonstrating greater attention, took longer to answer than right frontal asymmetry children. These findings contradict one another. Better performance and attention should revealed faster reaction times. Furthermore, it was assumed that greater attention and shorter reaction time would be moderated by right frontal activation as these are the children that performed better during the VRM tasks. EEG measures voltage fluctuations resulting from ionic current flows within the neurons of the brain and records the brain's spontaneous electrical activity. Due to its poor spatial resolution, it may be that right frontal asymmetry during VRM familiration and test is not the same type of right frontal activation that occurs during fearfulness.

4.4 Hypothesis 4.1 & 4.2 - Fearfulness Moderates the Relation Between Effortful Control & VRM

The effortful control construct is attentional in nature and connected to the development of attentional control and subsequently the Executive Attention System (Rothbart & Bates, 1998). It was hypothesis that if there was a moderating role of fearfulness on attention and VRM, there would also be a similar effect when investigating effortful control. Children may attempt to control fear by paying attention to threatening information with an effortful component compatible to the reactive influence of fearfulness that enhances attention to threat or novelty providing additional information. Indeed, child fearfulness has been shown to predict higher levels of effortful control later in childhood (Aksan & Kochanska, 2004). Fearfulness' regulation then can be thought of as reflexively enhancing attention to immediate sources of threat, while effortful control allows the child to modify attention as the situation may call for. Results indicated that effortful control was also positively associated with VRM. However, children rated as less fearful were rated by mothers as having greater effortful control and performed better during the first VRM task. Children rated as more fearful were rated by mothers as having less effortful control and had poorer performance during VRM. Given our previous finding with attention, it was expected that higher fearfulness would positively moderate the relation between effortful control and VRM. However, only the conceptual measure of effortful control revealed that children rated as more fearful had greater activation control and were better at correctly identifying images as old or new.

Substituting physiology for reported fear, however, resulted in an opposite pattern. Children with more right frontal asymmetry were rated by mothers as having greater effortful control and performed better in both VRM tasks. Children frontal asymmetry influenced the relation between effortful control and VRM1. Children with more right frontal asymmetry were rated by mothers as having more effortful control and correctly identified more images especially novel images compared to left frontal children. Children's frontal asymmetry also influenced the relation between effortful control and VRM2. Children with more right frontal asymmetry were rated by mothers as having more conceptual effortful control and correctly identified more images especially familiar images compared to left frontal children. These ambiguous findings between fearfulness, effortful control and VRM really need further investigation. This study did not have an effortful control task and relied on parental reports. The behavioral moderating effect of fearfulness on the association of attention and VRM occurred when using an attention control task. Perhaps if this study utilized an effortful control battery of task a clearer understanding of the regulating role of fearfulness can be made.

4.5 Caveats and Future Studies

This study is not without its limitations. The visual search task revealed little evidence toward the regulating role of children's fearfulness. One viable and interesting next step would be to replicate the task but employ more threatening images of snarling or attacking snakes as well as spiders to investigate its claim of capturing early fearful predispositions. It is also necessary to include multiple fear tasks as the video fear task may not have truly been fearful. In addition, having children rate their emotions right after the fear tasks would have provided further evidence towards the predictability of their fear EEG asymmetry scores. Though it was theory that drove the concept of fearfulness regulation attention and VRM, it is also necessary to rule out attention as a possible moderator between fear and VRM. Future studies should examine the role of attention further.

Furthermore, the results regarding effortful control were quite ambiguous and unclear. It is necessary for the next step in this investigation to measure children's performance during an effortful control task. Future studies should also limit the number of pictures in each VRM block in order to reduce fatigue and exhaustion.

Children were also predominately Caucasian and from highly educated families. Future studies should examine ethnic and culture differences between fearfulness, attentional and recognition memory abilities as well as social economical status as moderators of these relations. Studies have indicated differences in temperament across distinct ethnic group in various Eastern and Western cultures (Ahadi et al., 1993; Windle, Iwawaki, & Lerner, 1988). Culture is an important factor in understanding individual differences, as it may influence the development or maintenance of certain behaviors.

The FSSC-R/P was used to select non-clinical levels of fear in this sample and is generally a low fear sample given their mean scores. Subsequent studies should specifically select children based on high or low fearfulness (Buss, Davidson, Kalin, & Goldsmith, 2004). This method would allow for the investigation of extreme groups within high and low fearful children. In turn, these extreme groups may provide more evidence regarding the relation between fearfulness and recognition memory.

4.6 Conclusion

During middle childhood, children make great strides toward adulthood by becoming competent, independent and more self-aware. In the process they gain an increasing awareness of impulse control, and the ability to identify, express, and manage feelings (Santrock, 2012). Given the discrepancies relating cognition and negative affect (Karass & Braugart-Rieker, 2004), the findings from this study provide some evidence of the regulating role of temperament fear on attention and recognition memory in middle childhood. Behavioral tendencies of fear rather than discrete behavioral acts were associated with right frontal asymmetry. VRM performance was also associated with right frontal asymmetry. Maternal ratings of fearfulness moderated the relation between attention and VRM while children's fearfulness asymmetry regulated the relation of effortful control and VRM. Because fearfulness and visual recognition memory are associated with the differential attention paid to the novel and the familiar, studies that examine visual recognition memory as well as the role of attention can provide insight into the overall cognitive-emotion relation involved in an organism's adaptive fearful responses to their environment. These findings also add additional weight to the use of frontal asymmetries as central variables in the examination of temperament and cognitive capabilities in early development.

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Table 2.1

Summary Scores for Reported Temperamental Fear Variables Across All Ages

n=105	Mean	SD	Range
CBQ-SF Fear	3.64	1.28	1 - 7
FSSC-R/P	123.02	22.08	86 - 137
Self-Fear	1.72	.91	0 – 3.56

Summary Scores for Reported Temperamental Fear Variables at 6-years

n=35	Mean	SD	Range
CBQ-SF Fear	3.97	1.06	1.67- 6.2
FSSC-R/P	125.31	24.27	87- 132
Self-Fear	1.87	.90	0 – 3.56

Summary Scores for Reported Temperamental Fear Variables at 7-Years

n=35	Mean	SD	Range
CBQ-SF Fear	3.42	1.34	1- 4.11
FSSC-R/P	122.67	23.01	86 - 130
Self-Fear	1.65	.96	0 – 3.56

Summary Scores for Reported Temperamental Fear Variables at 8-years

n=35	Mean	SD	Range
CBQ-SF Fear	3.54	1.40	1.2- 7
FSSC-R	123.02	22.08	86 – 131
Self-Fear	1.64	.89	.33 – 3.33

Table 2.2

Summary Scores for Visual Recognition Memory Variables Across All Ages

	Mean	SD	Range
VRM1 (n=98)			
Reaction time	2.57	.17	.78 – 4.22
Total Identified	59.68	7.49	30-73
Correct old recognition	28.27	5.36	1-36
Correct new recognition	31.33	6.03	6-51
False Positive	7.03	5.91	.00-32
False Negative	7.45	4.61	.00-22
VRM2 (n=88)			
Reaction time	2.48	.81	1.6-5.59
Total Identified	48.57	6.54	35-62
Correct old recognition	18.94	5.68	5-29
Correct new recognition	24.91	11.28	.00-37
False Positive	12.09	11.28	.00-37
False Negative	13.07	5.68	3-27

Summary Scores for Visual Recognition Memory Variables at 6-Years

	Mean	SD	Range
VRM1 (n=32)			
Reaction time	2.68	1.10	1.62 – 7.72
Total Identified	57.69	7.24	39-68
Correct old recognition	28.03	3.96	19-35
Correct new recognition	29.66	6.03	6-38
False Positive	8.34	6.20	.00-32
False Negative	7.97	3.96	1-17
VRM2 (n=31)			
Reaction time	2.48	.81	1.6-5.59
Total Identified	46.90	6.62	35-62
Correct old recognition	17.06	6.18	5-29
Correct new recognition	27.00	9.19	.00-36
False Positive	10.00	9.19	1-37
False Negative	14.94	6.18	3-27

Summary Scores for Visual Recognition Memory Variables at 7-years

	Mean	SD	Range
VRM1 (n=30)			
Reaction time	2.37	.63	1.62 – 4.29
Total Identified	58.7	6.79	38-68
Correct old recognition	26.94	6.6	1-36
Correct new recognition	31.55	6.34	10-51
False Positive	7.61	5.95	1-28
False Negative	8.2	4.59	.00-20
VRM2 (n=30)			
Reaction time	2.36	.69	1.65-4.29
Total Identified	48.74	6.28	36-61
Correct old recognition	20.34	4.56	9-29
Correct new recognition	24.34	10.67	.00-37
False Positive	12.66	11.66	.00-37
False Negative	11.66	4.56	3-23

Summary Scores for Visual Recognition Memory Variables at 8-Years

	Mean	SD	Range
VRM1 (N=36)			
Reaction time	2.30	.45	1.46–3.51
Total Identified	60.28	7.72	30-73
Correct old recognition	29.64	5.06	14-36
Correct new recognition	32.64	6.03	10-37
False Positive	5.36	5.37	1-28
False Negative	6.36	5.06	.00-28
VRM2 (N=27)			
Reaction time	2.30	.48	1.5-3.15
Total Identified	50.3	6.49	37-62
Correct old recognition	19.52	5.82	6-28
Correct new recognition	23.5	13.47	1-36
False Positive	13.5	13.47	1-36
False Negative	12.48	5.82	4-26

Table 2.3

Summary Scores for Attention and Effortful Control Variables Across All Ages

	Mean	SD	Range
Attention Task (n=105)			
Efficiency Scores 1	.81	.14	.45-1.00
Efficiency Scores 2	.90	.11	.5-1.00
Reported Attention (n=105)			
CBQ Attentional Focusing	5.08	1.04	2.33-7
Self Attentional Focusing	2.26	.81	.29-4
Reported Effortful Control (n=105)			
CBQ Effortful Control	5.33	.58	3.85-6.59
Self Effortful Control	2.44	.45	1.05-3.77
TMCQ Activation Control	3.91	.46	2.73-4.93
Self Activation Control	2.20	.59	.73-3.73

Summary Scores for Attention and Effortful Control Variables at 6-Years

	Mean	SD	Range
Attention Task (n=35)			
Efficiency Scores 1	.83	.15	.5-1.00
Efficiency Scores 2	.90	.13	.5-1.00
Reported Attention (n=35)			
CBQ Attentional Focusing	5.12	.81	3.67-7
Self Attentional Focusing	2.22	.74	.57-4
Reported Effortful Control (n=35)			
CBQ Effortful Control	5.46	.51	4.10-6.59
Self Effortful Control	2.40	.43	1.10-3.35
TMCQ Activation Control	3.89	.46	2.80-4.80
Self Activation Control	2.16	.49	1.27-2.16

Summary Scores for Attention and Effortful Control Variables Across at 7-years

	Mean	SD	Range
Attention Task (n=35)			
Efficiency Scores 1	.81	.12	.45-1.00
Efficiency Scores 2	.91	.10	.64-1.00
Reported Attention (n=35)			
CBQ Attentional Focusing	5.13	1.16	2.33-6.67
Self Attentional Focusing	2.30	.82	.57-3.71
Reported Effortful Control (n=35)			

CBQ Effortful Control	5.30	.40	4.31-6.21
Self Effortful Control	2.46	.51	1.05-3.77
TMCQ Activation Control	3.87	.43	2.73-4.87
Self Activation Control	2.20	.61	.8-3.73

Summary Scores for Attention and Effortful Control Variables at 8-years

	Mean	SD	Range
Attention Task (n=35)			
Efficiency Scores 1	.80	.14	.56-1.00
Efficiency Scores 2	.90	.10	.67-1.00
Reported Attention (n=35)			
CBQ Attentional Focusing	4.99	1.14	2.33-6.83
Self Attentional Focusing	2.25	.88	.29-3.86
Reported Effortful Control (n=35)			
CBQ Effortful Control	5.24	.76	3.85-6.58
Self Effortful Control	2.45	.40	1.87-3.36
TMCQ Activation Control	3.96	.50	2.8-4.93
Self Activation Control	2.22	.66	.73-3.4

Table 2.4

Summary Scores for Visual Search Variables Across at All Ages

	Mean	SD	Range
Across Ages			
Visual Search Task (n=102)			
Reaction Time	38.39	13.57	20.38-85.67
6-years			
Visual Search Task (n=34)			
Reaction Time	44.37	12.46	25.21-78.70
7-years			
Visual Search Task (n=34)			
Reaction Time	36.75	12.4	23.37-85.67
8-years			
Visual Search Task (n=34)			
Reaction Time	34.17	13.99	20.38-82.25

Table 3.1.

Age Differences Among Study Variables

	6-year-olds Mean ±SD	7-year-olds Mean ±SD	8-year-olds Mean ±SD	F-value	p-value
VRM2 Reaction Time	2.77± 1.05 n=31	2.36±.69 n=30	2.3±3.2 n=27	.05	.02
Visual Search Reaction Time	44.37 n=34	36.75 n=34	34.39 n=34	5.89	.004

Table 3.2.

Correlations Between Fearfulness and Frontal Asymmetries during Baseline and Fear Video

	Baseline	Fear Video	Visual Search Task
		Fp1 / Fp2 Asymmetry	
CBQ Fear	.21*	.34**	.22*
Self Fear	.04	.14	.16
FSSC-R	.14	.22*	-.02
		F3 / F4 Asymmetry	
CBQ Fear	.20*	.28**	.18+
Self Fear	-.02	.009	.10
FSSC-R	.09	-.01	.09
		F7 / F8 Asymmetry	
CBQ Fear	-.06	-.06	-.11
Self Fear	-.20*	-.26*	-.11
FSSC-R	-.10	-.05	-.05

**p≤ .01; **p* ≤ .05; +p≤.08

Table 3.3

Correlations Between Search Fear Variables & Frontal Asymmetries during Search Task

	Fp1 / Fp2 Asymmetry	F3 / F4 Asymmetry	F7 / F8 Asymmetry
Across all Ages			
Search Task Reaction Time (n=99)	.01	-.05	.13
6-years			
Search Task Reaction Time (n=32)	.28	.16	.17
7-years			
Search Task Reaction Time (n=32)	.09	-.35*	-.30+
8-years			
Search Task Reaction Time (n=34)	-.27	.03	.25

Correlations between Search Fear Latencies and Baseline Frontal Asymmetries

	Fp1 / Fp2 Asymmetry	F3 / F4 Asymmetry	F7 / F8 Asymmetry
Across All Ages			
Search task Reaction Time (n=98)	.08	-.08	.03
6-years			
Search task Reaction Time (n=33)	.02	-.43*	.15
7-years			
Search task Reaction Time (n=33)	.28	.24	-.31+
8-yearss			
Search task Reaction Time (n=32)	-.11	-.04	-.01

Correlations between Search Fear Latencies and Fear Video Frontal Asymmetries

	Fp1 / Fp2 Asymmetry	F3 / F4 Asymmetry	F7 / F8 Asymmetry
Across All Ages			
Search task Reaction Time (n=98)	.12	.03	.1
6-years			
Search task Reaction Time (n=33)	-.04	.18	.08
7-years			
Search task Reaction Time (n=33)	.42*	.37*	-.09
8-years			
Search task Reaction Time (n=32)	-.07	-.11	.11

*$p \leq .05$; +$p \leq .08$

Table 3.4

Summary of Regression Analysis Predicting Fearfulness from Frontal Baseline and Fear Video EEG Asymmetry

Self Fear-Report (n=95)	b	SE b	β	t	p	sR^2
Step 1						
Baseline Asymmetry at F7/F8	-.46	.26	-.18	-1.77	.07	.03
Step 2						
Baseline Asymmetry at F7/F8	-.41	.46	-.16	-.90	.37	.01
Fear Asymmetry at F7/F8	-.07	.52	-.02	-.13	.90	.001

Note. Step 1 R^2 = .03, p=.07; Step 2 ΔR^2 = .00, p= .22

FSSC-R Fear (n=95)	b	SE b	β	t	p	sR^2
Step 1						
Baseline Asymmetry at F7/F8	1.48	6.40	.23	.23	.82	.0004
Step 2						
Baseline Asymmetry at F7/F8	23.88	11.03	.38	2.16	.03	.05
Task Asymmetry at F7/F8	30.78	12.5	.43	2.46	.02	.06

Note. Step 1 R^2 = .001, p=.82; Step 2 ΔR^2 = .06, p=.05

CBQ-SF Fear (n=100)	b	SE b	β	t	p	sR^2
Step 1						
Baseline Asymmetry at Fp1/Fp2	.93	.49	-.19	1.91	.059	.03
Step 2						
Baseline Asymmetry Fp1/p2	-.51	.80	-.10	-.63	.53	.004
Fear Asymmetry Fp1/Fp2	1.49	.67	.36	2.24	.03	.04

Note. Step 1 R^2 = .04, p=.059; Step 2 ΔR^2 = .05, p= .02

CBQ-SF Fear (n=100)	b	SE b	β	t	p	sR^2
Step 1						
Baseline Asymmetry at F3/F4	1.22	.40	.30	3.09	.003	.09
Step 2						
Baseline Asymmetry F3/F4	.23	.64	.06	.37	.72	.002
Fear Asymmetry F3/F4	1.25	.64	.30	1.96	.053	.04

Note. Step 1 R^2 = .09, p=.003; Step 2 ΔR^2 = .12, p= .002

Table 3.5.

Summary of Regression Analysis Predicting Visual Recognition Memory Performance From Visual Recognition Memory EEG

VRM1 Correct Old Recognition (n= 93)	b	SE b	β	t	p	sR^2
Familiarization F3/F4 Asymmetry	-3.11	1.84	-.17	-1.69	.09	.03

Note. Step 1 R^2 = .03, p<.09

VRM1 Correct Old Recognition (n= 93)	b	SE b	β	t	p	sR^2
Test F3/F4 Asymmetry	-3.49	1.72	-.21	-2.03	.05	.04

Note. Step 1 R^2 = .03, p<.09

VRM2 Correct new recognition (n=79)	b	SE b	β	t	p	sR^2
Test Fp1/Fp2 Asymmetry	-3.04	1.7	-.20	-1.76	.08	.04

Note. R^2 = .08, p=.04

VRM2 Correctly Identified (n= 79)	b	SE b	β	t	p	sR^2
Step1						
Familiarization Fp1/Fp2 Asymmetry	-1.04	3.06	-.04	-.34	.74	.002
Step2						
Familiarization Fp1/Fp2 Asymmetry	5.00	3.74	.18	1.34	.19	.02
Test Fp1/Fp2 Asymmetry	-9.04	3.45	-.36	-2.63	.01	.08

Note. Step 1 R^2 = .001, p<.74; Step 2 ΔR^2 = .08, p= .04

VRM2 Reaction Time (n= 75)	b	SE b	β	t	p	sR^2
Step 1						
Age	-.02	.11	-.20	-1.78	.08	.04
Step 2						
Age	-.02	.11	-.19	-1.71	.09	.04
Familiarization F7/F8 Asymmetry	.95	.38	.36	2.49	.02	.07
Test F7F/8 Asymmetry	-.74	.39	-.28	-1.91	.06	.04

Note. Step 1 R^2 = .04, p=.08; Step 2 ΔR^2 = .12, p= .03

Table 3.6.

Correlations Between Visual Recognition Memory 1 and Attention Measures

	Efficiency Scr1	Efficiency Scr 2	CBQ Att. Focusing	Self Att. Focusing
VRM1 (N=95)				
Reaction time	.17	.11	-.06	-.02
Total Identified	.01	.04	.25*	.03
Correct old recognition	.27**	.28**	-.003	-.02
Correct new recognition	-.20*	-.17	.23*	.05
False Positive	.20*	.17	-.18+	-.03
False Negative	-.27**	-.28**	-.05	-.001
VRM2 (N=84)				
Reaction time	-.11	-.08	-.03	-.003
Total Identified	.09	.06	.12	.23*
Correct old recognition	.05	.03	.23*	.13
Correct new recognition	.03	.06	-.12	.17
False Positive	-.03	-.06	.12	-.17
False Negative	-.05	-.03	-.23*	-.13

Correlations Between Visual Recognition Memory 1 and Effortful Control Measures

	CBQ Effort. Control	Self Effort. Control	TMCQ Act. Control	Self Act. Control
VRM1 (N=95)				
Reaction time	.07	-.04	.1	-.02
Total Identified	.27**	.002	.28*	.09
Correct old recognition	.25*	.14	.24*	.17
Correct new recognition	.13	-.13	.14	-.04
False Positive	-.24*	.13	-.19+	.003
False Negative	-.19+	-.17	-.24*	-.16
VRM2 (N=95)				
Reaction time	.07	-.04	.1	-.02
Total Identified	.05	.21*	.03	.11
Correct old recognition	.05	.08	.03	-.03
Correct new recognition	.03	.21*	.05	.21+
False Positive	-.03	-.21*	-.05	-.21+
False Negative	-.05	-.08	-.03	.03

$**p \leq .01$; $*p \leq .05$; $+p \leq .08$

Table 3.7

Summary of Moderation Regression Analysis

VRM2 Correct Identification (n= 82)	b	SE b	β	t	p	sR^2
Step 2						
Reported Self Fear	-1.5	.77	-.21	-1.95	.054	.04
Attention Efficiency Score 1	3.78	5.13	.08	.74	.46	.006
Interaction	11.18	5.92	.21	1.89	.06	.04

Note. Step 1 R^2 = .04, p=.21; Step 2 ΔR^2 = .08, p= .085

VRM2 Correct Identification (n= 84)	b	SE b	β	t	p	sR^2
Step 2						
CBQ-SF Fear	-1.17	.54	-.23	-2.16	.03	.05
Attention Efficiency Score 1	3.6	4.93	.08	.73	.47	.06
Interaction	11.97	4.26	.30	2.81	.006	.08

Note. Step 1 R^2 = .04, p=.22; Step 2 ΔR^2 = .12, p= .01

VRM2 Correct Old (n= 84)	b	SE b	β	t	p	sR^2
Step 2						
CBQ-SF Fear	-.74	.48	-.17	-1.56	.12	.03
Attention Efficiency Score 1	1.7	4.34	.04	.4	.7	.002
Interaction	9.31	3.74	.27	2.49	.02	.07

Note. Step 1 R^2 = .02, p=.51; Step 2 ΔR^2 = .08, p= .06

Table 3.8.

Summary of Moderation Regression Analysis

VRM1Correct Old (n= 92)	b	SE b	β	t	p	sR^2
Step 2						
Fp1/Fp2 Asymmetry	-.88	.88	-.1	-1.01	.32	.008
Attention Efficiency Score 1	-1.01	4.63	-.03	-.22	.83	.05
Interaction	17.93	6.41	.39	2.8	.006	.02

Note. Step 1 R^2 = .07, p=.03; Step 2 ΔR^2 = .15, p= .002

VRM1 Reaction Time (n= 83)	b	SE b	β	t	p	sR^2
Step 2						
F7/F8 Asymmetry	.26	.18	.16	1.5	.14	.03
Attention Efficiency Score 2	-.9	1.4	-.11	-.64	.52	.005
Interaction	3.45	1.78	.33	1.94	.056	.04

Note. Step 1 R^2 = .05, p=.1; Step 2 ΔR^2 = .1, p= .04

Table 3.9.

Correlations between Attention and Effortful Control

	1	2	3	4	5	6	7
1. CBQ Att. Focusing	-						
2. CBQ Effort. Control	.62**	-					
3. TMCQ Act. Control	.18+	.37**	-				
4. Self Att. Focusing	.16	.17+	.17+	-			
5. Self Effort. Control	-.04	.11	.18+	.53**	-		
6. Self Act. Control	.06	.08	.23*	.39**	.56**	-	
7. Efficiency Scr1	-.04	.12	,05	,22*	.29**	.08	-
8. Efficiency Scr 2	-.04	.04	.13	.15	.17+	-.01	.76**

**$p \leq$ .01; *$p \leq$ .05; +$p \leq$ .087

Table 3.10.

VRM1 Correct Identification (n= 92)	b	SE b	β	t	p	sR^2
Step 2						
Self Fear Group	-1.34	1.47	-.09	-.92	.36	.008
CBQ-SF Effortful Control	5.15	1.82	.40	2.83	.006	.08
Interaction	-4.28	2.55	-.24	-1.68	.097	.03

Note. Step 1 R^2 = .06, p=.05; Step 2 ΔR^2 = .09, p= .04

VRM1 Correct Identification (n= 95)	b	SE b	β	t	p	sR^2
Step 2						
CBQ-SF Fear Group	.45	1.41	-.03	-.32	.75	.003
CBQ-SF Effortful Control	7.5	1.76	.59	4.27	.000	.02
Interaction	-7.70	2.4	-.45	-3.21	.002	.09

Note. Step 1 R^2 = .07, p=.03; Step 2 ΔR^2 = .16, p= .001

VRM1 Correct Old (n= 95)	b	SE b	β	t	p	sR^2
Step 2						
Self Fear Group	-.43	.57	-.07	-.76	.45	.005
CBQ-SF Effortful Control	2.86	.89	.31	3.23	.002	.1
Interaction	-2.28	1.05	-.21	-2.17	.03	.04

Note. Step 1 R^2 = .1, p=.01; Step 2 ΔR^2 = .14, p= .003

VRM1 Correct Identification (n= 92)	b	SE b	β	t	p	sR^2
Step 2						
FSSC-R/P Group	-3.53	1.49	-.23	-2.37	.02	.05
TMCQ Activation Control	1.02	1.49	.06	.51	.61	.003
Interaction	6.77	3.35	.25	2.02	.04	.04

Note. Step 1 R^2 = .13, p=.001; Step 2 ΔR^2 = .17, p= .001

Table 3.11.

VRM1 Correct Identification (n= 88)	b	SE b	β	t	p	sR^2
Step 2						
Fear F7/F8 Asymmetry	-3.76	2.24	-.16	-1.68	-.96	.03
CBQ-SF Effortful Control	5.98	1.35	.44	4.42	.000	.2
Interaction	-13.4	4.37	-.31	-3.07	.003	.08

Note. Step 1 R^2 = .13, p=.002; Step 2 ΔR^2 = .22, p= .000

VRM1 Correct New (n= 88)	b	SE b	β	t	p	sR^2
Step 2						
Fear F7/F8 Asymmetry	-2.32	1.79	-.13	.2	.02	.04
CBQ-SF Effortful Control	3.35	1.08	.32	3.1	.003	.1
Interaction	-11.34	3.49	-.34	-3.25	.002	.1

Note. Step 1 R^2 = .05, p=.09; Step 2 ΔR^2 = .16, p= .002

VRM2 Correct Identification (n= 80)	b	SE b	β	t	p	sR^2
Step 2						
Fear Fp1/Fp2 Asymmetry	-5.94	2.54	-.25	-2.34	.02	.06
TMCQ Activation Control	.96	1.58	.07	.61	.55	.005
Interaction	-14.02	6.43	-.24	-2.18	.03	.05

Note. Step 1 R^2 = .05, p=.13; Step 2 ΔR^2 = .1, p= .03

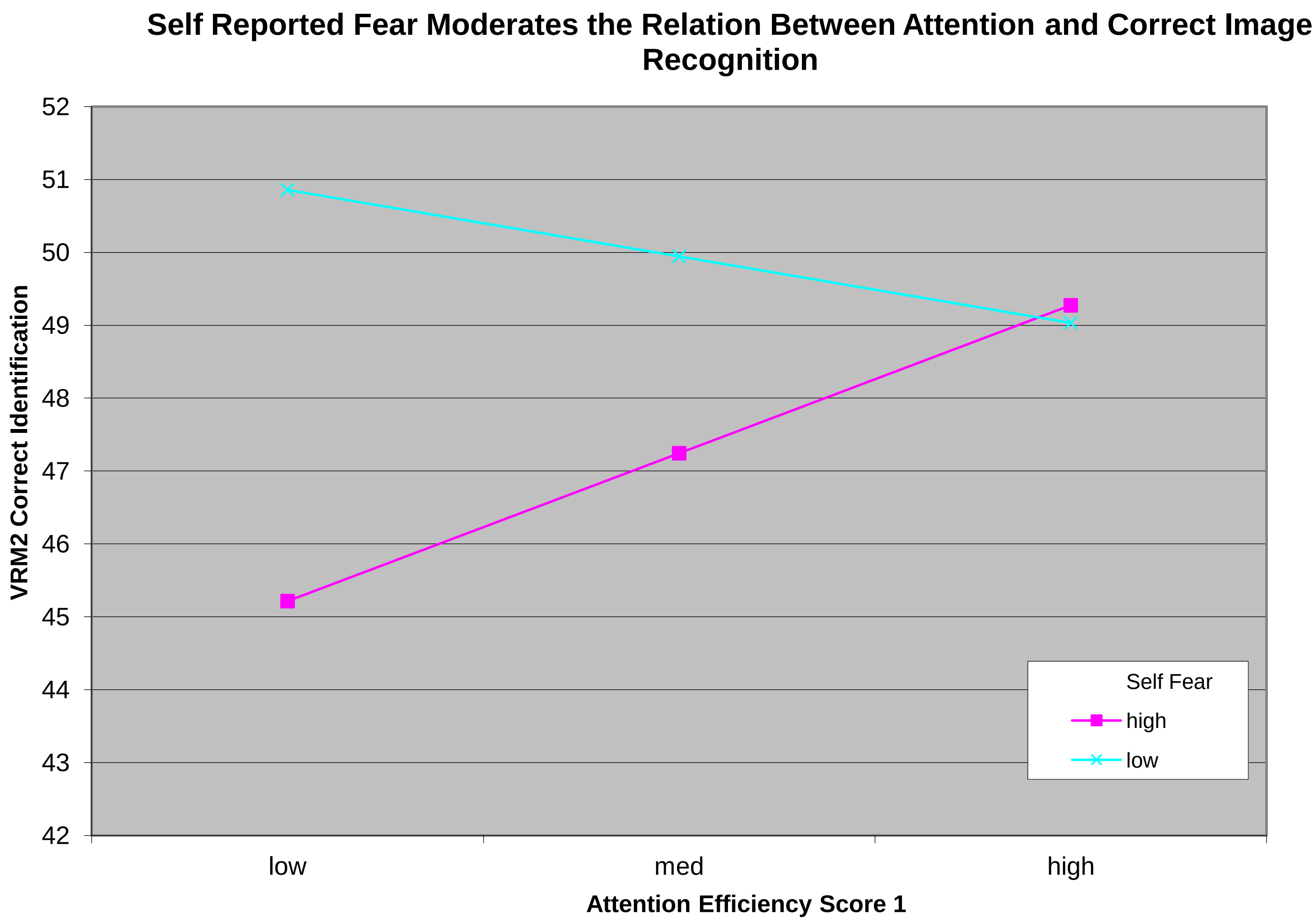
VRM2 Correct Old (n-80)	b	SE b	β	t	p	sR^2
Step 2						
Fear Fp1/Fp2 Asymmetry	-2.78	1.24	-.24	-2.24	.03	.06
TMCQ Activation Control	3.54	2.09	.28	1.7	.09	.03
Interaction	-5.7	2.75	-.35	-2.08	.04	.05

Note. Step 1 R^2 = .05, p=.13; Step 2 ΔR^2 = .1, p= .04

VRM2 Correct Old (n= 78)	b	SE b	β	t	p	sR^2
Step 2						
Fear F7/F8 Asymmetry	-3.42	1.86	-.20	-1.84	.07	.04
CBQ-SF Effortful Control	1.95	1.15	.20	1.69	.095	.03
Interaction	-6.42	3.61	-.21	-1.78	.079	.03

Note. Step 1 R^2 = .05, p=.16; Step 2 ΔR^2 = .08, p= .079

Figure 3.1.



Self Reported Fear Moderates the Relation Between Attention and Correct Image Recognition
VRM2 Correct Identification
52
51
50
49
48
47
46
45
44
43
42
low
med
high
Attention Efficiency Score 1
Self Fear
high
low

Figure 3.2.

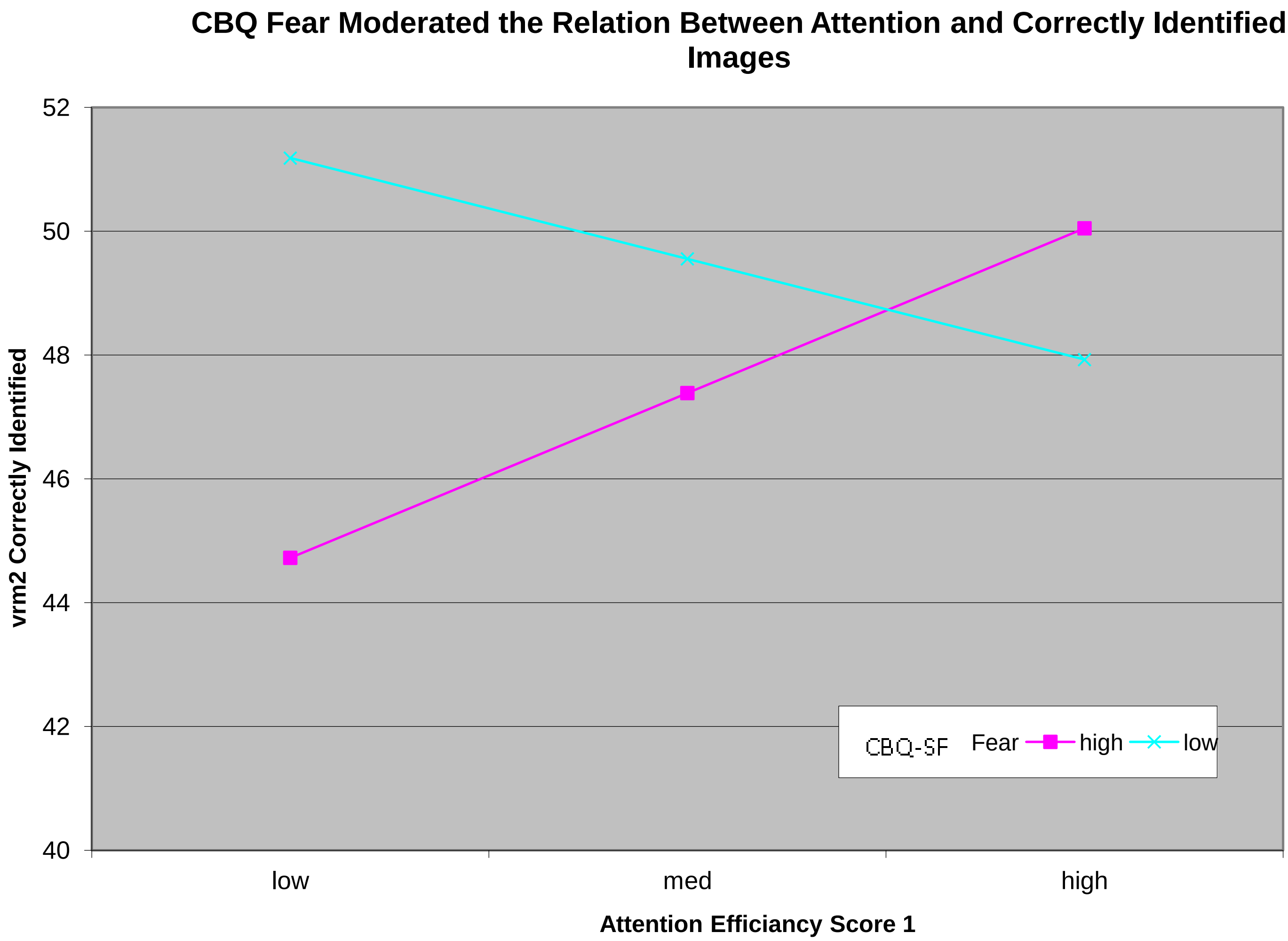

CBQ Fear Moderated the Relation Between Attention and Correctly Identified Images
52
50
48
46
44
42
40
vrm2 Correctly Identified
CBQ-SF Fear
high
low
low
med
high
Attention Efficiancy Score 1

Figure 3.3.

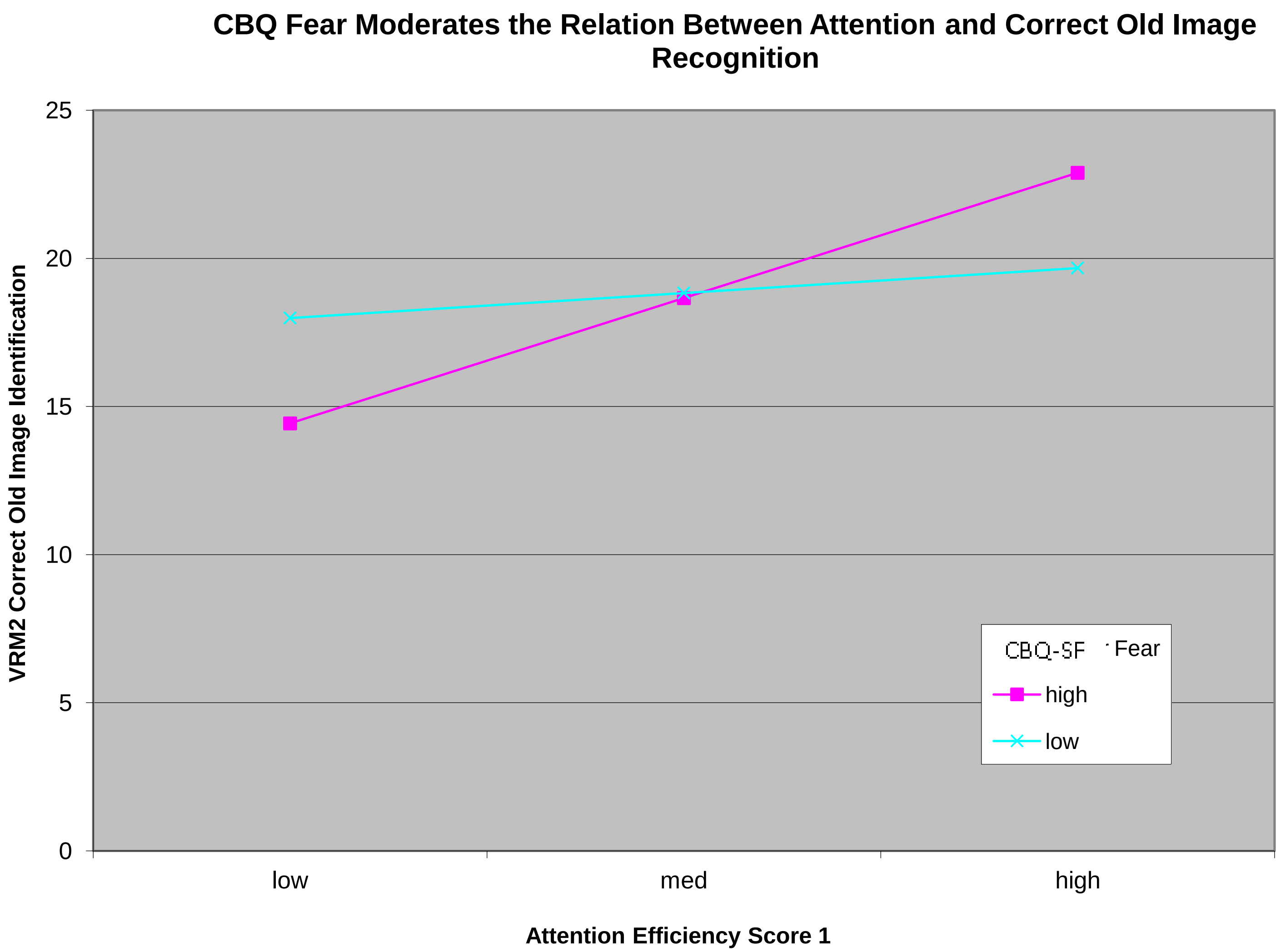

CBQ Fear Moderates the Relation Between Attention and Correct Old Image Recognition
VRM2 Correct Old Image Identification
25
20
15
10
5
0
low
med
high
Attention Efficiency Score 1
CBQ-SF Fear
high
low

Figure 3.4.

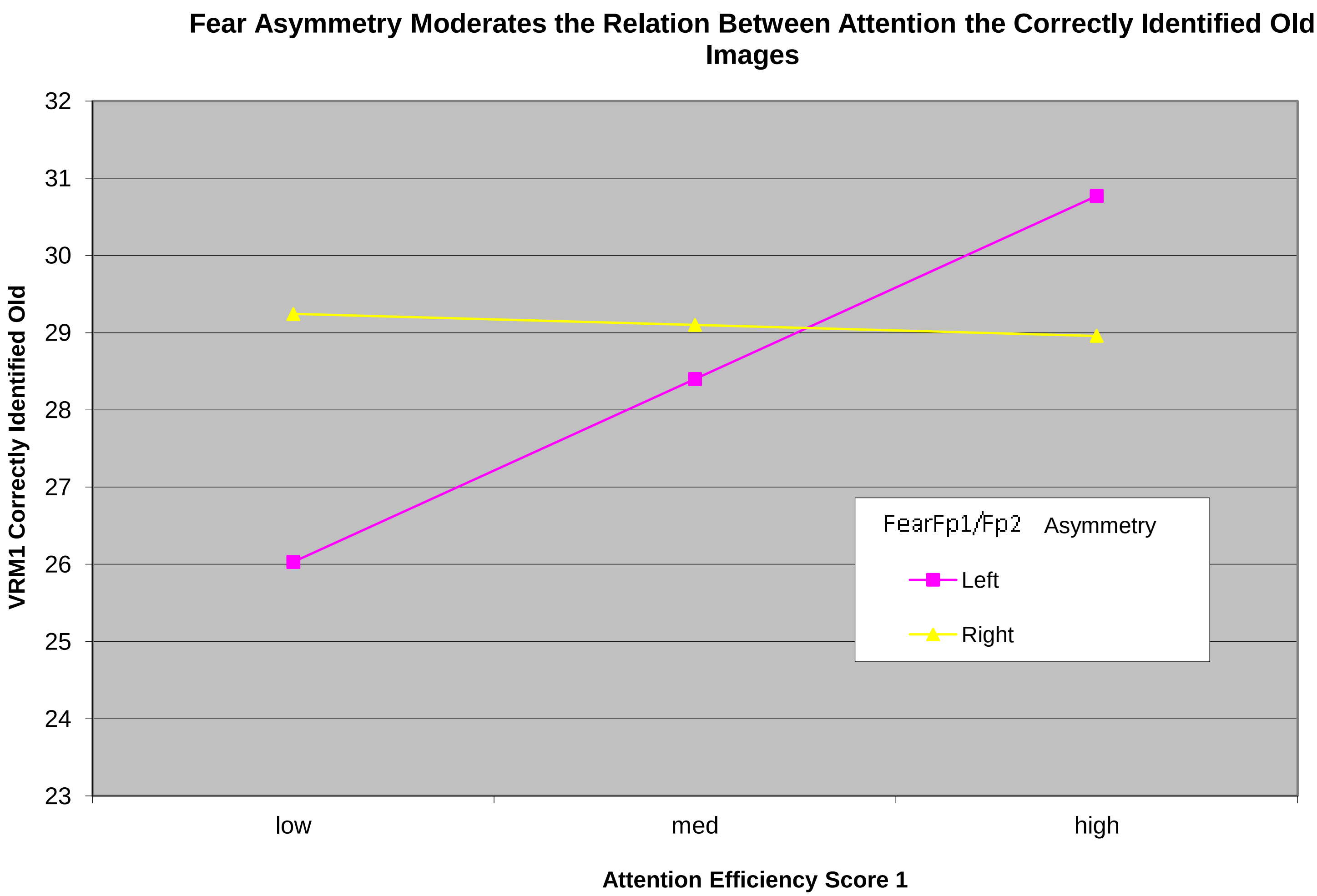

Fear Asymmetry Moderates the Relation Between Attention the Correctly Identified Old Images
VRM1 Correctly Identified Old
32
31
30
29
28
27
26
25
24
23
low
med
high
Attention Efficiency Score 1
FearFp1/Fp2 Asymmetry
Left
Right

Figure 3.5.

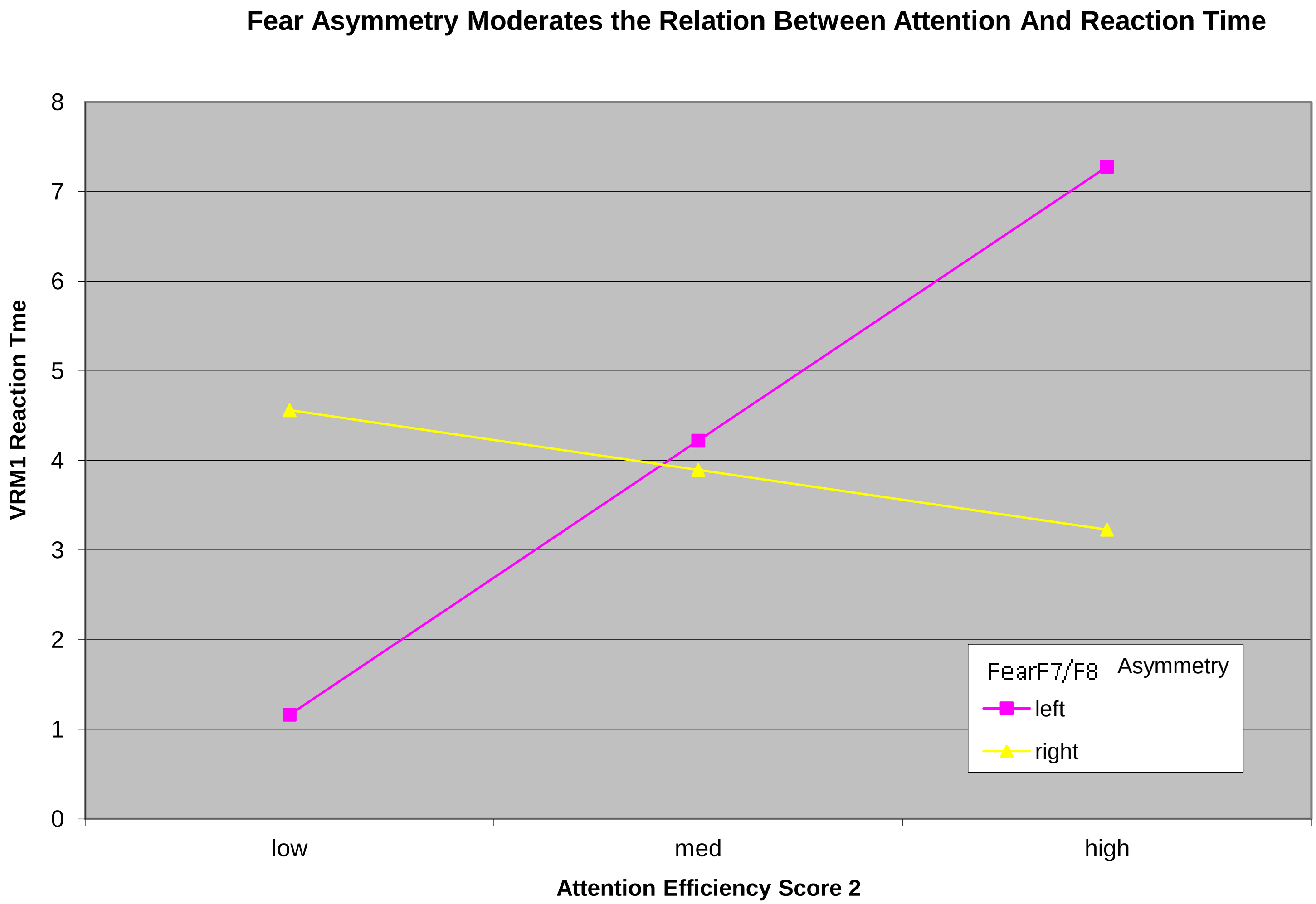

Fear Asymmetry Moderates the Relation Between Attention And Reaction Time
8
7
6
5
4
3
2
1
0
VRM1 Reaction Tme
low
med
high
Attention Efficiency Score 2
FearF7/F8 Asymmetry
left
right

Figure 3.6.

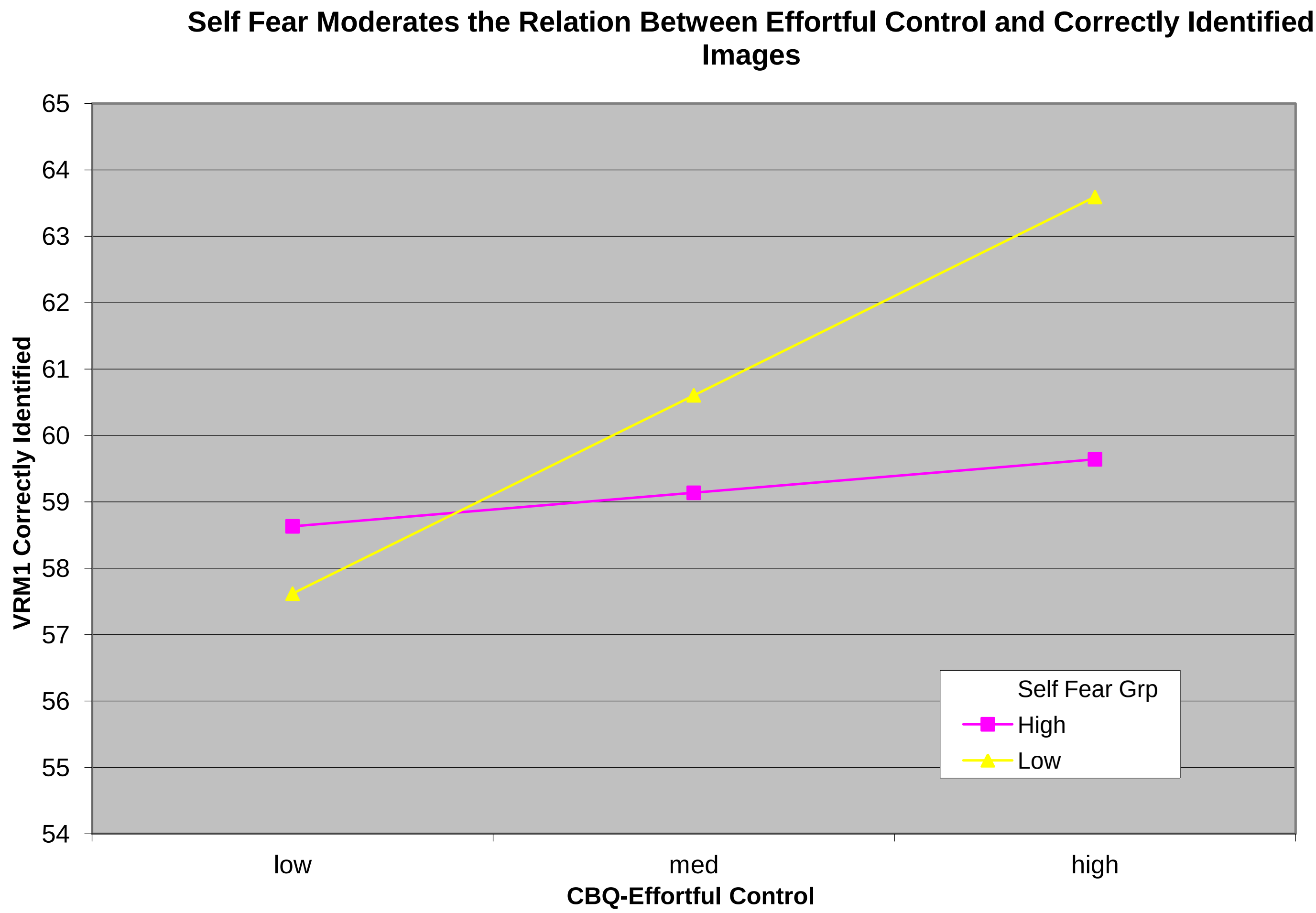

Self Fear Moderates the Relation Between Effortful Control and Correctly Identified Images
VRM1 Correctly Identified
65
64
63
62
61
60
59
58
57
56
55
54
low
med
high
CBQ-Effortful Control
Self Fear Grp
High
Low

Figure 3.7.

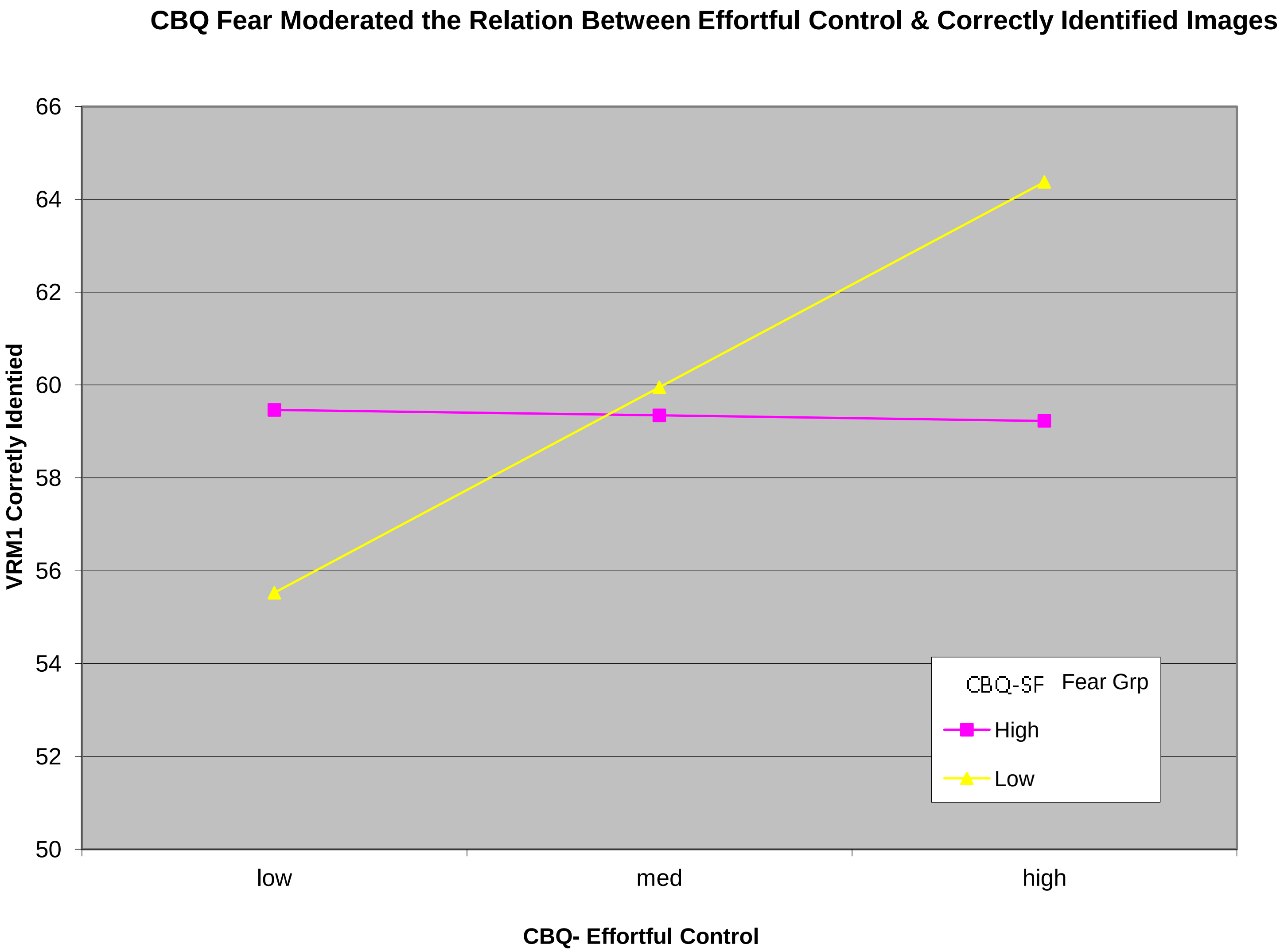

CBQ Fear Moderated the Relation Between Effortful Control & Correctly Identified Images
66
64
62
60
58
56
54
52
50
VRM1 Corretly Identied
low
med
high
CBQ- Effortful Control
CBQ-SF Fear Grp
High
Low

Figure 3.8.

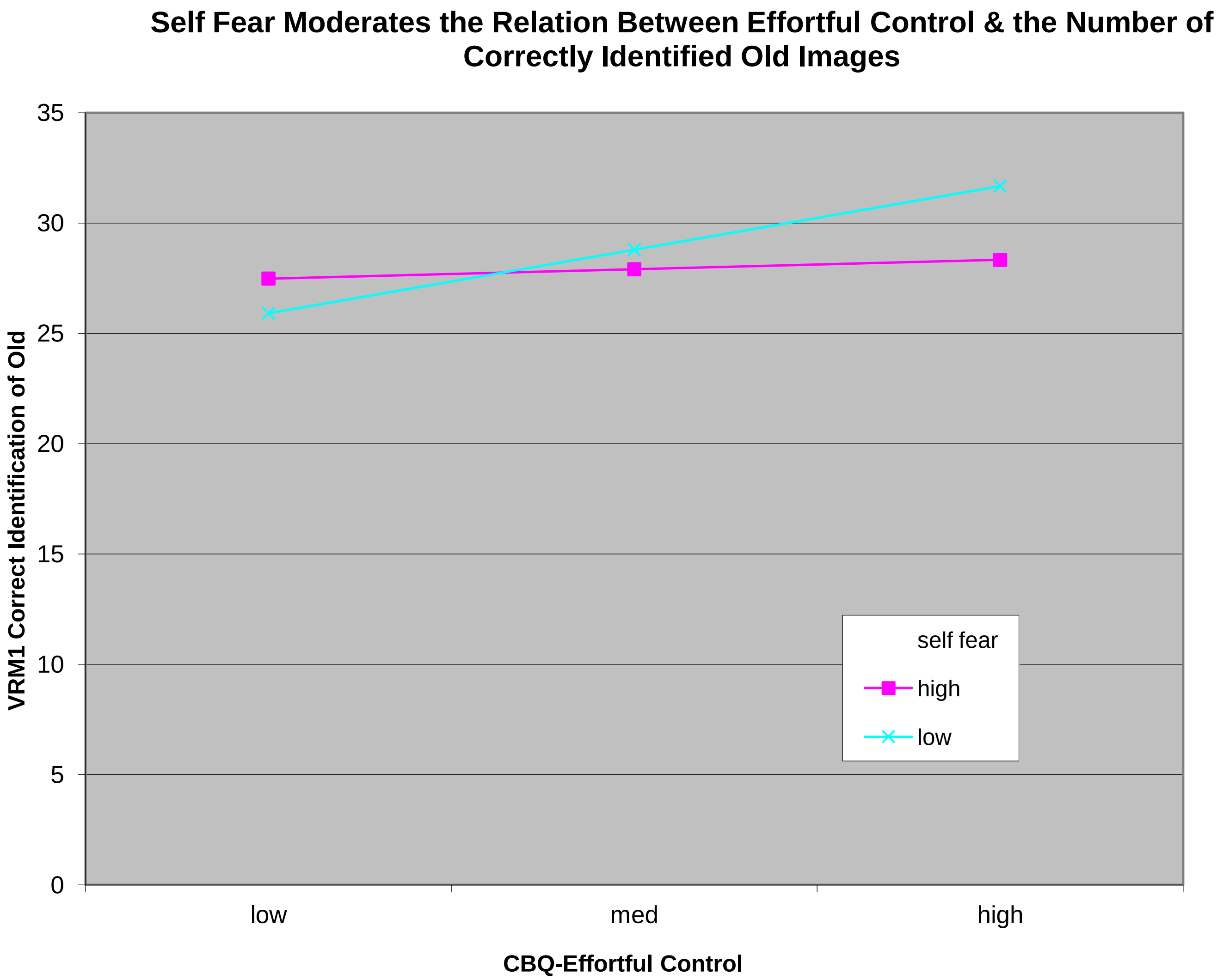

Self Fear Moderates the Relation Between Effortful Control & the Number of Correctly Identified Old Images
35
30
25
20
15
10
5
0
VRM1 Correct Identification of Old
low
med
high
CBQ-Effortful Control
self fear
high
low

Figure 3.9.

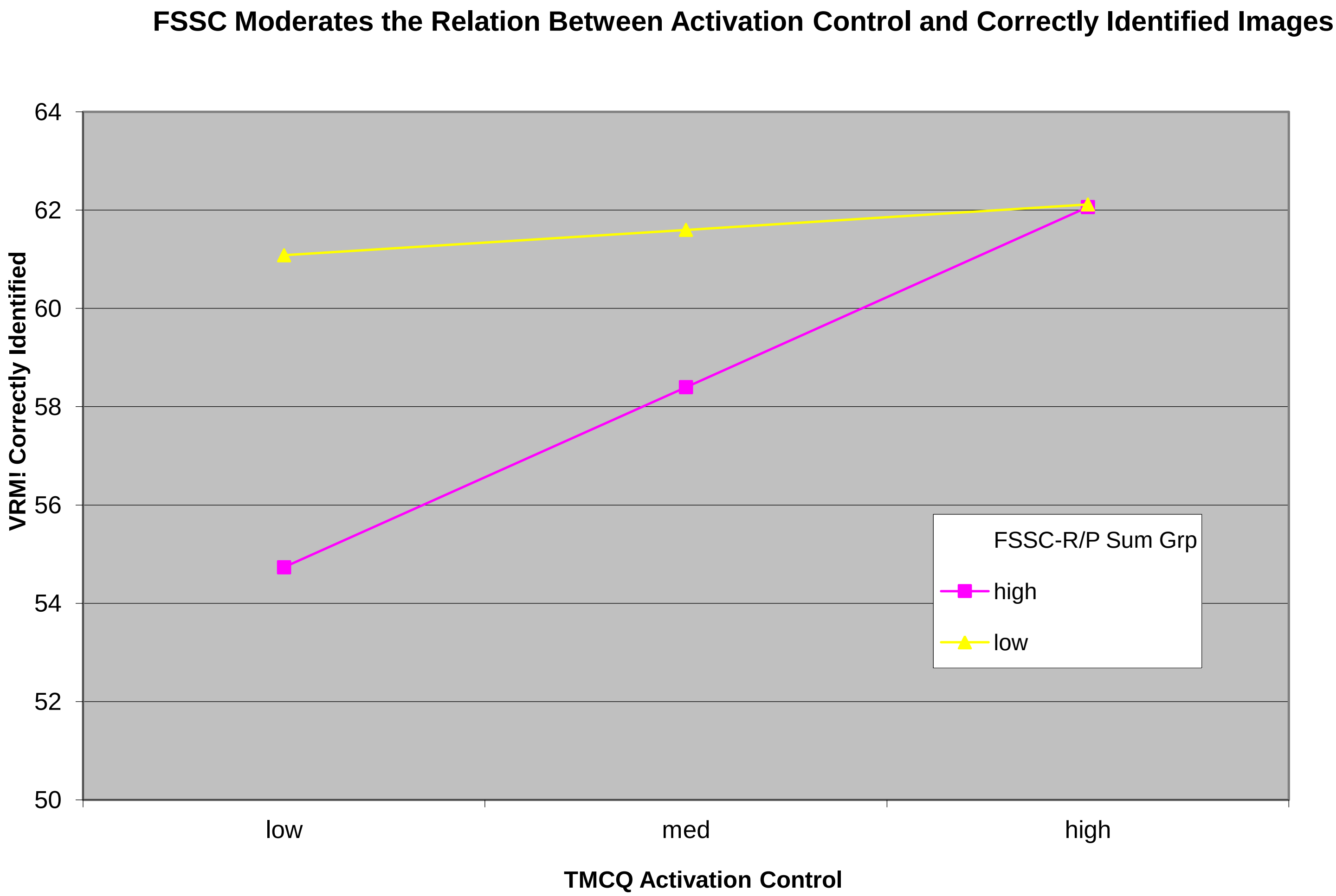

FSSC Moderates the Relation Between Activation Control and Correctly Identified Images
64
62
60
58
56
54
52
50
VRMI Correctly Identified
low
med
high
TMCQ Activation Control
FSSC-R/P Sum Grp
high
low

Figure 3.10.

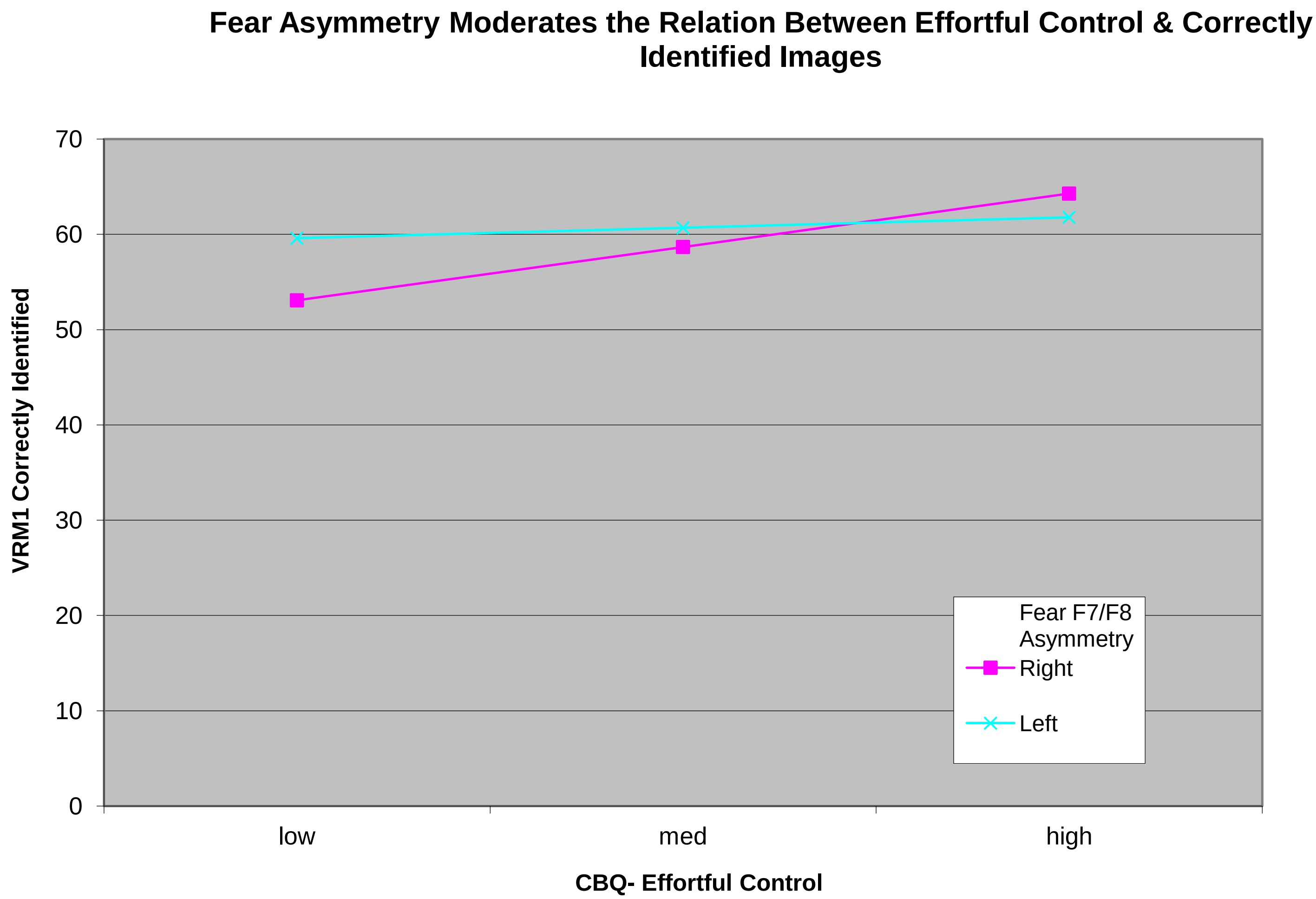
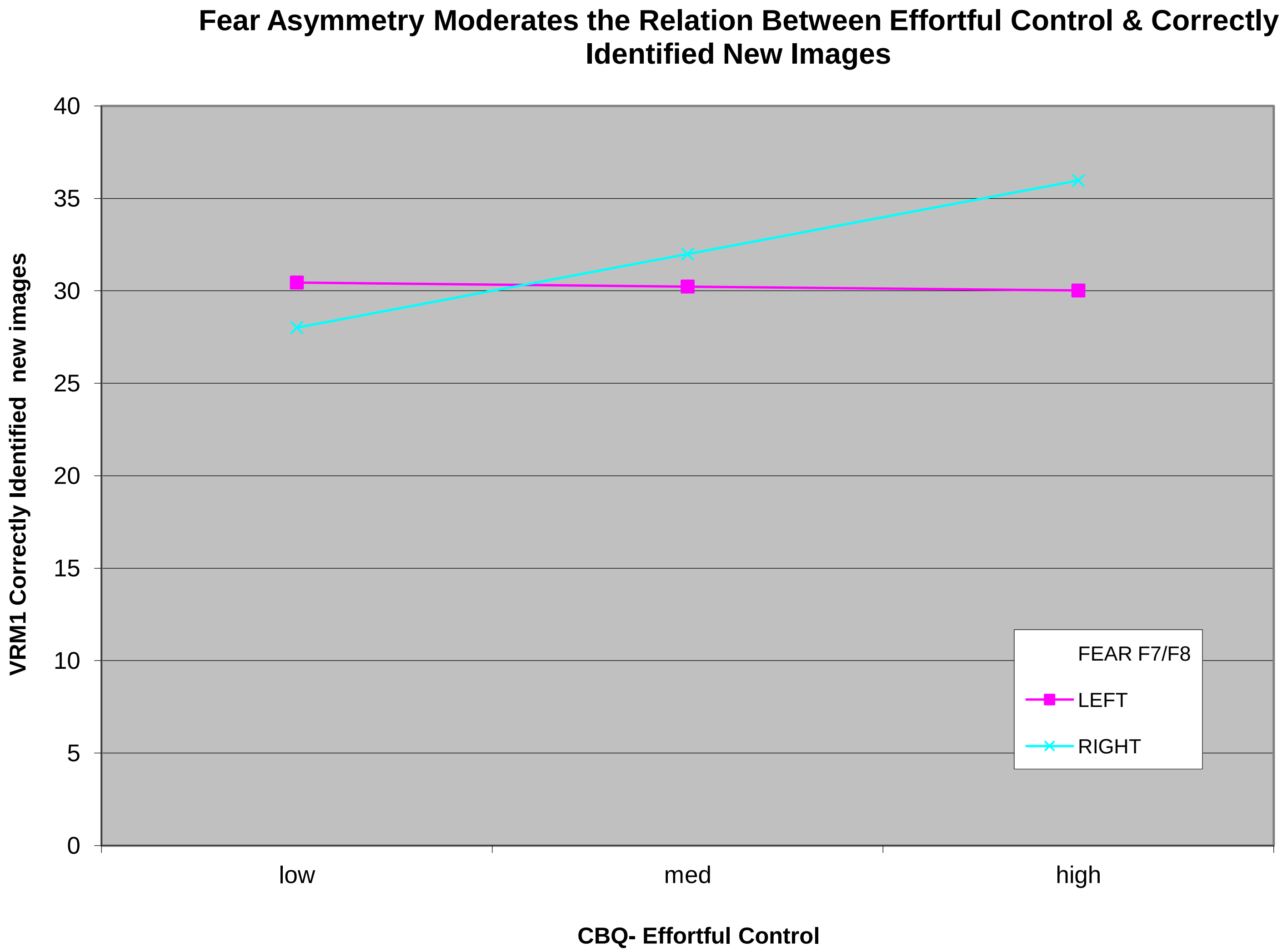

Fear Asymmetry Moderates the Relation Between Effortful Control & Correctly Identified Images
VRM1 Correctly Identified
70
60
50
40
30
20
10
0
low
med
high
CBQ- Effortful Control
Fear F7/F8 Asymmetry
Right
Left

Figure 3.11.



Fear Asymmetry Moderates the Relation Between Effortful Control & Correctly Identified New Images
VRM1 Correctly Identified new images
40
35
30
25
20
15
10
5
0
low
med
high
CBQ- Effortful Control
FEAR F7/F8
LEFT
RIGHT

Figure 3.12.

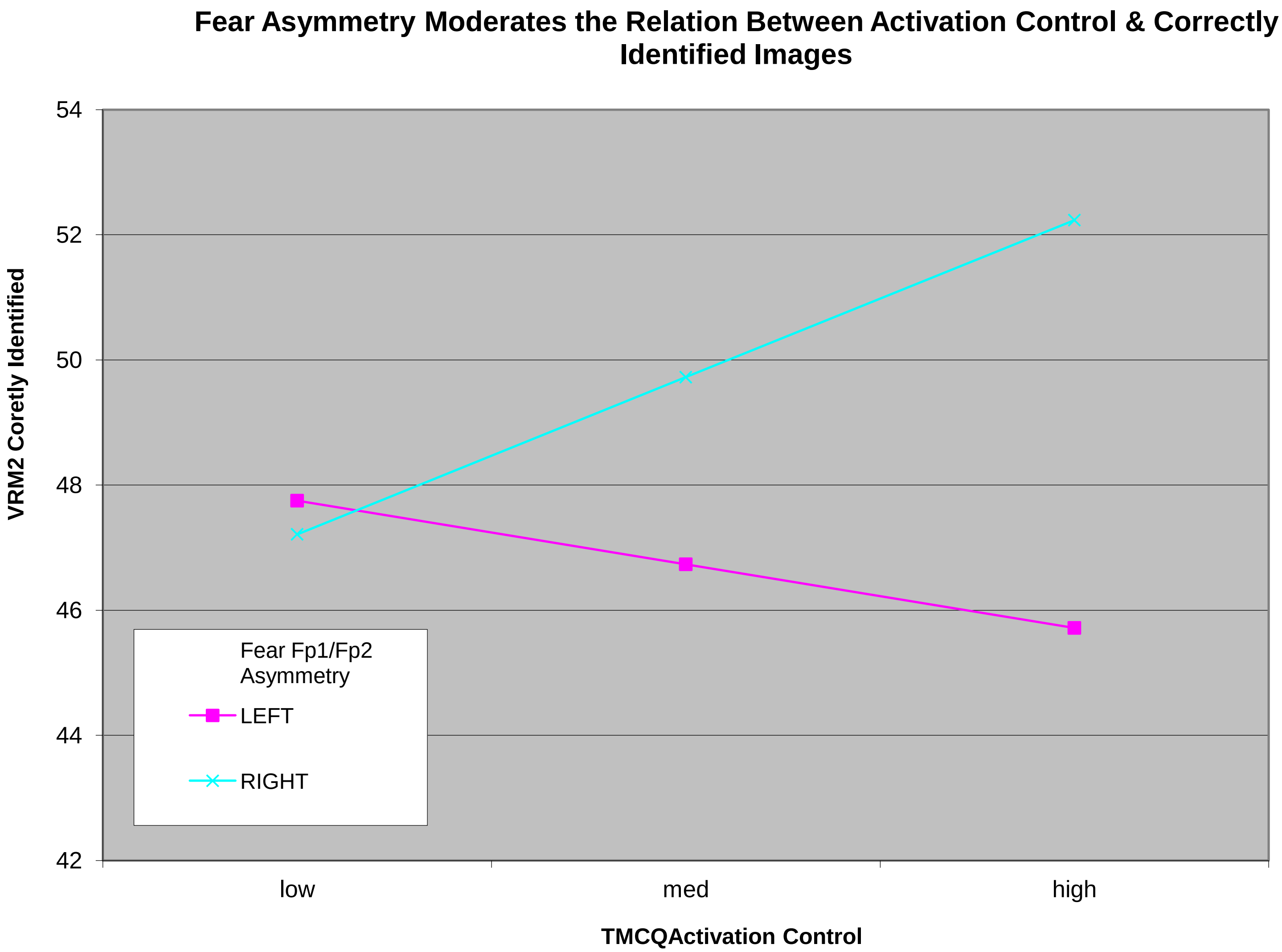

Fear Asymmetry Moderates the Relation Between Activation Control & Correctly Identified Images
VRM2 Coretly Identified
54
52
50
48
46
44
42
Fear Fp1/Fp2 Asymmetry
LEFT
RIGHT
low
med
high
TMCQActivation Control

Figure 3.13.

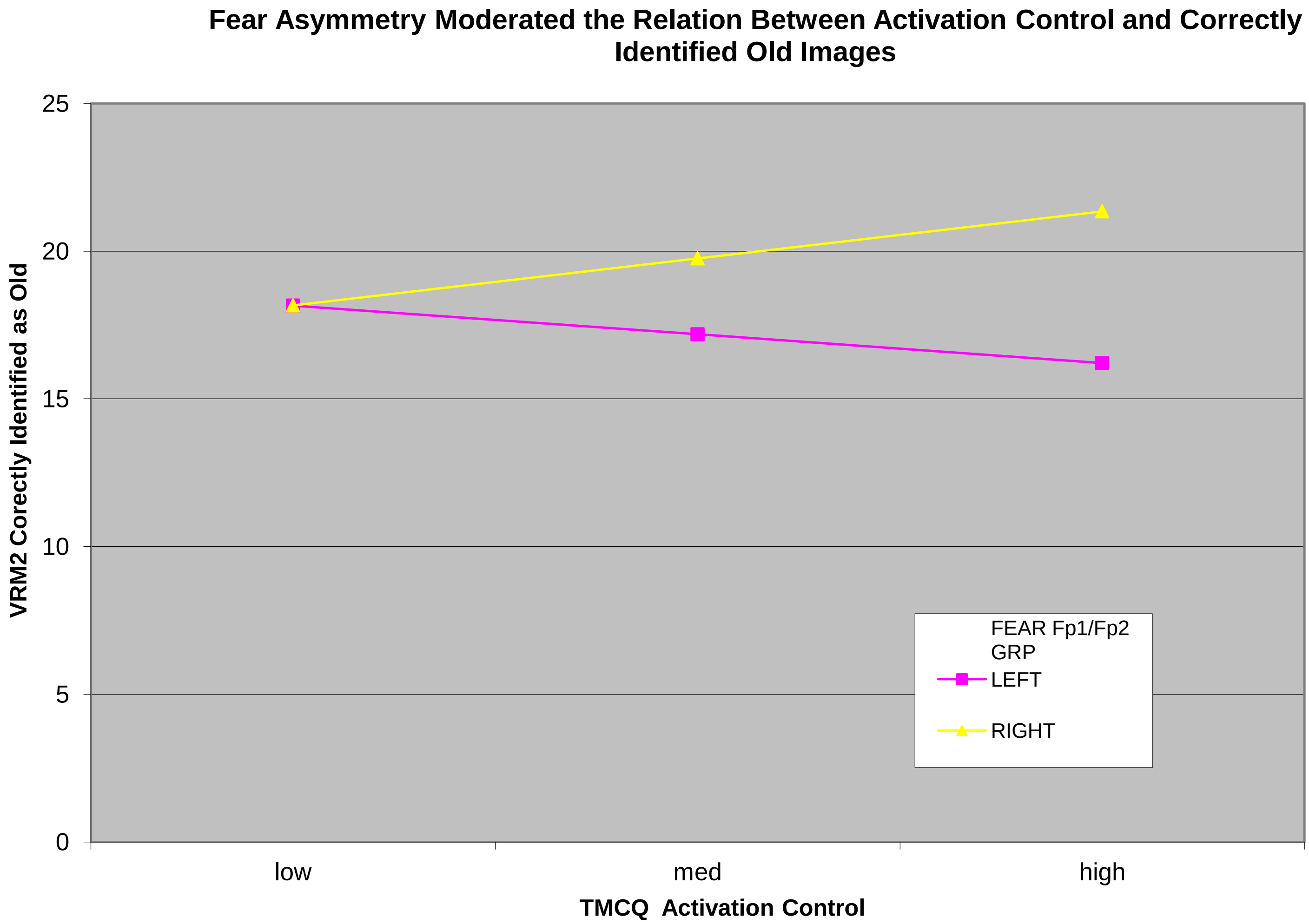
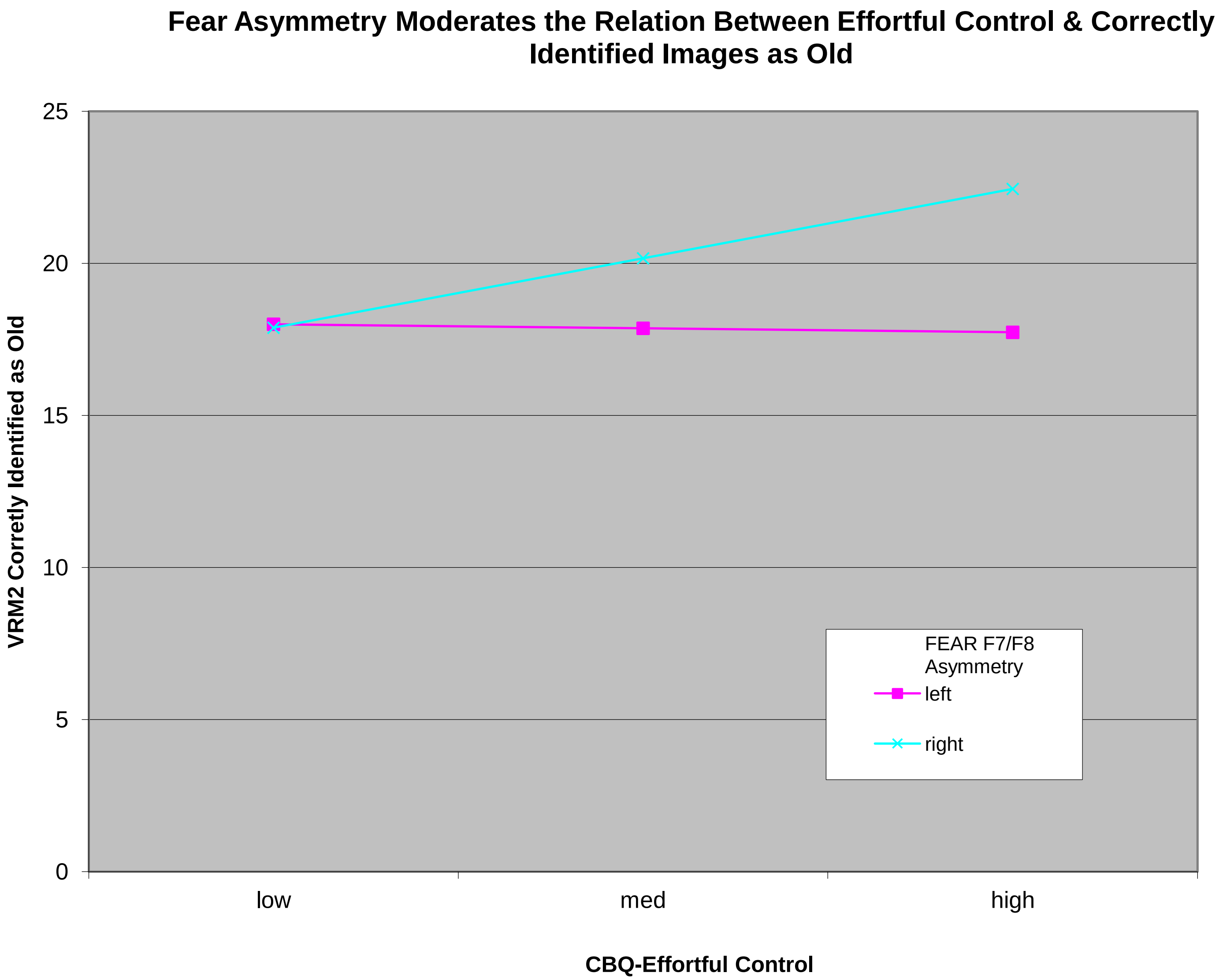

Fear Asymmetry Moderated the Relation Between Activation Control and Correctly Identified Old Images
VRM2 Corectly Identified as Old
25
20
15
10
5
0
low
med
high
TMCQ Activation Control
FEAR Fp1/Fp2 GRP
LEFT
RIGHT

Figure 3.14.



Fear Asymmetry Moderates the Relation Between Effortful Control & Correctly Identified Images as Old
VRM2 Corretly Identified as Old
25
20
15
10
5
0
low
med
high
CBQ-Effortful Control
FEAR F7/F8 Asymmetry
left
right

Appendix A

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
Parent Consent Form

Title of Thesis Project: "**Temperament Differences in Emotion Regulation in Infancy and Childhood: Frontal EEG Asymmetry and Memory**"

Researchers: Martha Ann Bell, PhD. and Anjolii Diaz

I. Purpose of this Research

You and your child are invited to be a part of a research study investigating memory and emotion regulation from 6 to 8 years of age. Specifically, we are examining how brainwave activity and heart rate activity associated with child temperament relate to the strategies children have for inhibiting a dominant response, remembering previously seen objects and faces, and detecting novelty.

What we learn from this study will help us better understand how these important skills emerge and begin to develop during childhood. A total of 105 6 to 8 year-olds will be participating in this study.

II. Procedures

You and your child will be asked to visit The C.A.P. Lab (350 Williams Hall) at Virginia Tech for approximately 90 minutes. Your child will be asked to sit in front of a table either in front of a television or a computer with you sitting nearby. The entire session will be videotaped. This study also involves three questionnaires (Child Temperament Questionnaire, Emotion Regulation Checklist, Fear Survey Schedule for Children-Revised and the Adult Temperament Questionnaire).We would asked you to try to complete these forms at home prior to your child's visit to our research lab. We would also ask you and your child to do the Temperament Middle Childhood Questionnaire and Development Questionnaire during the visit.

A little yellow cap that helps us to collect brainwave activity will be placed on your child's head. This cap looks and fits like a little swim cap. In order to collect brain-wave activity, gels will be applied to your child's hair through little holes in the cap. Two small stickers will be placed on your child's back to help us collect heart rate activity. These procedures are similar to those used in a doctor's office and are not harmful to your child. Brainwave activity and heart rate activity will be recorded during the entire research session.

We will play three memory games with your child. First we will show your child novel objects and faces on a touch screen computer monitor. After a delay we will as ask them to remember which ones they have seen before and which ones are new by pressing the words "new" or "old" on the screen. Next, we will observe how your child searches for a hidden object on an 11' x 18' page containing distracters. This task is analogous to the game of i-SPY. Lastly, your child will be presented with a row of digits and will be asked to count the number of digits presented. The emotion regulation games come next. First, children will be asked to locate either a single snake or caterpillar among eight flower images on a computer or the lone flower among eight snakes or caterpillars. None of the images will be depicted in a threatening pose. Children will also be asked to find a snake among eight caterpillars or the lone caterpillar among eight snakes. Finally, your child will be seated in front of the TV set, and asked to watch a total of four film clips. The clips will show slowly turning shapes in different colors, a fragment of the film "Dinosaur", an animation production of Walt Disney and another one depicting colorful objects moving in a slow rhythm. If your child protests by crying continuously for 15 seconds during any of these emotion tasks, we will stop the task and ask you to comfort your child.

After these recordings, the cap and sticky patches will be removed and the gel will be washed from your child's hair with warm water and a clean washcloth.

III. Risks

There is minimal risk associated with this research project. The brainwave and heart rate procedures are similar to that done in a doctor's office and are not harmful. All brain-wave equipment is disinfected after each use. The heart rate equipment is disposable. If your child has an allergy to skin lotions, please inform us so that we can discuss the allergy and determine if any procedural changes need to be made. Our EEG gels are water based and contain the same preservatives that are used in everyday skin lotions.

IV. Benefits of This Research

There are no tangible benefits for you or your child. No promise or guarantee of benefits has been made to encourage you and your child to participate in this study. In a scientific sense, however, this research study will give psychologists more information about the development of emotion and memory during childhood.

V. Extent of Confidentiality

Information gathered for this study will be confidential and the information from each individual child will be identified by code number only. Information linking child's name and code number will be kept in a file and locked in a file drawer. Only my professor Dr. Bell and I will have access to the file. Your child will be videotaped during the lab procedure. This allows us to go back at a later date and code your child's behaviors. Videotapes will identify childrens only by code number. Tapes will be stored in the research lab and will not be accessible to anyone else. Dr. Bell will supervise the confidentiality of the videotapes. Tapes will be erased 5 years after final publications of the results of this study.

If the Investigator (Dr. Bell) should ever become concerned that your child has a developmental delay, you will be told of the concerns. You will be given a list of referrals who will provide your family with a developmental screening of your child. If at any time during the study you request help in dealing with a child, Dr. Bell will provide referrals of both private and public agencies that offer assistance.

Also, if at any time there is a concern that your child is in danger due to abuse or neglect, the Investigator (Dr. Bell) will, after informing you, be obligated to contact the Department of Social Services and report the concern. This is in compliance with the mandatory reporting laws of the state of Virginia.

VI. Compensation

At the end of the session, your child will be given a $5 gift card to Books A Million. Also, your name will be entered into a drawing for a $50.00 gift certificate to a local store of your choice.

VII. Freedom to Withdraw

You may also elect to withdraw your child from participation at any time without penalty. Your child will still be given the toys, and your name will still be entered into the drawing for the gift certificate.

VIII. Approval of Research

This research project has been approved, as required, by the Institutional Review Board for Research Involving Human Subjects at VPI&SU and by the Department of Psychology at Virginia Tech.

IX. Parent's Responsibilities

You will be asked to transport and accompany your child to the research laboratory for this visit. We also ask that you complete the questionnaires.

X. Parent's Permission

I have read and understand the Informed Consent and conditions of this research study. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent for my child to participate in this project. I understand that I may withdraw my child from participation at any time without penalty. I understand that I will be given a copy of this consent form.

_______________________________________ _____________________

Parent's signature Date

Should I have any questions about this study, I may contact:

1) Anjolii Diaz
   Co-Investigator, Graduate student, 540-604-4406, adiaz07@vt.edu
1) Martha Ann Bell, Ph.D.
   Principal Investigator, Associate Professor of Psychology, 231-2546, mabell@vt.edu
2) David W. Harrison, Ph.D.
   Chair, Psychology Department Human Subjects Committee, 231-4422, dwh@vt.edu
3) David Moore, Ph.D.
   IRB Chair, 1880 Pratt Drive, Suite 2006, Blacksburg, VA 24060, 231-4991, moored@vt.edu

Photographer's Release (optional)

I understand that the photographs taken of my child are the property of Virginia Tech. These photographs will be used to illustrate Department of Psychology research at professional conferences, in professional publications, and/or in university/departmental literature (print and internet).

_____________________________________ _______________________

Parent's signature Date

Appendix B

Child Assent Form

Title of Thesis Project:“Temperament Differences in Emotion Regulation in Infancy and Childhood: Frontal EEG Asymmetry and Memory”

Researchers: Martha Ann Bell, Ph.D., and Anjolii Diaz

I. Explanation of Research to Child
We’re going to play some fun games today. We will be playing all these games in this room. Some of the games are memory games and some are picture games. For these games, you will get to wear our cool cap that looks like this (shows EEG cap to child). At any time you can decide to stop playing these games. Just tell us, and we will stop.

II. Asking for Child’s Verbal & Written Assent
Are you ready to play? Shall we get the games ready?

III. Witness Affirmation
The child verbally agreed to participate in this research study and signed their name. I understand that the parent will receive a copy of this assent form.

____
Child’s name

____
Child’s Signature

______________________________ ____________________
Signature of witness Date