# Attention Bias in Middle Childhood: The Impact of Effortful Control and Temperament

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ABSTRACT

Identifying whether a stimulus is threatening or not is critical for staying safe. The faster one can detect a threat, the greater chance there is to avoid any potential danger. Factors contributing to the visual attention of threat are therefore informative. Previous research has examined how aspects of temperament and effortful control interact and affect the attention allocated to threats, especially in clinically anxious populations. However, there is a sparsity of this literature existing for nonclinical populations. My study addressed previous gaps by examining whether negative affect and fear impact an attention bias to threat in children aged 6 through 8 while assessing how attentional control and inhibitory control moderate these relations. A modified visual search task with snakes as the threat was given to the participants after the children's parents completed questionnaires and the children completed an attentional control task. Results showed that an attentional bias to snakes was seen in the sample. Negative affect as a main effect nor as an interaction effect with attentional control predicted for the attention bias to snakes. Fear predicted for the attention bias to snakes as a main effect. Interestingly, inhibitory control moderated the relation between fear and the attention bias to snakes. Only children with high inhibitory control and high fear predicted for the attention bias to snakes. Findings may indicate children with this temperament are more vulnerable to the onset of anxiety.

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GENERAL AUDIENCE ABSTRACT

Identifying whether a stimulus is threatening or not is critical for staying safe. The faster one can detect a threat, the greater chance there is to avoid any potential danger. Factors contributing to the visual attention of threat are therefore informative. Previous research has examined how aspects of temperament and effortful control interact and affect the attention allocated to threats, especially in clinically anxious populations. However, there is a sparsity of literature existing for nonclinical populations. My study addressed previous gaps by examining whether aspects of temperament, specifically negative affect and fear, impact an attention bias to threat in children aged 6 through 8 while assessing how aspects of effortful control, specifically attentional control and inhibitory control, moderate these relations. A visual search task where participants would select a target among distractors with snakes as the target representing threat was given to the child participants after the children's parents completed questionnaires and the children completed an I-spy task which measured the children's attentional control. Results showed that an attentional bias to snakes was seen in the sample. Negative affect did not solely nor when interacted with attentional control predict for the attention bias to snakes. Fear predicted for the attention bias to snakes as a main effect. Interestingly, inhibitory control moderated the relation between fear and the attention bias to snakes, which meant that only children with high inhibitory control and high fear predicted for the attention bias to snakes. Findings may indicate children with this temperament are greater susceptible the development of anxiety.

# ACKNOWLEDGMENTS

The data used for my thesis project were collected by Dr. Anjolii Diaz Contino during her dissertation study in CAP Lab (defended May 2012). Dr. Diaz Contino reported correlations between the attention bias task and frontal EEG asymmetry in her dissertation document. No other analyses were reported using the attention bias task.  I am extremely grateful to Dr. Diaz Contino for sharing her data and allowing me to use them for a poster reporting initial analyses at the Occasional Temperament Conference (Nov 1-2, 2020) and now for the more extensive analyses I did for my thesis project.

The theoretical framework for my thesis project was influenced by Dr. Ran Liu and her prelim paper (Liu & Bell, 2020). Helping Dr. Liu collect her dissertation data introduced me to how the impact individual differences in effortful control can influence attention biases to threats.

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# Introduction

Identifying whether a stimulus is threatening or not has been cardinal to human survival. Intuitively, the faster one detects the threat, the greater chance there is to avoid harm. It is known that threats carry danger, which is why people are generally cognizant when these fear inducing stimuli are present. In accord with the theory of the threat-superiority effect, stimuli that are perceived as dangerous or scary are robust at seizing attention in comparison to nonthreatening stimuli (Brosch & Sharma, 2005; Fox et al., 2001), thus threats elicit a visual attention bias (AB). This introduction will overview ABs to threats, and the role of temperament and effortful control in ABs to threats with relevant background given before delving into the research findings.

## Literature Review

*Synopsis of Attention Biases*

An AB is when an individual preferentially attends to a specific type of stimuli in the environment while overlooking or disregarding another type of stimuli (Fadardi et al., 2016). The focus of this study concerns ABs in the visual modality. ABs can be prevalent for certain types of stimuli relevant to specific populations and in general populations. Examples of an AB for specific populations can be seen with overweight individuals showing augmented attentional allocation to pictures of food with higher fat content (Kökönyei et al., 2013), drug addicted individuals eliciting a stronger AB to drug-related cues than non-drug related cues (Stewart & May, 2016), and more optimistic people showing an AB to positive stimuli over negative stimuli (Segerstrom, 2001). An example of an AB seen with the general population include the anger superiority effect, in which there is faster allocation towards angry faces in a crowd of faces (Hansen & Hansen, 1988). This finding was further buttressed in a study by Fox and colleagues (2000) when they found that angry facial expressions were detected by participants more rapidly and efficiently than happy facial expressions. In general, ABs towards threat are seen in both clinical (Salum et al., 2013) and nonclinical populations (Gao & Jia, 2017).

Several theories concerning the mechanisms of AB exist. The schema theory has been offered as an explanation for ABs, with the reasoning that the schema is biased towards threats and that threats are always favored in cognitive processes (Beck & David, 2007). Some suggest that AB to threat only exist for anxious populations (Bar-Haim et al., 2007); however, an abundance of findings have refuted that claim with many non-clinical populations showing an AB to various types of threats including natural, social, and modern threats (Fox et al., 2007; LoBue & DeLoache, 2008; Peltola et al., 2013). Another theory is the vigilance avoidance model, which postulates that anxious populations show an automatic hypervigilance of threat-relevant information followed by an enhanced strategic avoidance of such information (Amir et al., 1998). In an alternative to this this theory, Mogg and colleagues (1997) argue that anxious individuals struggle with disengaging attention from threat stimuli after processing the threat.

One widely accepted perspective is that an AB appears to operate in early, automatic aspects of processing, before information has entered awareness (Mathews & MacLeod, 1986; Mogg et al.,1995; Williams, 1995). Research in a nonclinical sample supported the notion that greater anxiety levels are linked with faster AB, but with the AB being present regardless of the level of anxiety (Mogg et al., 1995). Apart from anxiety, factors such as relevancy (Pessoa & Adolphs, 2010; Purkis & Lipp, 2011), experience (LoBue, 2010), and temperament (Lonigan & Vasey, 2009) may differentially impact ABs to the threat. From the differing theories and multiple factors that can impact ABs to threat, I believe that the operation of an early and automatic AB best guides the framework for this study since we are focusing on AB to threats. Previous research notes that threatening stimuli are preconsciously identified (Ohman & Mineka, 2001), which would suggest an automatic AB to be precipitated by the threatening stimuli (i.e., snakes) in our study.

ABs are influenced by exogenous (bottom-up) and endogenous (top-down) processing. Top-down processing is a goal-driven processing in which our knowledge is responsible for our selection of the stimulus (Connor et al., 2004; Delorme et al., 2004). Bottom-up processing biases an observer towards attending to a stimulus due to its strong saliency (Barun & Julesz, 1998; Itti & Koch, 2000). Bottom-up processing is automatic, occurring without intent or control (Cisler & Koster, 2010; Connor et al., 2004; Delorme et al., 2004). Both endogenous and exogenous processing interact in everyday situations to bias attentional processing toward stimuli of behavioral relevance and/or salience (McMains & Kastner, 2011). Literature suggests that the strength of top-down processing of attentional modulation is dependent on the degree of competition induced by bottom-up processes, with top-down processing least effective when competition between stimuli is greatly influenced by bottom up processing (McMains & Kastner, 2011). For the parameters of my study, bottom-up processing is relevant. Threatening stimuli activate bottom-up processing as attention is captured automatically by saliency. Thus, the top-down processing responsible for the behavioral action of the task (i.e., selecting the target) for this study is expected to be impacted by the level of bottom-up processing caused by the salience of the threatening stimuli.

### *Measuring Attention Biases for Threats*

There are several common types of experiments that are used to determine if a stimulus evokes an AB or not. These include the dot-probe task, the Stroop task, the Posner cueing task, and the visual search task, all of which rely on reaction time as the measurement indicator (Pfabigan & Tran, 2015). During AB tasks focused on threat, there will be a presentation of threatening and nonthreatening stimuli. Participants are then assessed on the speed of responding to targets associated with threatening or nonthreatening stimuli. A participant with a significantly faster reaction time in response to targets associated with threatening stimuli in comparison to targets associated with nonthreatening stimuli is considered to display an AB towards threatening stimuli. For my study, the visual search task (VST) was used to present the stimuli.

### *Modified Visual Search Task*

The VST is a perceptual task which requires attention that involves an active scan of the visual environment for a certain object or feature (the target) among other objects or features (Treisman & Gelade, 1980). There are different types of VST, including feature search, conjunction search, and real-world visual search (Treisman & Gelade, 1980; Radvansky & Ashcraft, 2016). My study implemented a conjunction search approach. A conjunction search, or a serial search, focuses on identifying a previously requested target surrounded by distractors possessing one or more common visual features with the target itself (Treisman & Gelade, 1980). Conjunction search tasks can involve distractors (or groups of distractors) that may differ from each other but exhibit at least one common feature with the target (Shen et al., 2003). More specifically, my study's VST was a conjunction search based on the LoBue and DeLoache (2008) modified version task.

LoBue and DeLoache (2008) used a VST that included a 3x3 matrices with one target among eight distractors, which was inspired by Ohman and colleagues (2001). However, LoBue and DeLoache (2008) innovatively enacted a touch screen monitor to collect data from their participants opposed to the traditional method of retrieving data from keypress responses (Zsido et al., 2019). The touch screen response approach has several advantages. First, the touch screen method eliminates the need to include stimuli that do not contain a target, which was commonly implemented to combat the possibility of response learning which consequently doubled the length of a task (LoBue & DeLoach, 2008; Zsido et al., 2019). Second, this method eliminates the need to counterbalance hands that could lead to confounding results, due to collapsing responses of dominant and non-dominant hands (LoBue & DeLoach, 2008; Zsido et al., 2019). The lack of target-absent trials opens the possibility to augment the repetitions of stimuli presentation or use more exemplars per stimulus category (LoBue & DeLoach, 2008; Zsido et al., 2019). Lastly, it is important to further note that the use of a touchscreen, not the technology itself, is an efficient methodology that enables location specificity of the response. Importantly, later research demonstrated that regardless of the paradigm, key press or touch screen responding, the same pattern of findings regarding detection latency for threat-relevant versus threat-irrelevant stimuli are present (LoBue &Matthews, 2014).

Regarding the validity of the LoBue and DeLoache (2008) modified VST, many studies have yielded the same results across different populations and across different types of stimuli. Population demographics of studies that have used this modified VST include children in Western nations (Penkunas & Cross, 2013b; Thrasher & Grossmann, 2019; White et al., 2016), children of non-Western nations (Fančovičová et al., 2020; Hayakawa et al., 2011; Penkunas & Cross, 2013a), adults (Masataka et al., 2010; Masataka, & Shibasaki, 2012), and women with different stages of menstruation (Masataka, & Shibasaki, 2012). Studies that have included various types of stimuli, such as novel animals (Reynolds et al., 2014), different colored snakes (Hayakawa et al., 2011), known non-snake targets like cows and lions (Penkunas & Cross, 2013b), and emotional faces (Thrasher & Grossmann, 2019; White et al., 2016), thus these studies validate the robustness that the modified VST retains.

*Attention Bias to Threats Developmental Background*

With the establishment of the existence of an AB to threat and the VST modified version as a valid methodology to assess this phenomenon, it is important to understand the developmental aspects for ABs to threats, especially towards snakes, since my study used snakes as the apparatus for a threat. Greater visual attention to threat is a phenomenon first developed in infancy. In a study by Peltola and colleagues (2009), they found that 7-month-old infants were slower in disengaging attention from fearful faces in comparison to non-fearful faces, thus providing evidence that we hold preferential attention to threat related stimuli early in development. In a follow up experiment, researchers examined 5-, 7-, and 9-month-old infants' visual attention from a cross-sectional study to investigate the emergence and stability of AB to fearful expressions. It was found that 5-month-old infants did not show an AB towards fearful faces while 7-month-old infants did show an AB to fearful faces, which was shown again at 9 months of age (Peltola et al., 2013), indicating that ABs to threat can be detected as early as 7 months.

A more comprehensive study by LoBue, Buss, Taber-Thomas, and Perez-Edgar (2017) of infants between 4 and 24 months of age assessed developmental differences in attention for certain types of threat. A nonsocial, natural threat (snakes) was shown to have a stable perceptual bias and implies that this type of threat is stable across infancy. However, a social threat, an angry face, was shown early in infancy to increase attention for all stimuli subsequently presented after an angry face. As infants became older, their response latency to angry faces became longer, suggesting that their attentional vigilance from social threats diminishes (LoBue et al., 2017). Pertinent to my study was the evidence that developmental stability for a perceptual bias towards a nonsocial, natural threat (specifically snakes) is supported by previous findings. LobBue and DeLoache (2008) reported that children between the ages of 3 and 5 years showed the same AB towards snakes in comparison to nonthreatening stimuli as adults do. Importantly, DeLoache and LoBue (2007) showed that infants aged between 8 and 18 months associated snakes with fear, suggesting that the reason infants and young children are showing an AB to snakes is due to the threat that they evoke. With snakes being shown as a robust elicitor as a threat in AB studies, this previous work established validity for my study's implementation of snakes as the threatening stimuli in the modified VST.

I predicted that the children in my study will have a stronger AB to the threatening stimuli (snakes) in the modified VST, which will be evidenced by faster reaction times for selecting snake images among flowers images compared to selecting caterpillar images among flower images.

*Negative Affect and Attention Bias to Threat*

ABs can be impacted by an array of factors. This can include dispositional traits like addictive personalities (Zhang et al, 2019) or by exogenous factors, like stimulus onset asynchrony (Carlson et al., 2018). A factor relevant to this study that can alter ABs is temperament (Fox & Pine, 2012).

Temperament refers to individual differences in emotional, motor, and attentional reactivity measured by latency, intensity, and recovery of response, and self-regulation processes such as effortful control that modulate reactivity (Rothbart & Derryberry, 1981). Roberts and Delvecchio (2000) found, via a meta-analysis of longitudinal studies, retests stabilities of .32, .52, and .45 across temperamental traits in the periods stemming from birth to three years, three years to six years, and six to 12 years of age (Roberts & Delvecchio, 2000; Kopala-Sibley et al., 2018). Kopala-Sibley and colleagues (2018) reported that previous studies had used latent variables to assess the stability of temperament, with modest to moderate stabilities from early to middle childhood for positive affect, negative affect, and effortful control being reported. Although stability of temperament has been found across these age ranges, developmental outcomes of temperament are also dependent in the child's experience in social contexts (Rothbart & Bates, 2007). A temperamental trait for my study was negative affect.

General negative affect refers to the extent to which an individual experiences negative emotional states such as fear, sadness, and frustration (Singh & Jha, 2008; Snyder & Lopez, 2002). Izard and Tomkins (1966) assert that anxiety is a type of negative affect. Regardless, if that is the correct way to define anxiety, it at least indicates that anxiety and negative affect are related. This is apparent in a study by Brown, Chorpita, and Barlow (1998) when they found that negative affect was positively correlated (.74, $p < .05$) with generalized anxiety disorder. A myriad of studies concern ABs to threats in clinical populations diagnosed with anxiety, with one meta-analysis itself centered on 37 samples (Pergamin-Hight et al, 2015). However, not many studies focus on the impact that negative affect has on ABs to threats in non-clinical populations.

There are also previous studies that have focused on the relation between negative affect and ABs to threat in non-clinical populations. Nakagawa and Sukigara (2012) conducted a longitudinal study with infants tested at 12, 18, 24, and 36 months. Results indicate that 12-month-old infants with more negative affectivity show more difficulty in disengaging attention from fearful faces. AB to threat at 12 months was related not to parent-reported fear but to a broad factor of parent-reported negative affectivity (Nakagawa & Sukigara, 2012). A study by Martinos, Matheson, and de Haan (2012) investigated the relation between negative affect and regulation, with electrophysiological markers of attention to threatening and happy faces, in infants aged 3 through 13 months. They found no changes over time in the relation between temperament (negative affect and regulation) and electrophysiological markers of attention to either the threatening faces or the happy faces (Martinos et al., 2012).

A study by Cole and colleagues (2016) examined the relation between negative affect and social withdrawal in children aged 4 through 7 years with AB to threatening faces as a moderator. They found that children with ABs to threat had a significant, positive relation between negative affect and social withdrawal (Cole et al., 2016). A study by Perez-Edgar and others (2017) investigated the relations between individual differences in attention to emotion faces and temperamental negative affect across infants aged 4 through 24 months by use of an eye-tracking task modeled on the AB dot-probe task used with older children and adults. Results showed that young infants low in negative affect took longer to process angry faces which was associated with faster subsequent fixation to probes. Young infants high in negative affect, however, displayed the opposite pattern (Perez-Edgar et al, 2017).

The above studies focused on the interactions between negative affect and ABs to threatening faces. My study examined the effect that negative affect had on ABs to snakes with children aged 6 to 8 years old. I hypothesized that child negative affect will predict AB to threat, which will be evidenced by higher levels of negative affect predicting for faster reaction times of selecting the target (snake) in the snake/flower condition compared to the neutral target (caterpillar) in the caterpillar/condition. In accord with Perez-Edgar and colleagues' (2017) results that infants with high levels of negative affectivity process angry faces, a type of threat, quicker, then children with higher negative affect should process the threat to snakes more quickly in my study. This rapid processing allows for a faster reaction time (physically selecting the stimulus on the touch screen).

*Fear and Attention Bias to Threat*

Seeing a threat and feeling fearful seem to be intertwined. Ohman and Mineka (2001) proposed that there is an encoded detection and processing for threats as part of an adapted fear module that preconsciously identifies particularly threatening stimuli to which a rapid response should be made. Thus, the AB to threat is causal in the processes involved in human fear (Purkis et al., 2011). Fear has been shown to have a robust stability across development (Caspi et al., 2003; Fox et al., 2005). Previous studies have focused specifically on fear, as opposed to general negative affect, and an AB to threat.  One study conducted by White and colleagues (2014) longitudinally investigated the relation between early fearful temperament, ABs towards threat at ages 5 and 7, and presentation of anxiety symptoms at age 7 in a sustained attention task. Fearful temperament predicted greater anxiety symptoms at age 7 for children who displayed an AB to threat (White et al, 2014).

Several of the following studies depicted next focused on attention in initial fixations, ecologically similar with the modified VST task for my study. A study by Keogh and colleagues (2001) used a dot probe task to examine the difference in an AB to pain related stimuli between individuals with a high level of fear for pain and those with a low level of fear for pain. Results showed that those with a high fear level of pain exhibited a selective AB towards pain-related information, compared to those classified having low fear levels of pain (Keogh et al., 2001). Another study by Armstrong and colleagues (2012) found that participants that had a high level of fear for contamination oriented their attention to contamination more often than individuals with low contamination fear in initial fixations. Lastly, a study by Mogg and Bradley (2006) examined the patterns of an AB to spiders for individuals with a high level of fear for spiders and those with a low level fear for spiders. They found that both groups showed an AB to spiders compared to nonthreatening stimuli (cats) in the 200 ms condition of a visual probe task. However, those with a high fear level of spiders exhibited a stronger AB to the spiders. The results indicate that greater fear is associated with an increased initial AB for fear relevant stimuli (Mogg & Bradley, 2006).

I hypothesized that child temperamental fear in my study will predict AB to threat, which will be evidenced by higher levels of fear correlating with faster reaction of selecting the target (snake) in the snake/flower condition compared to the neutral target (caterpillar) in the caterpillar/condition.

*The Moderation of Effortful Control on Negative Affect in Predicting for ABs to Threat*

Effortful control (EC) can be defined as a self-regulatory trait that includes processes that can aid children in the modulation of their attentional and emotional reactivity (Rothbart & Ahadi, 1994). EC continuously develops across toddlerhood and childhood until becoming stable and reaching adult-level pattern during adolescence (Gerardi-Caulton 2000; Luna et al., 2004; Simonds et al., 2007; Liu & Bell, 2020). Attentional control (AC), inhibitory control (IC), and activational control are components of EC (Rothbart et al., 2001). AC pertains to the ability to flexibly focus and shift attention (Rothbart et al., 2001). IC is the suppression of a dominant response to instead perform a subdominant one (Rothbart et al., 2001). Activational control indicates the ability to initiate behaviors when not motivated (Rothbart et al., 2001). Children with high levels of EC can better control their behaviors, attention, and emotions (Eisenberg et al., 2009; Liu & Bell, 2020). For my study, the implications of EC interacting with negative affect and fear in predicting for an AB to threat will be examined.

Some developmental studies focused on negative affect have not separated EC into individual components. For example, a review article by Lonigan and colleagues (2004) discussed the relation between negative affect, general EC, and the AB to threat in children. They proposed that EC would moderate for negative affect predicting AB to threat, with children high in negative affect and low in EC function showing an AB to threat. They argued that the threatening stimuli would need to be present at longer intervals (1250-1500 ms) to assess the strategic control of attention of children with high negative affect with the expectancy that children high in EC override the AB to threat while children with low EC could not. This model explicates that all children with high negative affectivity are susceptible to an automatic AB for threat but will differ in their capacity to implement voluntary AC to overcome the bias to the threat (Lonigan et al., 2004).

With regards to the Lonigan and colleagues (2004) review, Lonigan and Vasey (2009) examined whether EC would moderate the association between negative affect and an AB toward threat in a study that used a dot probe detection task at 1250 ms with words (threat versus neutral words) as the stimuli. The study included 104 participants between 4th grade and 12th grade, recruited by means of a larger screening sample in which individuals reported high or low levels of trait negative affect and EC. Their results showed that EC did moderate the relation between negative affect and the AB to threat, but only for children with low EC and high negative affectivity. Children with high EC and high negative affectivity were able to disengage attention from the threat, thus not showing an AB to threat in this long interval dot probe task. They also found that none of these patterns were moderated by grade or age (Lonigan & Vasey, 2009).

Another study by Derryberry and Reed (2002) examined the role of self-reported AC, instead of EC as whole, in regulating AB related to trait anxiety in a sample that included 114 undergraduates. In a simple detection task, they found that trait anxious participants dispensed an early AB favoring the threatening location 250 ms after the cue and a late bias favoring the safe location 500 ms after the cue. This indicates that anxiety-related AB was moderated by AC. Specifically, anxious participants with poor AC still showed threat bias at the 500-ms delay, whereas those with good AC were better able to shift from the threatening location. Thus, the skilled control of voluntary attention may allow anxious individuals to limit the impact of threatening information (Derryberry & Reed, 2002).

In a review paper, Liu and Bell (2020), explicated how previous findings show that when EC is separated into individual components, AC and IC have different effects in how they moderate the association between fearful temperament and anxiety through AB to threat. Fearful children with higher AC are more flexible in shifting attention away from threat; specifically, they are able to interrupt sustained AB toward threat. This makes fearful children with high AC at lower risk of anxiety. On the other hand, children with higher IC are less malleable in their ability to react to threat and are more likely to get stuck on threats. This makes fearful children with high IC at higher risk of anxiety (Liu & Bell, 2020).

In accord with the model presented by Liu and Bell (2020), I hypothesized in my study that AC will operate as a moderator for negative affect positively predicting AB to threat, thus greater negative affect will predict an AB (i.e., a faster reaction time) to the threat (snake/flower) condition only for children with low levels of AC. Although much of the AC literature focused on individuals with anxiety, I expected that the same patterns for the AC interaction with negative affect in predicting AB to threat in previous literature will be found in my study, since negative affect and anxiety are related (Brown et al., 1998).

*The Moderation of Effortful Control on Fear in Predicting for ABs to Threat*

Henderson and Wilson (2017) proposed a model focused on the different roles that AC and IC have on the association between fearful temperament, AB to threat, and anxiety. They postulated that the combination of greater IC and a greater fearful temperament will create an inflexible over-controlled system that results in an elongation of the initial, automatic AB towards threats. In contrast, greater AC will aid in directing attention from threat to non-threatening stimuli or back to the goal-directed behaviors, if applicable. Therefore, high AC prevents the persistence of an automatic AB toward threat (Henderson & Wilson, 2017; Liu & Bell, 2020).

The Henderson and Wilson (2017) model and the review paper by Liu and Bell (2020) postulate the notion that AC and IC will govern as moderators for the relation between fear and the AB to threat. In accord with the previous models (Henderson & Wilson, 2017; Liu & Bell, 2020), I hypothesized for my study that both AC and IC will operate as moderators for fear positively predicting for AB to threat. I predicted that temperamental fear will positively predict an AB (i.e., a faster reaction time) to the threat (snake/flower) condition only for children with low levels of AC. Inversely, an AB (i.e., a faster reaction time) to the threat (snake/flower) will only occur with children showing high levels of the IC and high levels of fear.

## The Present Study

My thesis study assessed how temperamental negative affect and temperamental fear impact AB to threat in children age 6 to 8 and how AC and IC moderate these relations. My study addressed some gaps present in the literature. It is to my understanding that no study has observed the role that negative affect has on an AB to snakes, as this investigation did. It is also novel that my study focused on the moderating effects of AC, not EC as a whole component observed in the Lonigan and Vasey (2009) study, on the relation between negative affect and AB to threat, specifically a natural threat (snakes), in children aged 6-8 years old. Examining the moderating effects of AC and IC on the relation between fear and AB to a natural threat in a non-clinical population of 6 to 8 years old children was novel as well. These were my hypotheses:

1. Children in my study will have a stronger AB to the threatening stimuli (snakes) in the modified VST, which will be evidenced by faster reaction times for selecting snake images among flowers images compared to selecting caterpillar images among flower images.
2. Child negative affect will predict for the AB to threat, which will be evidenced by higher levels of negative affect predicting for faster reaction times for selecting the target (snake) in the snake/flower condition compared to the neutral target (caterpillar) in the caterpillar/condition.
3. Child fear in our study will predict for the AB to threat, which will be evidenced by higher levels of fear correlating with faster reaction for selecting the target (snake) in the snake/flower condition compared to the neutral target (caterpillar) in the caterpillar/condition.

4. AC will operate as a moderator for negative affect redicting for the AB to threat. Greater negative affect will predict for an AB (i.e., a faster reaction time) to the threat (snake/flower) condition only for children with low levels of AC.
5. In accord with the previous models (Henderson & Wilson, 2017; Liu & Bell, 2020), both AC and IC will operate moderators for temperamental fear predicting AB to threat. Greater temperamental fear will predict for an AB (i.e., a faster reaction time) to the threat (snake/flower) condition only for children with low levels of AC. Inversely, an AB (i.e., a faster reaction time) to the threat (snake/flower) will only occur with children showing high levels of the IC and high levels of fear.

# Methods

The data used for my study is archival from former PhD candidate at Virginia Tech and now tenured associate professor at Ball State University, Dr. Anjolii Diaz. The data were collected as part of Dr. Diaz's dissertation project. Her defense was in May 2012. Permission was given by Dr. Diaz to resurrect this dataset to assess hypotheses that were not analyzed by Dr. Diaz for her dissertation.

## *Participants*

One hundred and five children (59 girls, 46 boys) between the ages of 6-8-years (mean age 7.13 years; SD = 10.04 months) were recruited from the New River Valley area of southwest Virginia. Parents identified the children this way with respect to race: 99 White (2 Hispanic ethnicity), 4 Black, 2 Asian. All participants had normal or corrected-to-normal vison. Children were full term, born within 3 weeks of their expected due dates, and experienced no prenatal or birth complications. All the children's parents completed high school. Ninety percent of mothers had a college degree or higher, with 82% of fathers holding a college degree or higher. Children were healthy at the time of the visit and had no developmental delays or cognitive disabilities. Three children (boys) were excluded from data analysis because they did not complete the AB task.

## *Procedure*

Two questionnaires, the Children Behavior Questionnaire short form and the Fear Survey Schedule for Children-Revised parent version were given to the parents, while children conducted an attentional control task prior to the children performing the visual search task used for AB.

## Measures

*Children Behavior Questionnaire short form*

The Children Behavior Questionnaire short form (CBQ-SF; Putnam & Rothbart, 2006) was utilized to measure parent observations of child temperament outside of a laboratory setting on a seven-point Likert scale ranging from 1 (*extremely untrue of your child*) to 7 (*extremely true of your child*). This 95-item questionnaire assessed the child's emotional and behavioral responses across different situations. This instrument measures 15 domains of child temperament. The focus for my study was the negative affect and IC scores, which will be used for the planned regression analyses. The internal consistency (alpha coefficient) of the CBQ-SF inhibitory control scale was reported to be 0.72. The negative affect scale had an alpha coefficient of 0.70 and was formed as a factor from the scales of fear, sadness, and anger/frustration present in the CBQ-SF. The CBQ-SF fear scale had 6 items and an alpha coefficient of 0.68. The CBQ-SF sadness scale had 7 items and an alpha coefficient 0.61. The CBQ-SF anger/frustration scale had 6 items and an alpha coefficient of 0.76.

*Fear Survey Schedule for Children-Revised parent version*

The Fear Survey Schedule for Children-Revised parent version (FSSC; Ollendick, 1983) was given as it is a widely used measure of children and adolescents' fears. 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 (Ollendick, 1983). The internal consistency (alpha coefficient) of the FSSC was reported to be 0.941. The average fear composite of all 80 items on the survey was used for the analyses.

*Attentional Control Task*

Parallel to the game of i-SPY, children were given a visual attention task that requires AC in the continual selective processing of differentially relevant stimuli features. Children were instructed to find a specific target (bears) displayed on an 11' x 18' page containing both targets and distracters (NEPSY; Korkman et al., 1998). In 2 minutes, children were tasked with finding as many targets (bears) as possible. The AC score was indexed by the ratio of unique efficiency that is calculated with uniquely identified items divided by the total responses. Uniquely identified items were represented as the number of correct targets (bears) that the child selected (i.e., touched). Total responses were signified as the total number of responses the child made. The unique efficiency from this task was used when conducting regression analyses.

*Visual Search Task*

A modified version of a VST (LoBue & DeLoache, 2008) to measure the reaction time of the participants was implemented. The lab's primary investigator, Dr. Martha Ann Bell hired a software engineer in the community to write the program for the VST. The program pulled photos from the relevant folders (snake folder, flower folder, or caterpillar folder) and randomly generated a 3 x 3 matrix for each trial. Which target (e.g., snake), which distractors (e.g., flowers), and placement of the target (e.g., snake) in the matrix were all randomly generated.

For the experiment, the child was seated in front of the touch-screen monitor (approximately 70 cm from the base of the screen) and told to place his or her hands on their lap. This ensured that the child's hands were in the same place at the start of each trial, making it possible to collect reliable latency data. Four practice trials were given so that the children would acclimate to the task. For the first two trials, 1 target and 1 distractor were presented on the screen and the child was instructed to touch the target picture only. For the last two practice trials, 3 by 3 matrices were shown on the screen and the child was told to find the single target stimulus ("X") among the eight distractor stimuli ("Ys") and touch it as quickly as possible.

Then return their hands back to their lap. Test trials followed these same instructions. All children demonstrated they learned the procedure by successfully completing the practice trials.

Three blocks were implemented in the test trials. Each block contained 24 test trials with a different picture matrix (3 x 3) consisting of one target and eight distractors. A large smiley face appeared on the screen in between trials. The face was pressed by the experimenter when it was judged that the child was looking at it, causing the next matrix to appear in order to ensure 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 touched one of the pictures on the screen, along with recording the total number of correctly selected pictures per block.

Block 1 required that the children to either locate a single threat (i.e., a snake) among eight neutral distractors (i.e., flowers) or single distractor (i.e., a flower) among eight threat distractors (i.e., snakes). The snake stimuli were depicted as either coiled on the ground or in a tree. No snake was depicted in a threatening pose. Block 3 operated procedurally akin to block 1, however caterpillars were used instead of snakes. This was done to better elucidate any existence of rapid threat-detection, because caterpillars hold the same salient physical characteristic of snakes, an elongated body (LoBue & DeLoache, 2008). The procedure for block 2 was the same as it was for blocks 1 and 3, but with snakes and caterpillars. Only mean reaction times for when the caterpillar was the target was available to me. Therefore, I cannot use the data from block 2 because I do not have the mean reaction times for when the snake was the target. See Figures 1 and 2 for sample matrices of block 1 and block 3 stimuli respectively used for data collection.

## Data Analysis Plan

Hypothesis 1, the reaction time to snakes will be faster than the reaction time to caterpillars, was evaluated by conducting a paired t test to observe the difference in mean reaction time (ms) between the snake/flower and the caterpillar/flower condition.

Hypothesis 2, child negative affect predicting the AB to snakes, was examined by conducting a hierarchical regression analysis with child sex and child age included in the first step as controls and child negative affect reported on the CBQ-SF in the second step and AB to snakes (mean difference in RT between snake/flower condition and caterpillar/flower condition) as the dependent variable.

Hypothesis 3, child temperamental fear predicting the AB to snakes, was examined by conducting a hierarchical regression analysis with child sex and child age included in the first step as controls and temperamental fear reported from the FSSC will be included in the second step and AB to snakes (mean difference in RT between snake/flower condition and caterpillar/flower condition) as the dependent variable.

Hypothesis 4, AC moderating the relation between child negative affect and AB to snakes, and hypothesis 5, AC and IC moderating the relation between child temperamental fear and AB to snakes, was examined by conducting hierarchical regressions analyses. Before running these analyses, continuous variables were centered prior to conducting the regression analyses by subtracting the sample mean from all individual scores on the variable of interest; producing a revised sample mean of 0. This procedure reduced any possible multicollinearity between the predictors (fear and negative affect) and any interaction terms among them and facilitate the testing of simple slopes (Holmbeck, 2002).

In step one of the hierarchical regression analysis, child sex and child age will be included as controls. In step two, the predictor (e.g., negative affect) and the potential moderator (e.g., AC) will be entered into the regression equation with AB to snakes as the criterion variable. In step two, the predictor (e.g., negative affect) and the potential moderator (e.g., AC) will be both entered again along with the interaction term of the predictor and moderator (e.g., negative affect X AC), still retaining the AB to snakes as the criterion variable. If the significant interaction terms, PROCESS 3.5 by Hayes (2017) was used to conduct a multiple regression analysis to investigate the significance for low and high levels of the moderator that interacted with the predictor (Hayes & Rockwood, 2017). The low-level group of the moderator was calculated by subtracting 1 standard deviation from the centered moderating variable of interest (Holmbeck, 2002; Rogosa, 1980). A high-level group of the moderator was conversely calculated by adding 1 standard deviation to the centered moderating variable of interest (Holmbeck, 2002; Rogosa, 1980). Simple slope analyses were conducted for the significant interaction terms afterwards to visually display the moderated relation.

*Power Analysis*

Using G*Power (version 3.1.9.2) to determine sample size for my main moderation analysis, we assumed medium effect size of .15, alpha error probability of .05, and power of .95. For testing one of three total predictors (my hypothesis focuses on the interaction term), a sample size of 89 is necessary. Thus, the 102 participants in this dataset were sufficient to test my moderation hypothesis.

## Results

Descriptive statistics and correlations for study variables are shown in Table 1.

For hypothesis 1, a paired T test via SPSS 26 was conducted to assess whether children in the experiment showed an AB, faster reaction time, to snake stimuli in comparison to caterpillar stimuli among distractor (i.e., flower) stimuli (see Table 2). The results showed that children were significantly faster (.638 seconds) in finding snakes among flowers than caterpillars among flowers, $t(100) = 7.247$, $p < .001$, thus supporting that children show an AB to snakes over caterpillars. See Figure 3 for a visual representation of the mean reaction times for each block. Additional t tests showed that children had faster reaction time as they got older, but when calculating the AB, those age differences in the raw RTs disappeared since the AB measure was a difference score.

For the remaining hypotheses, AB to snakes was the dependent variable in regression analyses. The AB was calculated as caterpillar reaction time "minus" snake reaction time, with positive values indicating an AB for snakes and higher numbers indicate a greater AB to snakes.

For hypothesis 2, a two-step hierarchical regression model was conducted via SPSS 26 (see Table 3) to examine whether children's negative affect score on the CBQ will positively predict for the AB to snakes. Step 1 included child sex and child age as controls ($R^2 = .028$, F = 1.438, $p = .242$). Step 2 included the same variables with the addition of CBQ child negative affect ($R^2 = .046$, F = 1.574, p = .201). The change in $R^2$ from step 1 to step 2 was 0.18 and not significant (F = 1.821, p = .180). The results indicate that child sex (beta = .084, p = .403), child age (beta =-.119, p = .241), and CBQ child negative affect (beta = .134, p = .180) were not significant as main effects in impacting the AB to snakes.

For hypothesis 3, a two-step hierarchical regression model was conducted via SPSS 26 (see Table 4) to examine whether children's average fear score on the FSSC will positively predict for the AB to snakes. Step 1 included child sex and child age as controls ($R^2$ = .028, F = 1.438, *p* = .242). Step 2 included the same variables with the addition of the FSSC child fear ($R^2$ = .094, F = 2.505, p = .047). The change in $R^2$ from step 1 to step 2 was 0.65 and significant (F = 7.042, p = .009). The main effect for FSSC child fear was significant (beta = .256, p = .009), with the positive beta weight indicating a positive relation between fear reported by children on the FSSC and the AB to snakes. Child sex (beta = .076, p = .441) and child age (beta =-.117, p = .235) were not significant as main effects in the AB to snakes.

For hypothesis 4, a three-step hierarchical regression model was conducted via SPSS 26 (see Table 5) to examine whether children's negative affect score on the CBQ will negatively interact with children's AC task score to predict for the AB to snakes. Step 1 included child sex and child age as controls ($R^2$ = .020, F = .986, *p* = .377). Step 2 included the same variables with the addition of CBQ child negative affect and child AC ($R^2$ = .035, F = .861, p = .490). The change in $R^2$ from step 1 to step 2 was 0.15 and not significant (F = .741, p = .479). Step 3 included the same predictors used in step 2 along with the addition of an interaction variable between CBQ child negative affect and child AC ($R^2$ = .041, F = .810, p = .545). The change in $R^2$ from step 2 to step 3 was .006 and not significant (F = .619, p = .433). In the final step, there were no significant main effects and no significant interaction effect (beta = -.081, p = .433)

For hypothesis 5a, a three-step hierarchical regression model was conducted via SPSS 26 (see Table 6) to examine whether children's fear score on the FSSC will negatively interact with children's AC task score to predict for the AB to snakes. Step 1 included child sex and child age as controls ($R^2$ = .020, F = .986, *p* = .377). Step 2 included the same variables with the addition of FSSC child fear and child AC ($R^2$ = .069, F = 1.757, p = .144). The change in $R^2$ from step 1 to step 2 was 0.49 and not significant (F = 2.497, p = .088). Step 3 included the same predictors used in step 2 along with the addition of an interaction variable between FSSC child negative fear and child AC ($R^2$ = .073, F = 1.472, p = .206). The change in $R^2$ from step 2 to step 3 was .004 and not significant (F = .378, p = .540). In the final step, the only significant main effect was FSSC child fear (beta = .230, p = 0.24) and no significant interaction effect (beta = -.064, p = .540).

For hypothesis 5b, a three-step hierarchical regression model was conducted via SPSS 26 (see Table 7) to examine whether children's fear score on the FSSC will positively interact with children's CBQ IC score to predict for the AB to snakes. Step 1 included child sex and child age as controls ($R^2$ = .028, F = 1.438, *p* = .242). Step 2 included the same variables with the addition of FSSC child fear and child IC ($R^2$ = .095, F = 2.551, p = .044). The change in $R^2$ from step 1 to step 2 was 0.067 and significant (F = 3.589, p = .031). Step 3 included the same predictors used in step 2 along with the addition of an interaction variable between FSSC child fear and child IC ($R^2$ = 1.45, F = 3.264, p = .009). The change in $R^2$ from step 2 to step 3 was .050 and significant (F = 5.627, p = .020). In the final step, the only significant main effect was FSSC child fear (beta = .237, p = 0.17), with the positive beta weight indicating that greater fear reported by children on the FSSC predicts for a stronger AB to snakes. The interaction effect was significant (beta = .228, p = .020). PROCESS 3.5 (Hayes, 2017) and a simple slopes analysis were conducted to examine the interaction effect. The regression analysis of the high IC level of children with FSSC fear was significant (p < .001), while the low IC level of children with FSSC fear was not significant (p = .884). This indicates that child FSSC fear significantly predicts for the AB to snakes only when children report a high level of IC on the CBQ. A simple slopes analysis (see Figure 4) displays the interaction.

All regressions were repeated without controlling for age and sex and yielded the same results.

## Discussion

In the discussion of each hypothesis, I include the limitations of my study and suggestions for future research.

*Hypothesis 1 supported – Children Show an AB to Snakes*

The results showed that children were faster in reaction time for selecting the threatening stimuli (i.e., snakes) compared to the nonthreatening stimuli (i.e., caterpillars) when paired with neutral stimuli (i.e., flowers), thus supporting the hypothesis that children will have an AB to snakes. The phenomenon observed in this study is not surprising. As it would have been unexpected if it did not occur.

The literature overwhelmingly indicates that an AB to threats is the norm, even across differing individual characteristics. Across development, it has been shown that both children and adults show an AB to threats over neutral stimuli (LoBue, 2010), with the AB to threats being observed as young as infancy (Peltola et al., 2009). It was argued by some researchers that ABs to threats exist only for anxious populations (Bar-Haim et al., 2007). However, there is evidence that ABs to threats are observable in in both clinical (Salum et al., 2013) and nonclinical populations (Gao & Jia, 2017). ABs are seen with different types of threats; social (Fox et al., 2007; Peltola et al., 2018), natural (LoBue & DeLoache, 2008; Mogg & Bradley, 2006), and modern (Brosch & Sharma 2005; Blanche, 2006) threats, thus this finding further corroborates the previous findings.

Although the AB to threat was a simple and non-novel hypothesis, it was still crucial to this study, especially since it bears ramifications for the other hypotheses of this study. Without the affirmation of an AB being shown, then all the following hypotheses could not have been tested. Thus, hypothesis 1 was the foundation for this study.

Limitations in examining the AB to snakes come from the data being archival. For example, the AB to snakes over a similarly featured, neutral stimuli (caterpillars) were determined by the difference in the reaction times that both snakes and caterpillars had when they were the target stimulus amongst distractor stimuli (flowers). Though this inference is valid, it would have been more elucidating if there were available reaction times for when the VST included the snake and caterpillar condition. That way, then the recorded reaction times for the snake targets (with caterpillar distractors) could have been compared to the caterpillars (with snake distractors), thus getting a direct competition for visual attention between the two stimuli of interest and better assessing the presence of an AB. However, the experimenter at the time likely noted these reaction times in a different dataset that is no longer available. And with the experiment being conducted several years ago, it is impossible to recover this data. Future studies should have a condition of the target stimuli of interest with recorded reaction times to better assess the AB of their interest.

An additional concern with the design of the study for assessing the AB to snakes was the difference in coloration and size of the stimuli. This is a confound that could have negatively affected our results, as Hagtvedt and Brasel (2017) note that size and color can impact an individual's attention. In particular, the caterpillar stimuli were more brightly colored (often green) than the snake stimuli. Camgoz and colleagues (2004) found that bright colors, especially green, attract the most attention. Yet, the snake stimuli still showed an AB in comparison to the caterpillars. This may be preliminary evidence suggesting that the threat aspect of a stimulus dominates over the visual attentional process over of the colored feature for a stimulus. However, it should be noted that the snake stimuli were larger than the caterpillar stimuli, which may be a confound in favor of the snake stimuli. In a study by Proulx (2010), it was found that larger items capture greater attention.

More importantly, the greatest concern was the lack of counterbalancing between snake and caterpillar conditions. With block 1 always being the condition of the snake as the target and block 3 always being the condition of the snake as the target, this could have led to an order effect among the participants, such that the slower average reaction time to caterpillars was due to fatigue. Ideally, the experimental design of all the conditions of the VST should have had all stimuli be of the same color and size, however it may be unadvisable to alter the pictures of caterpillars to be the same size of snakes as this may inadvertently create a novelty effect and diminish generalizability as well. More importantly, the blocks should have been randomly assigned to participants to control for any order effects. Future studies should adhere to these standards. Future studies can also investigate if there is an AB for threat even when size and color differ in favor of the nonthreatening stimulus.

*Hypothesis 2 not supported – Child Negative Affect Was Not a Predictor for the AB to Snakes*

The results showed that children's negative affect was not a predictor for the faster reaction time in selecting the threatening stimuli (i.e., snakes) compared to the nonthreatening stimuli (i.e., caterpillars) when paired with neutral stimuli (i.e., flowers), thus refuting the hypothesis that children's negative affect will predict for children's AB to snakes. It is important to assess as to why this might be the case. From the previous literature examining the role of a participant's negative affect in the relation between AB to threat, several aspects are noticeable. First, there are mixed results with assessing negative affect as a main effect on the AB to threats, as seen in infant studies. Nakagawa and Sukigara's (2012) longitudinal study of infants and toddlers between 12- and 36-month-olds only showed greater negativity associated with a form of an AB to fearful faces at 12 months, as it was not observed with the 18-, 24-, and 36-month-old subjects. Martinos and colleagues (2012) found no relation between negative affect and attention to either threatening faces or happy faces in a 3-13-month-old sample.

Second, other studies that have observed a significant relation between negative affect and the AB to threats occurred with moderation. Cole and colleagues (2017) found that the AB to threat moderated the relation between negative affect and social withdrawal. While Lonigan and Vasey (2009) found in a sample of participants between the 4th and 12th grade that only children with low effortful control and high negative affect showed an AB to threatening words in a dot probe task. Perhaps, considering these results, it was ambitious to hypothesize that negative affect solely would predict for the AB to threats. It could be that negative affect is only impactful in the AB to threats when moderated with another factor. My study did take that into consideration with the 4th hypothesis and such will be further evaluated in that section of the discussion.

*Hypothesis 3 supported – Child Fear Was a Predictor for the AB to Snakes*

The results showed that children's fear was a predictor for the faster reaction time in selecting the threatening stimuli (i.e., snakes) compared to the nonthreatening stimuli (i.e., caterpillars) when paired with neutral stimuli (i.e., flowers), thus supporting the hypothesis that children's fear will predict for the children's AB to snakes. This finding is aligned with the previous studies.

As previously mentioned, studies of participants with high levels of fear for specific types of stimuli showed an AB to those stimuli in comparison to neutral stimuli, while subjects with low levels of fear did not show the AB (Armstrong et al., 2012; Keogh et al., 2001). Although my study does support the finding of those studies, the stimuli of interest that attracted the participants AB were not traditionally threatening stimuli (e.g., contaminants). However, Mogg and Bradley (2006) found that fear significantly predicted for the AB to spiders in a sample of subjects with high and low levels of fear towards spiders, a commonly perceived threatening stimulus, with those having greater fear towards spiders showing significantly faster reaction times (i.e., a stronger AB). This finding helps cement that fear has a fundamental impact on our attention towards threats. My study further corroborates these findings with fear being a predictor of the AB to another perceived threat: snakes.

Although these findings are intuitive and seem to be robust, future studies can further assess the validity of the claim that fear is a predictor for the AB to threats. Something that Mogg and Bradley (2006) may have not thought of was using neutral stimuli that are physically akin to spiders. Using a cat as a competitive attentional resource is sufficient, but maybe it is the distinct characteristics of a spider that draw attention. Spiders having many long and thin legs could possibly operate as a reason for the AB. A future study can try to replicate Mogg and Bradley (2006) findings by using crabs or other multi-legged organisms as the neutral stimuli to see if an AB is still seen towards spiders. Regarding my study, caterpillars were used as the neutral stimuli to match the physical characteristics of snakes, specifically the limbless and elongated body. Yet, one could argue that a caterpillar is not similar enough to snakes. A future study could use another type of lizard as a neutral stimulus, like a salamander, to examine if the results will still hold. Investigating if other factors interact with fear in predicting for the AB to snakes was assessed in hypothesis 5 of this study.

*Hypothesis 4 not supported – Child AC did not Interact with Child Negative Affect in Predicting for the AB to Snakes*

The results showed that the interaction between children's AC and negative affect did not predict for the faster reaction time in selecting the threatening stimuli (i.e., snakes) compared to the nonthreatening stimuli (i.e., caterpillars) when paired with neutral stimuli (i.e., flowers), thus failing to support the hypothesis that children's AC will negatively interact with children's AC task score to predict for the AB to snakes. Several reasons may explain this result.

Similar to the Lonigan and Vasey (2009) study, my study assessed the interaction of negative affect with effortful control (EC). However, their study assessed the whole EC composite as the moderator while my study specifically examined AC, a component of EC (Rothbart et al., 2001), as the moderator. My study was inspired by the findings of Derryberry and Reed (2002), which showed that all trait-anxious participants showed an AB to the threatening location at 250 milliseconds (ms) but only those with low AC still showed an AB at the 500 ms interval. My study however, used a behavioral task to measure AC, while the Derryberry and Reed (2002) study used a self-report measure for AC, which may have been a reason for the difference in findings.

Derryberry and Reed (2002) used short interval tasks (250 and 500 ms). In contrast, the Lonigan and Vasey (2009) task had a longer interval of 1250 ms per trial. For my study, the response time for the VST was longer than both studies, with the average responses all above 3000 ms (3 seconds) regardless of the stimulus type. Perhaps this difference may be a confound in observing the impact that negative affect when moderated has in predicting the AB to threats. I will note however that my study was with children, as was the Lonigan and Vasey study, but the research protocol for my study children beginning each trial with hands in their laps. This makes it difficult to compare my findings with studies focused intensely on the length of task interval. Also, strikingly different from this study were the aspects that the two mentioned studies (Lonigan & Vasey, 2009; Derryberry & Reed, 2002) did not use pictorial stimuli in their tasks.

In an AB to food study by Frejiy and colleagues (2014), there was no difference between pictorial and word stimuli, however, there were differences in interaction effects. An AB was present to the negative stimuli (i.e., high calorie food) for pictorial stimuli but away from high calorie food word stimuli. Interestingly, there was an AB bias towards low-calorie words, but away from low-calorie pictures (Frejiy et al., 2014). Thus, the difference between pictorial and non-pictorial stimuli in the interaction between negative and EC (as a whole or component) may be important.

Future studies in assessing how negative affect impacts the AB to threats could include several experiments to better examine the functionality of this relation. First, one experiment could use a dot probe task and try to replicate Lonigan and Vasey's (2009) findings of the interaction between low EC and high negative affectivity in predicting for the AB to threatening words and examine if their finding extends to threatening pictures. Second, another experiment could extend the previous suggestion but investigate high negative affect and low AC. Lastly, if any significant results are yielded from the previous suggestions, then those findings could then be extended to examine if those phenomena occur in a VST paradigm. If these experiments are conducted and replicated without significant results, then it might indicate that negative affect is only impactful in the AB to threats in anxious populations.

*Hypothesis 5a not supported – Child AC did not Interact with Child Fear in Predicting for the AB to Snakes*

The results showed that the interaction between children's AC and fear did not predict for the faster reaction time in selecting the threatening stimuli (i.e., snakes) compared to the nonthreatening stimuli (i.e., caterpillars) when paired with neutral stimuli (i.e., flowers), thus, not supporting the hypothesis that children's AC will interact with children's AC task score to predict for the AB to snakes. Examination of previous studies may illuminate why this result occurred.

In accord with the Henderson and Wilson (2017) model, higher levels of AC will help orient attention from threat to non-threatening stimuli, evidencing that greater AC is preventive in the persistence of an automatic AB towards threatening stimuli in anxious populations with a fearful temperament (Henderson & Wilson, 2017; Liu & Bell, 2020). With this logic, then the inverse would be that anxious individuals with a fearful temperament having lesser AC would have difficulty diverting attention away from the threatening to the non-threatening stimuli, resulting in their attention being fixated on the threat (Henderson & Wilson, 2017; Liu & Bell, 2020). In a study by Susa and colleagues (2014) with a non-anxious sample of school-aged children (age range was between 9 years 1 month and 13 years 10 months), results indicated that only children with high fear and low AC showed an AB to angry faces. Their study implemented a dot probe task measure for the AB to angry faces and the Attentional Control Scale (ACS-C; Derryberry & Reed, 2002) was used to measure AC (Susa et al., 2014). In another study by Sippel and Marshal (2013) with a sample of individuals with PTSD, the result showed that AC was negatively correlated with fear emotions. That study also used the ACS-C (Derryberry & Reed, 2002) to measure AC (Sippel & Marshal, 2013). Referring to Lonigan and Vasey (2009) study again, their measure for EC was arguably mainly AC measured with self-report scales that emphasize the flexible control of attention.

Thus, the possible confound that could be responsible for the non-significant interaction of AC with fear for predicting the AB to snakes could be how AC was measured in this study. As mentioned earlier, children's AC was measured via a behavioral task. It could be that the use of ACS-C (Derryberry & Reed, 2002), or other validated parent-report scales, is a more valid assessment for measuring AC. The mentioned studies that used this scale all retain significance for AC as either a moderator for the AB to threat (Susa et al., 2014; Derryberry & Reed, 2002) or as a correlate of fear (Sippel & Marshal, 2013). It could also be that the AC behavioral measure itself was not truly assessing AC, which could be another plausible reason why AC did not significantly interact with neither child negative affect nor child fear. Thus, a future study may replicate this study but instead use the ACS-C (Derryberry & Reed, 2002) to measure AC and assess the interaction of the AC with fear in predicting for the AB to snakes.

*Hypothesis 5b supported – Child IC Did interact with Child Fear in Predicting for the AB to Snakes*

The results showed that the interaction between children's IC and fear did significantly predict for the faster reaction time in selecting the threatening stimuli (i.e., snakes) compared to the nonthreatening stimuli (i.e., caterpillars) when paired with neutral stimuli (i.e., flowers).  This finding is aligned with previous literature.

My study's finding is in accord with the Henderson and Wilson (2017) model, which theorized that the amalgamation of high levels of IC with high levels of a fearful temperament will generate an inflexible over-controlled system that results in an extended initial, automatic AB towards threats in anxious individuals (Henderson & Wilson, 2017; Liu & Bell, 2020). Previous developmental neuroscience research suggest that anxiety is associated with behavioral over-control and hyper- monitoring (Brooker et al., 2016; Brooker & Buss, 2014; Santesso, Segalowitz, & Schmidt, 2006; Torpey, Hajcak, & Klein, 2009) and that the occurrence of behavioral inhibition when it is unnecessary may be maladaptive (Brooker et al., 2016). In a study by Brooker and colleagues (2016), they found that observed socially anxious behaviors at age 5 were predicted by high levels of reported social fear across childhood when coupled with high levels of reported IC at age 2. These findings further support the Henderson and Wilson (2017) model and add contextual relevance to the significance of my study's finding. This is a critical finding because cross-sectional studies suggest ABs to threats are linked to the vulnerability of anxiety disorders in both children and adults (Fu & Perez-Edgar, 2019).

The finding of non-anxious children aged 6-8 with high levels of fear and high levels of IC predicting for the AB to threat, especially with natural threats (i.e., snakes) is in my understanding novel to the literature. This finding extends the trajectory of the Henderson and Wilson (2017) model to include non-anxious individuals as susceptible to the development of an inflexible overcontrolled system that leads to a prolonged initial AB to threats when coupled with high levels of both fear and IC. It could very well be that within non-anxious populations, children with great levels of both fear and IC are more vulnerable to the development of anxiety. Future research can conduct a longitudinal study to observe if non-anxious children with high levels of both fear and IC that predict for the AB to threats will predict for anxiety or anxious symptoms at a later stage in childhood. It would also be advantageous to use an AB task with both natural threats (i.e., snakes) and social threats (i.e., emotive faces) to observe if there any differential prediction in the type of AB to threat that predicts for the later measure of anxiety. Results from any future study supporting the view that non-anxious children with high levels of both fear and IC that have an AB to threats are more vulnerable to the development of anxiety should then strongly considered the method of assessing fear and IC in the relation of AB to threat as a measure in the screening of anxiety in clinical assessments.

## Conclusion

Children aged 6-8 showed an AB to snakes in a VST. This finding supports the theory that the saliency of a threat will activate a bottom-up process that triggers an early and automatic AB (Mathews & MacLeod, 1986; Mogg et al.,1995; Williams, 1995), which is predicated from an adapted fear module that preconsciously recognizes threatening stimuli (Ohman & Mineka, 2001). Child negative affect had no predictive impact on the AB to snakes. Child AC did not moderate either the association between negative affect and AB to threat or fear and AB to threat. This could be because of the AC behavioral task measure being implemented instead of a report scale as used with previous research. The finding of high levels of both fear and IC predicting for the AB to threat extends the Henderson and Wilson (2017) model to non-anxious individuals. This finding may show that children with this temperament are at greater risk for anxiety and could be instrumental in screening for additional precipitants for the onset of anxiety.

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**Table 1**

*Descriptive Statistics and Correlations for Temperament, Inhibitory and Attentional Control, and Reaction Time Scores for Children Ages 6 Through 8*

| | N | Mean | SD | Range | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. NA | 105 | 3.81 | .78 | 2.08 – 5.59 | | | | | | |
| 2. Fear | 105 | 0.53 | .27 | 0.08 – 1.29 | .47* | | | | | |
| 3. IC | 105 | 5.15 | .94 | 2.00 – 7.00 | -.46* | -.25* | | | | |
| 4. AC | 105 | .81 | .13 | .50 - 1.00 | .10 | .10 | -.03 | | | |
| 5. RT Snakes | 102 | 3.22 | .93 | 1.80 – 5.85 | -.10 | -.02 | .03 | -.06 | | |
| 6. RT Caterpillar | 102 | 3.86 | 1.1 | 2.40 – 7.77 | .03 | .14 | -.05 | -.04 | .61* | |

*Note.* NA = negative affect, CBQ-SF Negative Affectivity factor;
Fear = fear composite score, FSSC;
IC = inhibitory control, CBQ-EF Inhibitory Control scale;
AC = attentional control, visual search controlled attention behavioral task;
RT = reaction time.
*$p < 0.05$.

**Table 2.**

*Paired Samples T-Test Between the Caterpillar/Flower and Snake/Flower Conditions*

| **Paired Samples T-Test** | | | | | | |
|---|---|---|---|---|---|---|
| | Mean Difference (RT) in seconds | St. Deviation | St. Error Mean | t | df | Sig. (2-tailed) |
| Caterpillar/Flower RT vs.Snake/Flower RT | 0.638 | 0.889 | 0.088 | 7.247 | 101 | <.001 |

**Table 3.**

*Hierarchical Regression Analysis of Child CBQ Negative Affect Predicting Attention Bias to Snakes*

| | B | Std. Error | Beta | t | Sig. |
|---|---|---|---|---|---|
| Step 1 | | | | | |
| Age | -.012 | .009 | -.136 | -1.349 | .180 |
| Sex | .141 | .180 | .079 | .782 | .436 |
| $R^2$ = .028 F = 1.438 (2, 99) *p* = .242 | | | | | |
| Step 2 | | | | | |
| Age | -.011 | .009 | -.119 | -1.180 | .241 |
| Sex | .151 | .179 | .084 | .839 | .403 |
| CBQ NA | .153 | .113 | .134 | 1.350 | .180 |
| $R^2$ change = .018 F = 1.821 (3, 98) *p* = .180 | | | | | |

**Table 4.**

*Hierarchical Regression Analysis of Child FSSC Fear Predicting Attention Bias to Snakes*

| | | B | Std. Error | Beta | t | Sig. |
|---|---|---|---|---|---|---|
| Step 1 | | | | | | |
| | Age | -.012 | .009 | -.136 | -1.349 | .180 |
| | Sex | .141 | .180 | .079 | .782 | .436 |
| | $R^2$ = .028 F = 1.438 (2, 99) *p* = .242 | | | | | |
| Step 2 | | | | | | |
| | Age | -.010 | .009 | -.117 | -1.196 | .235 |
| | Sex | .135 | .175 | .076 | .773 | .441 |
| | FSSC Fear | .842 | .317 | .256 | 2.654 | .009 |
| | $R^2$ change = .065 F = 7.042 (3, 98) *p* = .009 | | | | | |

**Table 5.**

*Hierarchical Regression Analysis of Child CBQ Negative and Child Attentional Control Task Score Predicting Attention Bias to Snakes*

| | | B | Std. Error | Beta | t | Sig. |
|---|---|---|---|---|---|---|
| Step 1 | | | | | | |
| | Sex | .067 | .170 | .040 | .392 | .696 |
| | Age | -.011 | .008 | -.128 | -1.258 | .211 |
| | $R^2$ = .020 F = .986 (2, 97) *p* = .377 | | | | | |
| Step 2 | | | | | | |
| | Sex | .070 | .175 | .042 | .402 | .689 |
| | Age | -.009 | .008 | -.112 | -1.084 | .281 |
| | CBQ NA | .132 | .108 | .126 | 1.217 | .227 |
| | AC Score | .116 | .656 | .019 | .177 | .860 |
| | $R^2$ = .015 F = .741 (4, 95) *p* = .479 | | | | | |
| Step 3 | | | | | | |
| | Sex | .093 | .178 | .056 | .521 | .603 |
| | Age | -.008 | .009 | -.101 | -.967 | .336 |
| | CBQ NA | .138 | .109 | .131 | 1.264 | .209 |
| | AC Score | .089 | .658 | .014 | .135 | .893 |
| | NA-AC | -.652 | .828 | -.081 | -.787 | .433 |
| | $R^2$ = .006 F = .619 (5, 94) *p* = .433 | | | | | |

**Table 6.**

*Hierarchical Regression Analysis of Child FSSC Fear and Child Attentional Control Task Score Predicting Attention Bias to Snakes*

| | | B | Std. Error | Beta | t | Sig. |
|---|---|---|---|---|---|---|
| Step 1 | | | | | | |
| | Sex | .067 | .170 | .040 | .392 | .696 |
| | Age | -.011 | .008 | -.128 | -1.258 | .211 |
| | $R^2$ = .020 F = .986 (2, 97) $p$ = .377 | | | | | |
| Step 2 | | | | | | |
| | Sex | .069 | .172 | .042 | .404 | .687 |
| | Age | -.009 | .008 | -.116 | -1.147 | .254 |
| | FSSC Fear | .678 | .304 | .222 | 2.234 | .028 |
| | AC Score | -.065 | .634 | -.011 | -.103 | .918 |
| | $R^2$ = .049 F = 2.497 (4, 95) $p$ = .088 | | | | | |
| Step 3 | | | | | | |
| | Sex | .076 | .173 | .045 | .437 | .663 |
| | Age | -.008 | .009 | -.098 | -.939 | .350 |
| | FSSC Fear | .703 | .307 | .230 | 2.288 | .024 |
| | AC Score | -.085 | .637 | -.014 | -.134 | .894 |
| | Fear-AC | -1.551 | 2.522 | -.064 | -.615 | .540 |
| | $R^2$ = .004 F = .378 (5, 94) $p$ = .540 | | | | | |

**Table 7.**

*Hierarchical Regression Analysis of Child FSSC Fear and Child CBQ Inhibitory Control Predicting Attention Bias to Snakes*

| | | B | Std. Error | Beta | t | Sig. |
|---|---|---|---|---|---|---|
| Step 1 | | | | | | |
| | Sex | .141 | .180 | .079 | .782 | .436 |
| | Age | -.012 | .009 | -.136 | -1.349 | .180 |
| | $R^2$ = .028 F = 1.438 (2, 99) *p* = .242 | | | | | |
| Step 2 | | | | | | |
| | Sex | .137 | .176 | .077 | .782 | .436 |
| | Age | -.011 | .009 | -.121 | -1.229 | .222 |
| | FSSC Fear | .805 | .329 | .245 | 2.445 | .016 |
| | CBQ IC | -.042 | .095 | -.044 | -.440 | .661 |
| | $R^2$ = .067 F = 3.589 (4, 97) *p* = .031 | | | | | |
| Step 3 | | | | | | |
| | Sex | .205 | .174 | .115 | 1.180 | .241 |
| | Age | -.008 | .009 | -.095 | -.979 | .330 |
| | FSSC Fear | .781 | .322 | .237 | 2.426 | .017 |
| | CBQ IC | -.044 | .093 | -.047 | -.476 | .635 |
| | Fear-IC | .882 | .372 | .228 | 2.372 | .020 |
| | $R^2$ = .050 F = 5.627 (5, 96) *p* = .020 | | | | | |

**Figure 1**

*Sample Matrix for Block 1: Snake as the Target*

**Figure 2**

*Sample Matrix for Block 3: Caterpillar as the Target*

**Figure 3.**

*Bar Graph of the Reaction Times (in seconds) for the Snake/Flower and Caterpillar/Flower Conditions*

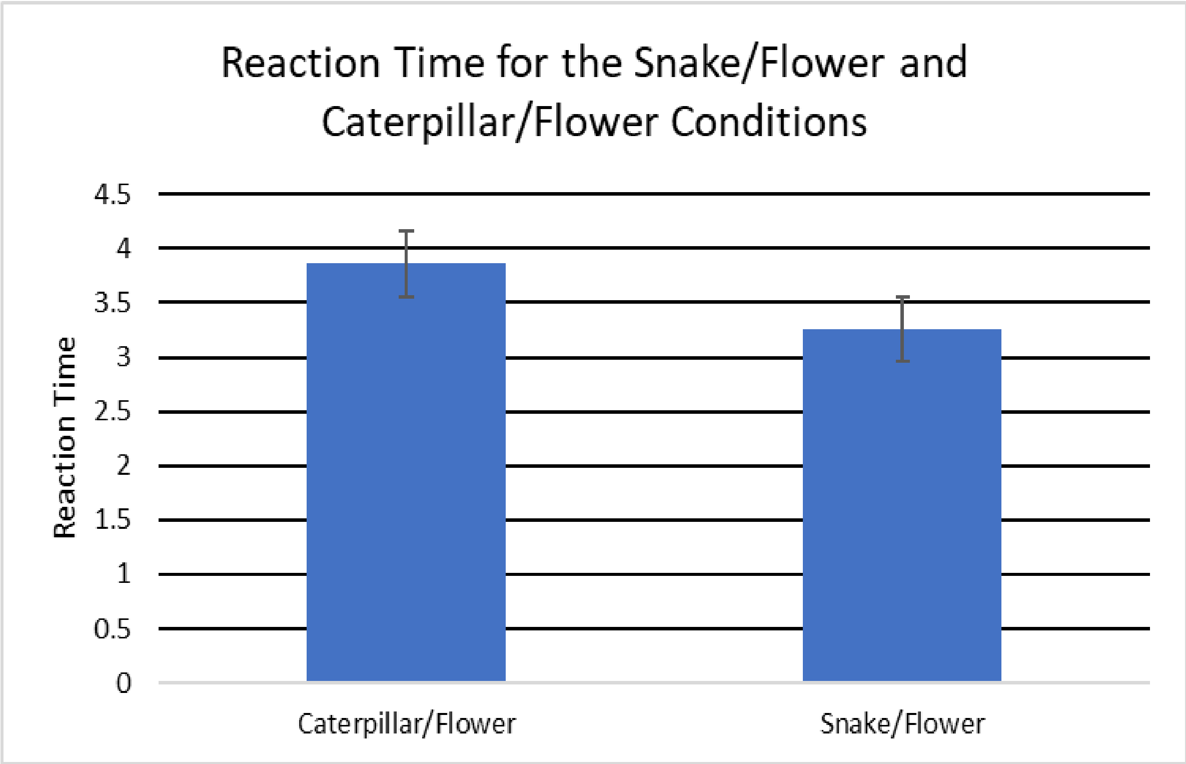
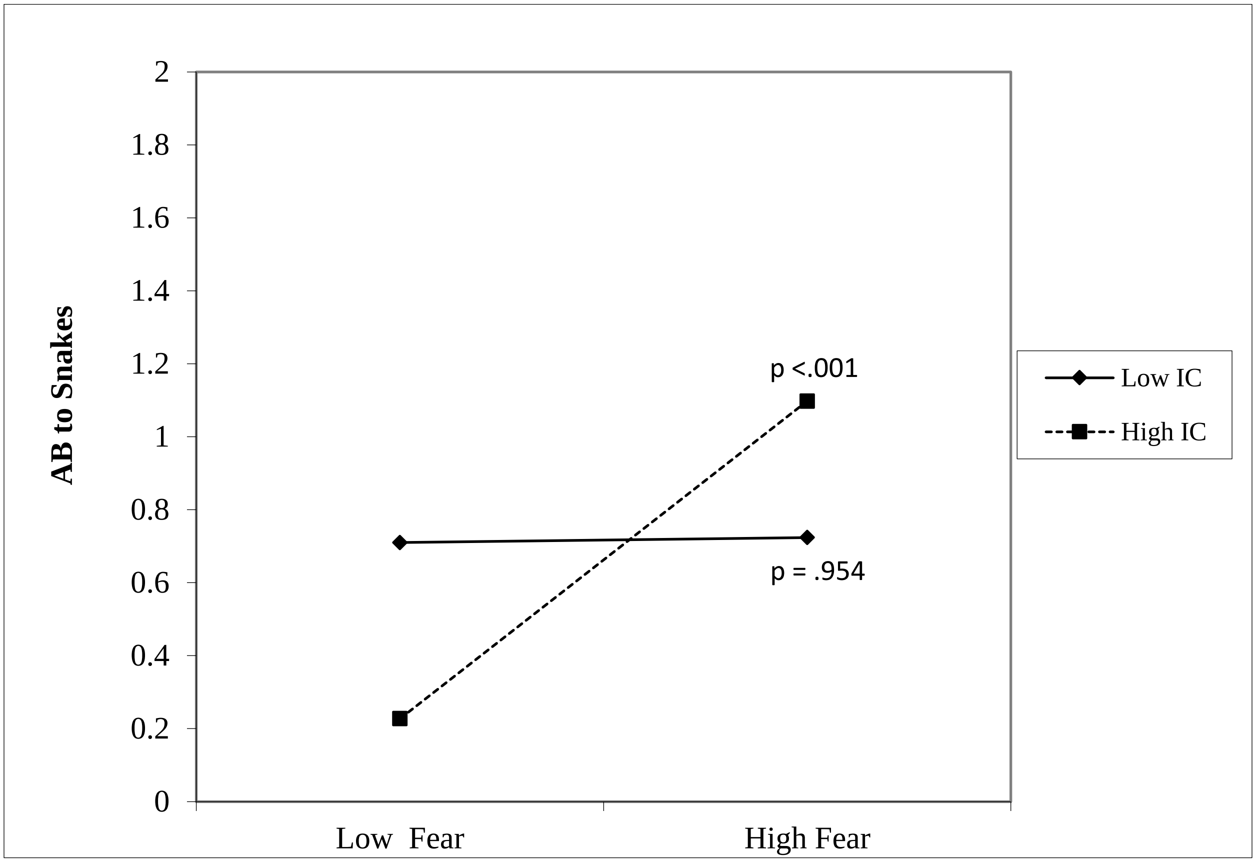


**Figure 4.**

*Child CBQ Inhibitory Control Moderates the Association Between Child FSSC Fear and Attention Bias to Snakes*




*Note*. IC = Inhibitory Control of Children.

# Appendix A – IRB Approval Letter

Office of Research Compliance
Institutational Review Board
2000 Kraft Drive, Suite 2000 (0497)
Blacksburg, VA 24060
540/231-4606 Fax 540/231-0959
email irb@vt.edu
website http://www.irb.vt.edu

**MEMORANDUM**

**DATE:** April 5, 2013

**TO:** Martha Ann Bell, Anjolii Diaz

**FROM:** Virginia Tech Institutional Review Board (FWA00000572, expires May 31, 2014)

**PROTOCOL TITLE:** Temperament Differences in Emotion Regulation in Infancy and Childhood: Frontal EEG Asymmetry and Memory

**IRB NUMBER:** **08-277**

Effective April 4, 2013, the Virginia Tech Institution Review Board (IRB) Chair, David M Moore, approved the Continuing Review request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report within 5 business days to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

http://www.irb.vt.edu/pages/responsibilities.htm

(Please review responsibilities before the commencement of your research.)

**PROTOCOL INFORMATION:**

| | |
|---|---|
| Approved As: | **Expedited, under 45 CFR 46.110 category(ies) 6,7** |
| Protocol Approval Date: | **April 28, 2013** |
| Protocol Expiration Date: | **April 27, 2014** |
| Continuing Review Due Date*: | **April 13, 2014** |

*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

**FEDERALLY FUNDED RESEARCH REQUIREMENTS:**

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals/work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

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VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
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| Date* | OSP Number | Sponsor | Grant Comparison Conducted? |
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* Date this proposal number was compared, assessed as not requiring comparison, or comparison information was revised.

If this IRB protocol is to cover any other grant proposals, please contact the IRB office (irbadmin@vt.edu) immediately.