Impacting factors for attention in children who are internationally adopted

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Impacting Factors for Attention in Children Who Are Internationally Adopted

by

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Abstract

Internationally adopted (IA) children often have attention deficits related to the unique experience they have with early-life stress. The current study focused on how elements of the care experienced by IA children related to attention deficits. Specifically, this study assessed how length of care and type of care related to attention. The study assessed attention using parent report questionnaires, the Colors Flanker Task, and event-related potentials (e.g., Error related negativity, N2). A post-hoc analysis of a pre-existing data set included 96 IA children ages 5-10. The main finding indicated that children cared for in foster care over time were rated by parents as less impulsive and had lower parent ratings of Attention Deficit Hyperactivity Disorder than children cared for in institutional facilities. These results support the idea that foster care placement in earlier childhood may be a helpful intervention for attention problems in IA children.
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Introduction

International adoption (IA) is the process by which a parent takes legal custody of a child from the child’s country of origin to another (Felix, 2014). In 2018, out of 4,059 international adoptions, about half of these children were female (52.1%), most were ages 5-12 (32.5%), and largely their country of origin was China (Bureau of Consular Affairs, 2018). IA predominantly began in the 1940s and was largely attributed to the need to home children after World War II (Felix, 2014). Throughout its history, IA has served to remove children from environments during times of strife. China’s one-child policy, the Korean War, and natural disaster in Haiti are a few examples that led to humanitarian efforts to adopt. The 1980s saw an increase for IA, which peaked in 2004 and has been dropping since. International adoptions have steadily decreased amidst controversy about children being removed from their home country, and the implications that removal has for their future. As discussed by McCall et al. (2016), policy surrounding IA is varied. Noted issues include child buying, corrupt private agencies, vulnerable families being targeted, and profit seeking. IA is controversial in some countries, with some going as far as banning it. Regardless of its decline, IA has increasingly become accepted as an option for people seeking to become parents.

Internationally adopted children can be cared for in several different settings before placement in an adoptive family (i.e., institutional care facilities and foster care systems). Institutional care at an early age is related to increased rates of persistent attention and social problems (Gunnar et al., 2007). A core concept in the literature is early life stress (ELS) or early life deprivation (Behen et al., 2009; Faturi et al., 2010; Heim et al., 2003; Loman et al., 2013; McClelland et al., 2011). In a setting where a child is not with their birth parent, or an alternative family, institutional care does not often provide the same environment one would expect a child
to have. This includes not having consistent access to a caregiver, having different caregivers, and having limited or no access to engaging stimuli. Lack of consistency does not allow these children to form secure bonds with a caregiver, and often their psychosocial needs are not being met (Merz & McCall, 2010). This lack of proper care, or deprivation, is stressful for developing children and may lead to a plethora of future pathologies including attention problems. Quality of caregiving in early life is predictive of a child’s distractibility, which is a precursor for hyperactivity (Carlson et al., 1995). In a sample of children with attention deficit hyperactivity disorder (ADHD), inattention was significantly related to maltreatment, including supervision neglect, physical neglect, physical abuse, and contact sexual abuse (Ouyang et al., 2008). IA children can be exposed to similar experiences in their care and could be at the same risk for attention deficits. Furthermore, disruption in attachment is related to the levels of inattention/overactivity. In a sample of United Kingdom adoptees, this relationship was noted, and this inattention was persistent at a two year follow up (Kreppner et al., 2001). Thus, early experiences between caregivers and IA children appear to be predictive of later difficulties in other domains, including physical development, brain development, and behavior.
**Deficits**

Adopted children experience deficits in various areas of development as compared to their non-adopted peers. For example, Dalen and Theie (2014) found initial lags in gross motor development and a consistent delay in communication skills. Additionally, when children experience early deprivation, physiological systems involved in helping humans cope with stress can become overactive; this can lead to growth delays or stunting (Faturi et al., 2010; Johnson et al., 2011; McClelland et al., 2011; Nelson et al., 2007). These delays might take many forms, but commonly include the following: At time of adoption, such children often have smaller head circumference, lower weight, higher rates of iron deficiency, and growth deficits. Three key predictors include malnutrition, a lack of sensory stimulation, and inconsistent access to a caregiver (Johnson et al., 2011; Nelson et al., 2011). In particular, malnutrition leads to further impairment; for example, iron deficiency can play a role in improper development of the brain, as iron is a necessary micronutrient for brain growth.

Across multiple imaging techniques, abnormal structure, function, and metabolism of the brain are noted for IA children. Positron emission tomography of adopted 8-year-olds showed reduced metabolism in select regions of the prefrontal cortex and the temporal lobe (orbitofrontal cortex and the amygdala) that were associated with impairments in impulsivity, attention, and social skills (Nelson et al., 2011). Additionally, Behen and colleagues (2009) reported that children placed in orphanages from birth are more likely to have an inattentive/overactive phenotype. The study used diffusion tensor imaging and found for children who experience early deprivation there was a reduced probability of connective tracts to the right frontal pole, and increased probability of connection of striatal projections in the cortex. These variations in connections were related to more externalizing behavior problems (e.g., acting out, aggression,
impulsivity). Areas involved in higher cognitive functioning were also found to have white matter connectivity issues, specifically related to attention, inhibition, impulse control, and planning (Nelson et al., 2011). Similarly, Behen and colleagues (2010) found reduced organization of frontal, temporal, and parietal white matter in children with histories of early deprivation. Reduced volume of the superior-posterior cerebellum mediated performance on neuropsychological tests for postinstitutionalized children from Eastern Europe, with lower volume meaning worse performance on tasks of memory, executive function, and attention (Bauer et al., 2009). Variation in brain development in areas of higher cognitive functioning is related to behavior differences seen in IA Children.

Behavior deficits for IA children are seen in cognitive control, emotion regulation, and attention (Chugani et al., 2001). Common behavior problems are externalizing, internalizing, ADHD, learning disabilities, and mental health disorders; in one study, 38% of the study’s sample had more than one of the listed behavior problems (Miller et al., 2009). Additionally, when children experience early deprivation, systems involving stress can be overactive, and this is associated with the development of learning and memory impairments, and cognitive functioning deficits (Faturi et al., 2010; Johnson et al., 2011; McClelland et al., 2011; Nelson et al., 2007). Finet and colleagues (2018) and Rutter and colleagues (2001) found that with more deprivation in early life there are more attention problems in internationally adopted children. Having postinstitutionalized status was also associated with greater attention problems (Gunnar et al., 2007). Similarly, Stevens et al. (2008) found that inattention and overactivity have a strong relationship with institutional deprivation. In a sample of children adopted from former Soviet Russia, 42% of its participants had ADHD. Furthermore, symptoms of ADHD were the second most prevalent disorder in the sample (Beverly et al., 2008).
The type of neglect experienced in early life can create variation in the specific deficits for each IA child. For example, in a review, Heim and colleagues (2003) discussed that abnormalities or deficits are noticed in the hypothalamic pituitary adrenal axis and neuroendocrine systems of children with ELS. Type of ELS, the age of onset, and the duration of exposure to early life stress are all important factors (Heim et al., 2003). Based on these findings, the current study will focus on the effects that length of care and type of care (i.e., institutional care, foster care) can have on levels of attention in IA children.

**Length of Care**

Deficits are evident for IA children in several domains with any exposure to ELS, but it is important to understand if longer exposure can lead to more severe deficits. Longer amounts of time spent in an institution, as opposed to foster care or an adoptive family, is associated with higher deficits overall (Fjell et al., 2012; Govindan et al., 2010; Miller et al., 2009; Nelson et al., 2011, Nelson et al., 2007). Additionally, Behen and colleagues (2010) found that magnitude of white matter disorganization is associated with the duration of stay in an orphanage. Furthermore, older age at adoption is related to more behavior problems (Merz & McCall, 2010). Socioemotional difficulties affecting several behaviors are evident; length of care is related to disinhibited social behavior and negatively related to cognitive control (Bruce et al., 2009).

Specifically, for attention deficits, Beverly and colleagues (2008) found that for girls adopted from Russia, if adopted at 36 months of institutional care or greater, they were four times more likely to have ADHD than girls adopted with fewer than 36 months of care. Similarly, Gunnar et al. (2007) found greater attention problems for IA children who were exposed to 24 or more months of institutional care. A higher age at adoption was shown to be associated with more
ADHD symptoms with each additional month of institutional care increasing these symptoms (Roskam et al., 2014).

Further, duration of deprivation had a significant effect on levels of inattention/overactivity for United Kingdom adoptees which was persistent (Kreppner et al., 2001). However, there is some evidence from electroencephalography (EEG) alpha band waves, which are associated with alertness, that shows children can improve their attention. Children were removed from institutional care and placed in foster care; their alpha waves were subdued before placement, and they increased after placement (Vanderwert et al., 2010). Length of deprivation as reported on the Child Behavior Checklist for Romanian orphans found that at ages 4.5, 10.5, and 17, compared to controls, these children had significantly higher scores for inattention/overactivity which were at a borderline clinical level. Furthermore, Romanian orphans who had 8 or more months of deprivation were significantly more inattentive/overactive than those with 4 months or less deprivation. Kreppner and colleagues (2001) found a positive correlation between length of deprivation and inattention/overactivity, and this effect did not fade with time (Audet & Le Mare, 2010; Maclean, 2003).

The current study plans to add to the current literature, which does not have a clear consensus on the specific length of exposure to a care system that is necessary to show noted changes in attention. In addition to the length of exposure to ELS, it is important to understand if differences between types of care can create more severe deficits. If longer exposure to ELS can affect attention levels for IA children, it is also possible that dynamics of ELS in different types of care can affect attention as well.
Type of Care

There are various care systems that exist for children not with their birth families (i.e., institutional care and foster care systems). Institutional care refers to the general placement of children in grouped settings that focus on sheltering and assessing children and may also help to prepare them for placement with families. This type of care can vary as a function of several factors including: size of the groups, emergency placement, institutions that have their own schooling internally, and whether the institution focuses on changing the behavior of the children or only focuses on getting children placed (Barth, 2002). Foster care generally refers to the placement of children into homes with a family. These children can be placed in with their siblings, with other foster children, or they can be placed individually. Additionally, foster care placements can be with a relative or with non-relative care takers (Barth, 2002). Currently, most research on this topic often discusses institutional care and foster care in their broad sense and do not always discuss the factors that may vary an experience in that setting (e.g., size of groups, individual or non-individual placement). Foster care is more likely to be a one-on-one connection with a child than institutional care as institutions often have larger grouped settings. As discussed previously, some of the main risk factors contributing to early life stress are disruption of attachment, access and consistency of a caregiver, and access to food and stimuli (Kreppner et al., 2001; Merz & McCall, 2010; Ouyang et al., 2008). In a foster care setting, it is possible that due to the less grouped nature, a child would have more access to a consistent caregiver, food, stimuli, and the ability to form an attachment. Broadly speaking, there are differences noticed between institutional care and foster care regarding IA children’s attention. Inattention and overactivity has a strong relationship with institutional deprivation (Stevens et al., 2008). Based on parent and teacher report, higher levels of hyperactivity and inattention were found for
institutionalized children compared to foster children; both groups had higher levels of these symptoms as compared to control participants (Roy et al., 2000). On attention and inhibitory control tasks, children cared for in institutions performed worse than peers in both foster and control settings (McDermott et al., 2012). Specifically, on several cognitive control and attention tasks, children at 8 years old in institutional care were less accurate and slower to respond than those in foster care. Additionally, when compared to controls, both types of care had diminished attention processing. Furthermore, this effect is reflected in EEG recordings of alpha waves; Vanderwert and colleagues (2010) removed children from institutional care and placed them with foster families at 8 years old. The authors discussed that alpha wave are often used as an assessment of attention and alertness as well as information processing. After placement, the children’s alpha waves increased, which suggested they were suppressed before placement. This study brings to light an interesting dimension that current study plans to address: What is the interaction between length of care and type of care? Would behavioral measures improve scores similarly? The current plans to address these questions by assessing the length of exposure of IA by type of care on both flanker performance and behavioral assessments. In addition to type of care, dynamics of gender may have effects on levels of attention in IA children.

**Differences for the Sexes**

Research that assesses sex differences in the attention of adopted children is lacking in the literature. This gap may be due to sex often being a confound due to unequal amounts of sexes being adopted in certain regions (e.g., China’s one-child policy). There is some evidence to suggest that inattention related to early deprivation and ELS is higher in boys than for girls (Stevens et al., 2008). For example, one study that examined this topic found that the accuracy of responses on a measure of selective attention (i.e., flanker task) was lower in boys than for girls.
(Loman et al., 2013). However, beyond these two examples, most studies do not report findings related to sex difference in their studies. The current study is an attempt to further our knowledge related to this questions. There is a large body of research about ADHD that can give insight about which children may be at most risk for attention deficits. Data analyzed from the Bergen Child Study found that boys had higher scores on measures of inattention/hyperactivity based on teacher reports for children ages 7-9 years (Ullebø et al., 2012). Teachers rated boys higher than girls for disruptive behaviors disorders, including ADHD. This effect was not noticed after 11th and 12th grade (Evans et al., 2013). Russian adopted boys were 1.69 times more likely to have ADHD than girls (Beverly et al., 2008). Roskam and colleagues (2014) found a noted sex difference in ADHD symptoms with more prevalence in boys. However, there is some research to suggest mixed results, showing no significant difference between sexes (Biederman et al., 2005; Faraone et al., 1995). The current study will take an exploratory approach to investigate the effects of sex on attention by assessing countries of origin that have more equal distributions of sex.
Flanker

The flanker task is an assessment of how well a participant can pay attention to a target stimulus amid other distracting (flanking) stimuli, which makes it both an assessment of attention and inhibitory control. Eriksen and Eriksen (1974) needed to understand what effect visual distractors—“noise”—could have on searching tasks. Therefore, the flanker task was created such that no visual search was required. Eriksen and Eriksen (1974) wanted to see if adding noise to a target letter stimulus changed reaction times (RT) to identify that letter when compared to having no noise, even if the letter stayed in a constant position. In the original test, two central target letters are surrounded by either the same stimuli or by differing stimuli (e.g., H target surrounded by H’s, or H target surrounded by K’s). Participants are presented with a row of seven stimuli, in Eriksen and Eriksen’s (1974) case, seven letters in a row. Participants in Eriksen and Eriksen’s task pressed a lever in one direction for a target H and one direction for a target S. Trials can either be congruent or incongruent; congruent trials are those with the target stimulus surrounded by the same stimuli, and incongruent trials are those with the target stimulus surrounded by differing stimuli (e.g., HHHHHHH, KKKHKKK). The test is designed to make the participant selectively attend to the target stimulus and monitor conflict by only responding to the target stimulus amidst distracting stimuli. The test was conducted on a small sample ($N = 6$) of undergraduate and graduate students at University of Illinois. The main analyses found that presenting any amount of flanking into a target search task increases the amount of time it takes to identify the target, even when the target letter’s location is held constant. Noise effects were due to response competition and not simply a “distraction effect.” Participants attended to the target stimulus and then discriminated from there; they do not view the whole string of letters before its parts, meaning that the target stimulus is “competing” for the participants attention
(Eriksen & Eriksen, 1974). Therefore, differences in response time and accuracy are a measurement of how well the participant can attend to the target and deal with the incorporated conflict.

The noted slower reaction times when noise is incorporated have been well documented in studies after the original study by Eriksen and Eriksen (1974). Additionally, there are several studies that support the flanker task as a measure of selective attention (Larson et al., 2012; Servant & Logan, 2019; Yeung et al., 2004). Servant and Logan (2019) confirmed that the flanker task is a measure of selective attention where participants focus on the central target and discriminate from this point. Furthermore, several patterns of response times are evident in the literature that further support the work done by Eriksen and Eriksen (1974). When trials are incongruent, participants take longer to respond than congruent trials, which is consistent with the flanking “noise” effect (Larson et al., 2012). Most errors are made on incongruent trials where there is a higher amount of noise (Yeung et al., 2004). Regardless of trial type, when participants commit an error, they have shorter reaction times, suggesting an impulsive response (Torpey et al., 2009). Trials that occur after an error take longer for participants to respond; this effect is called post-error slowing (Torpey et al., 2011). All of this suggests a pattern of impulsive responding, meaning that participants make a quick response, detect an error and then adjust their responding for the next trial.

It has been argued that the original flanker task is not well adapted to children, specifically due to cognitive restraints during earlier development (McDermott et al., 2007). For this reason, an adapted flanker task was created. McDermott et al. (2007) conducted a study of the flanker task to assess if adaptations of the stimuli in the paradigm were stable measures of selective attention. Additionally, the study assessed whether the adapted paradigm was
accurately able to measure selective attention in children ages 4 to 6. Other paradigms have been created using arrows (Henderson, 2002; Ridderinkhof et al., 1997), geometric shapes (Enns & Ahktar, 1989), and fish (Rueda et al., 2004). McDermott et al. (2007) tested variations of color, dimension (shapes), and direction (fish). Each variation of the flanker paradigm began with eight practice trials followed by blocks that included the varying stimuli (red and green circles, black and white shapes, and fish facing left or right). The study found that all three adaptations reproduced the noise effect, such that incongruent trials had slower reaction times than congruent trials. Four-year-olds had significantly slower reaction times than 6-year-olds. Faster reaction times were associated with higher percentage error. These results comply with the idea that faster responding can be due to both mastery of the task and impulsive responding (McDermott et al., 2007). Overall, McDermott and colleagues (2007) found the adjusted flanker tasks to be stable measures of selective attention in children ages 4 to 6.

Additionally, McDermott and colleagues (2007) assessed behavioral monitoring and response control. Both of these concepts are related to post error slowing in the flanker task. Behavioral control is a compensation that occurs after an incorrect trial, whereas response control deals with trial-to-trial performance. Response control reflects levels of control or impulsivity related to a participant’s reaction times. If an individual is higher in behavioral control, after an incorrect response there should be more controlled and slower responses. Results on behavioral control and response control in the sample of children ages 4 to 6 showed that reaction times slowed after incorrect trials; this suggests a level of behavioral control such that participants slow down to compensate for their incorrect response. This pattern is consistent with the post-error slowing seen in the original flanker task, and subsequent studies using the
flanker on adults. This adds support to adjusted flanker tasks being stable measures of selective attention in children ages 4 to 6.

The adjusted flanker tasks from McDermott and colleagues (2007) matched the results of the original flanker task well, even with the substantial age difference from the original sample. However, the authors discussed that regulatory behavior for impulsivity (response control and behavioral control) are influenced by factors other than a child’s age. This is supported by other studies that use both the flanker and other associated tasks of cognitive control such as the go/no-go task (Lewis et al., 2006; Torpey et al., 2011). While there is some support for age being a less important factor, age is cited to affect performance on attention and cognitive control tasks. For example, Lewis and colleagues (2006) found that older children were more accurate on a go/no-go task. Older children have both higher accuracy and faster response times. On trials where an error was committed and therefore a response time was recorded, for all children the no go response times were faster than go response times, which was argued to relate to greater impulsivity. Similarly, Torpey and colleagues (2011) found that older children responded faster than younger children overall, including responding quicker when they committed errors. For correct go trials following an error, younger children responded slower than older children, suggesting a trend of more impulsive responding in older children in trials after errors. However, while quicker to respond, older children had more correct go trials than younger children, and older children were more accurate than younger children. Overall, this shows a trend of more accuracy and more impulsivity or efficiency with age.

In sum, the flanker task and the effects of flanking a target stimulus have been replicated in various studies (Larson et al., 2012; Servant & Logan, 2019; Yeung et al., 2004). Additionally, this task has been shown to measure attention in children as young as 4-6 years old when
adaptations are in place (McDermott et al., 2007). It is a useful measure when considering children who have been internationally adopted who can experience behavioral problems with their attention and impulsivity. For example, Loman et al. (2013) found that post-institutionalized children had lower accuracy on both congruent and incongruent trials of the flanker task than their never adopted peers. Additionally, age at adoption was negatively related with overall accuracy on the flanker. When paired with physiological indicators, the flanker task can give a broader understanding of the underpinnings for exhibited behavioral deficits in attention. Specifically, EEG has commonly been paired with behavioral measures of both cognitive control and attention.
**Electroencephalography and Event-Related Potentials**

Electroencephalography (EEG) is a physiological index of electrical activity happening in the cortex. An electroencephalogram shows the waveforms of that electrical activity. Changes in the waveform in microvolts (mV) are related to events occurring during that scan. Event-locked changes in the waveform are called event-related potentials (ERPs). There are various stereotyped negative deflections and positive deflections of waveforms that are related to different events. For the current study, we will discuss some of the ERPs related to error detection, error processing, inhibitory control, and attention, along with their relationship to the flanker task.

**Error-Related Negativity**

Error-related negativity (ERN) is an ERP that has a negative deflection and is response locked to an error. An ERN begins at the behavioral onset when an error is committed. ERN can be elicited in children as young as 5-7 years old (Torpey et al., 2009).

ERN is not error correction; it is seen in both corrected and uncorrected trials of a choice reaction task (Falkenstein et al., 2000). ERN is also present in go/no go tasks when the participant makes a mistake, and this task does not allow for correction. When there is pressure because of a time limit, meaning that there is less time allotted to respond, there is lower response time (RT) and higher error (Hajcak, 2012). ERN amplitudes decrease during this heightened time pressure. Smaller ERN amplitudes are not related to shorter or faster RT, but to the higher level of error within this pressured condition.

ERN amplitudes were shown to be larger when participants rate their accuracy than when they do not, regardless of whether they were aware of their error or not. This work is in support of a previous study that found, during a flanker task, there were greater ERN amplitudes when
there was more focus on accuracy of responses than on speed (Gehring et al., 1993). These results suggest that ERN is a generic error-detection mechanism, which would align with results showing that ERN amplitudes are present even when a participant is unaware of their error (Grützmann et al., 2014; Hajcak, 2012). This suggests that ERN can be noted in EEG without the need of the participant to be cognizant of their errors. Furthermore, it is argued that ERN is not specific to types of errors and that it can occur for errors of choice, action, or time-estimation (Miltner et al., 1997).

There is evidence to suggest that the anterior cingulate cortex (ACC) is involved in the activation of ERN (Davies et al., 2004; Ladouceur et al., 2004; Ladouceur et al., 2007; Larson et al., 2012). Additionally, Davies et al. (2004) found that ERN amplitude increases with age, which supports the idea of a model based around development. The ACC develops similarly to the areas involved in cognitive control (i.e., frontal cortex); therefore as the ACC develops, so does the production of ERN. However, there is some dispute over when the ERN begins to be present. Ladouceur and colleagues (2004) found that ERN had greater amplitude for errors for older adolescents, but not for younger adolescents. The study’s results suggest that while early adolescents are able to be aware of error, being able to monitor conflict created by error does not occur until later as a part of developing cognitive control which incorporates the ability to plan, organize, and schedule mental operations (American Psychological Association, 2018). Younger adolescents had generally greater negativity for error trials than for correct trials that are associated with post-error adjustment. ERN may only be present in early adolescents when performance adjustment is utilized. This would add evidence to ERN being a part of the cognitive control system. The data supports the idea that as the ACC develops with age, so do ERN amplitudes (Ladouceur et al., 2004). Ladouceur and colleagues’ (2007) subsequent work
found that ERNs were elicited with error trials having a more negative deflection than correct trials, but this was only seen in the adult and the older adolescent groups. In adults, ERN amplitude predicted their performance on a flanker task. A large amount of variance in ERN amplitude was explained by activation in the ACC. This is in accordance with the idea that the ERN is late to mature and matures with the ACC (Ladouceur et al., 2007). In contrast to Ladouceur and colleagues (2007), other studies have found that younger children have ERNs but at varied amplitudes compared to their older peers. Torpey and colleagues (2011) found that older children simply had a larger ERN (more negative) than younger children. Although there is debate over the age of onset for ERN, there is a large amount of evidence to suggest that the ACC elicits the ERN. As the ACC develops, the noted trends with amplitude of ERN are larger (Davies et al., 2004; Ladouceur et al., 2004; Ladouceur et al., 2007; Larson et al., 2012).

Functionally, the ACC is the area of production for the ERN, but also of note is why the ERN functions in the manner it does and its evolutionary origins. Hajcak (2012) suggested that ERN is elicited as a system of evolutionary response to error making, such that when survival was more of a prominent issue, making a mistake could be fatal. Additionally, when an error is committed, physiological changes related to the sympathetic nervous system are noted. To test the hypothesis that ERN is related to a system of defense, Hajcak (2012) ran a flanker paradigm; during this task, a loud sound was made to elicit a startle response from participants. Startle responses that occurred after incorrect trials were larger than after correct trials, and larger ERN amplitudes were predictive of a larger startle response after incorrect trials. With larger ERN’s being predictive of larger startle responses, the evidence of the study would support the hypothesis that ERN is related to an evolutionary system of defense.
ERN is particularly helpful in studies utilizing the flanker task because it shows when an error occurs. Participants’ accuracy on flanker trials can be used as a measure of how well they were able to selectively attend to the target stimulus. Differences in ERN amplitude can then be paired with accuracy and response time data. For IA children who complete the flanker task, if they cannot selectively attend to the target and commit an error, the ERN amplitude can be assessed to see if it differs from their non-adopted peers. One study assessing ERN in post-institutionalized children found that their ERNs were smaller (less negative) than their non-adopted and foster care peers on a flanker task (Loman et al., 2013). This would support the notion that they are not as able to control their response as compared to their non-adopted and foster care peers.

**N2**

N2 is an ERP that is a biomarker of conflict monitoring; it is a negative deflection around 150-450 milliseconds (ms) after presentation of a stimulus (Esposito, 2015). N2 is an attention control process to focus on task relevant aspects of a situation (Tillman & Wiens, 2011). N2, similarly to ERN, is localized to the ACC and would therefore develop as the ACC develops.

N2 is a conflict between execution and inhibition (Nieuwhuis et al., 2003). Tension between execution and inhibition is the idea that in order to elicit the correct response, a participant must inhibit an immediate reaction and use cognitive resources to select the correct response. Conflict, where multiple competing response options are present, is proposed to have a higher demand for cognitive resources and can be an assessment of cognitive control. Clayson and Larson (2011) assessed N2 presentation in an arrow flanker task adaptation, specifically looking for differences between subsequent trials based on their congruence and how well participants can adapt to conflict. The study found that when the previous trial was congruent,
there were greater N2 amplitudes for the following trial. Additionally, when the current trial was incongruent, there were greater N2 amplitudes. A significant interaction effect was found for previous-trial congruency by current-trial congruency; N2 amplitudes were the lowest for incongruent to congruent trials and the highest for congruent to incongruent trials. Overall, higher amounts of conflict in the trial map on to larger N2 amplitudes. The authors claimed this as evidence of reliable adaption to conflict, and the study as a whole supports the idea that neurophysiological indices of cognitive control (N2) are sensitive to conflict adaptation (Clayson & Larson, 2011; Ladouceur et al., 2007).

N2 is present until a very fast response time and increases in amplitude and latency with increasing response time. N2 is more negative for errors than correct trials (Yeung et al., 2004). If N2 is related to monitoring of conflict, the ability to monitor conflict may be compromised if a participant is responding too quickly, leading to the cut off at faster response times.

Delayed N2 and shorter latency N2 were noted for children with ADHD and compared to controls had smaller N2 amplitudes (Johnstone & Clarke, 2009). Children with ADHD also had dramatically smaller N2 during incongruent trials on a flanker task and enhanced N2 amplitudes during neutral stimuli (Johnstone et al., 2009). This suggests that children with attention deficits may struggle to deal with the conflict in the trial effectively.

Age differences exist for N2, and noted differences are similar to ERN such that development of the brain is needed to have N2s similar to adults. Differences were noted in latency, RT, and appearance of N2. In one study, latency was longer between peaks and N2 was larger for a group of 10-year-olds than adults (20 years old and 36 years old). N2 also had a severe drop with age (Johnstone et al., 2005). In one sample, N2 had larger amplitudes for incongruent trials in the late adolescent group but not early adolescents. Similarly to ERN, N2
did not appear for younger adolescents (Ladouceur et al., 2004). Regardless of age differences, it is important for the current study to assess N2 to assess the conflict during the flanker task.

N2 is important to assess in combination with the flanker task for its ability to assess conflict. The basis of the flanker task is the amount of response conflict that is incorporated when flanking stimuli are added to a target stimulus. If participants struggle to attend and deal with the conflict incorporated, their N2 can be assessed to see if it differs from their non-adopted peers. One study found that IA children had smaller (less negative) N2s than their non-adopted and foster care peers on the flanker task (Loman et al., 2013). In combination with ERN which gives us error locked data, the N2 incorporates the conflict portion of the task. Both are important aspects in elucidating the neurophysiological underpinnings of attention for IA children.
Rationale

Early life stress and early life deprivation that are experienced by internationally adopted children can have significant impacts in several domains of life. Deficits encompass areas of growth stunting, behavioral externalizing and internalizing, ADHD, and disorganization of white matter in the cortex. Specifically, attention is affected by ELS. Length of care in an institution, and type of care system are noted risk factors associated with attention problems. When paired with a physiological indicator, such as ERP, evidence also suggests that physiologically, there are lower amplitudes of ERPs associated with cognitive control and conflict monitoring. Overall, this area of research needs to be explored further. There is not a large body of research that looks specifically at internationally adopted children during a flanker task, and the further EEG indices of attention and impulsivity. Many studies focus on non-adopted children, adolescents, and adults or only focus on EEG. The current study looks to address this gap in the current literature by investigating internationally adopted children within the context of selective attention tasks and EEG to gain the best understanding of what factors may be causing noted deficits behaviorally and physiologically. Specifically, while it is supported that length of care increases rates of deficits, it is not clear the specific length of exposure that is necessary for this effect to be noted. Additionally, the interaction between type of care and length of care is an important dimension to contextualize deficits seen for IA children. This can further elucidate dimensions of care that impacts the effects seen in attention for IA children and whether exposure to a certain type of care can either improve or decrease their outcomes.
Specific Aims

**Specific Aim 1:** To examine whether the length of care within each adoption system (i.e., foster system, adoption agency) affected the severity of deficits experienced to attention in internationally adopted children.

- **Hypothesis 1.1:** The longer a child was exposed to either foster system or adoption agency the more severe deficits (inattention/impulsivity; hyperactivity/inattention) there would be as demonstrated in MacArthur Health and Behavior Questionnaire and Strengths and Difficulties Questionnaire.

- **Hypothesis 1.2:** The longer a child was exposed to either adoption care system, the faster reaction times they would have on the incongruent trials but not on the congruent trials of the flanker task.

- **Hypothesis 1.3:** The longer a child was exposed to either adoption care system, they would commit more errors (lower accuracy) on the incongruent trials but not on the congruent trials of the flanker task.

**Specific Aim 2:** To examine whether the type of care experienced (foster care vs adoption agency) could affect the severity of deficits to attention in internationally adopted children.

- **Hypothesis 2.1:** Children cared for in adoption agencies would have higher scores than children cared for in foster care on measures of inattention and impulsivity in MacArthur Health and Behavior Questionnaire and hyperactivity/inattention in Strengths and Difficulties Questionnaire.
• **Hypothesis 2.2**: Children cared for in adoption agencies would have faster reaction times than children in foster care on the congruent trials but not on the incongruent trials of the flanker task.

• **Hypothesis 2.3**: Children cared for in adoption agencies would have more errors (lower accuracy) than children in foster care for the incongruent but not on the congruent trials of the flanker task.

**Specific Aim 3**: To evaluate the differences of the effects of length of care and type of care on attention as demonstrated on behavioral assessments and the flanker task.

• **Hypothesis 3.1**: It was expected to see differential patterns of change between type of care groups based on length of care for their performance on behavioral measures (MacArthur Health and Behavior Questionnaire and Strengths and Difficulties Questionnaire), such that there should be a significant difference between these relationships.

• **Hypothesis 3.2**: It was expected to see differential patterns of change between type of care groups based on length of care for their reaction time on the incongruent but not on the congruent trials of the flanker task, such that there should be a significant difference between these relationships.

• **Hypothesis 3.3**: It was expected to see differential patterns of change between type of care groups based on length of care for their accuracy on the incongruent but not on the congruent trials of the flanker task, such that there should be a significant difference between these relationships.
Specific Aim 4: To evaluate if type of care moderates the relationship between length of care on attention as demonstrated on behavioral assessments and the flanker task.

- **Hypothesis 4.1**: Type of care would moderate the relationship between length of care and inattention/impulsivity in MacArthur Health and Behavior Questionnaire and the hyperactivity/inattention in Strengths and Difficulties Questionnaire.

- **Hypothesis 4.2**: Type of care would moderate the relationship between length of care and reaction time on incongruent trials of the flanker task, but will not moderate the relationship for congruent trials.

- **Hypothesis 4.3**: Type of care would moderate the relationship between length of care and accuracy on incongruent trials of the flanker task, but will not moderate the relationship for congruent trials.

Specific Aim 5: To evaluate neural correlates, measured as ERN and N2, in the flanker task and their relationship with behavioral assessments, and accuracy in the flanker task.

- **Hypothesis 5.1**: Performance on the inattention/impulsivity in MacArthur Health and Behavior Questionnaire and the hyperactivity/inattention in Strengths and Difficulties Questionnaire would be correlated with amplitudes of neural correlates (ERN, N2) in incongruent trials during the flanker task but not on congruent trials.

- **Hypothesis 5.2**: Accuracy on the flanker task would be correlated with ERN amplitudes on incongruent trials of the flanker task.

Specific Aim 6: To explore sex differences on behavioral measures (MacArthur Health and Behavior Questionnaire & Strengths and Difficulties Questionnaire), as well as the ERN and N2 amplitudes of children from regions where sex is evenly dispersed.
• **Hypothesis 6.1:** Males would show higher scores on measures of inattention and impulsivity in MacArthur Health and Behavior Questionnaire and hyperactivity/inattention in Strengths and Difficulties Questionnaire.

• **Hypothesis 6.2:** Males would have faster reaction times than females on incongruent and congruent trials of the flanker task.

• **Hypothesis 6.3:** Males would commit more errors (lower accuracy) than females on incongruent and congruent trials of the flanker task.

• **Hypothesis 6.4:** Males would have lower amplitudes of ERN and N2 than females during the flanker task.
Methods

This is a post-hoc study based on a pre-existing data set from *Neural Correlates of Mindfulness and Executive Function Training in Internationally Adopted Children: A Randomized, Controlled Trial* (Esposito, 2015). All the analyses employed the pre-intervention data from the study. The relevant methods and procedures were modified from the original study for the purpose of the current study. Data from the original study was deidentified, removing any information that could be traced back to the participants in the original study. The Institutional Review Board (IRB) at Eastern Michigan University (EMU) reviewed the current study as a secondary study. Approval was granted from the IRB. The deidentified data set was shared after IRB approval was received.

Participants

Participants were 96 internationally adopted children and their families. Children were adopted from the following countries: China (n = 22), Colombia (n = 6), Guatemala (n = 21), India (n = 5), Russia (n = 14), South Korea (n = 11), Ukraine (n = 1), Vietnam (n = 3), Haiti (n = 1), Nepal (n = 2), Ethiopia (n = 6), Peru (n = 1), Taiwan (n = 1), and other not listed (n = 2). Participants were about 8 years old ranging from 5 to 10 (M = 7.86, SD = 1.50), and most were female (60.4%). Children at the time of adoption were anywhere between 3 and 60 months old (M = 15.27, SD = 12.04). Most participants had some length of care in an institution (69.8%).

A portion of participants had diagnoses of ADHD (14.5%). About 30% of participants were scored in the clinical range for ADHD based on parent reports on the Strength and Difficulties Questionnaire (SDQ; Goodman, 1997). Because stimulant-based medications can impact behavioral assessments, families were asked about any current medications for their child in order to evaluate confounds that may exist from medication schedules. Participants current
medications or treatments were not stopped during participation; any treatments were held constant throughout testing, meaning that participants took any medications or treatments in the same way on the day of testing sessions.

A phone registry of families from the Minnesota International Adoption Project was the main tool for recruitment. In addition, recruitment flyers were placed on University of Minnesota’s campus in a research building. Families in the registry marked that they were willing to be contacted for research participation and had at least one internationally adopted child. Children whose parents reported fetal alcohol syndrome, autism spectrum disorder, pervasive developmental disorder, or severe cognitive impairment were excluded from the study. Three hundred and twenty families from the initial pool of 464 were able to be contacted, all were internationally adopted ages 6-10 and lived within 50 miles of University of Minnesota. One hundred and seventeen children and their parents agreed to participate and were eligible.

Sessions were completed for 107 children of those who agreed to participate. An undisclosed autism diagnoses led to the exclusion of one participant after the initial session. This left the final sample with 96 participants.

All methods, material and procedures of the original study were approved by the University of Minnesota Institutional Review Board.

**Procedure**

The original study (Esposito, 2015) conducted extensive measures. Consent and assent were obtained before any testing and compensation was distributed. A testing session included behavior tasks and parents completing questionnaires about their child. The EEG net was applied at the beginning of the testing session and was recording during the entire Colors Flanker Task. The Colors Flanker Task began immediately after EEG net application.
Most of the measures in the original study are beyond the scope of the current study. After the IRB approval at EMU was acquired, Dr. Lawler shared the data set that included only the measures relevant to the current study. The following descriptions provide information on these measures.

**Measures**

**Demographic Measures**

The Health and Resources Questionnaire (HRQ) is a survey for demographic information including family information, education services, pre-adoption history, and post-placement history.

**Behavioral Measures**

The MacArthur Health and Behavior Questionnaire (HBQ; Essex, et al., 2002) assesses a child’s mental and physical health as well as their social and academic functioning. The HBQ has 140 items and is a parent report questionnaire. Parents reported on their child’s behavior in the past several weeks on the HBQ. Only subscales of inattention and impulsivity were included as measures of executive function. The attention subscale is six items, and the impulsivity subscale is nine items; higher scores indicate greater problems in each respective domain. The mean of the two scores from these subscales is called the ADHD subscale.

The Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997) assesses a child’s emotional symptoms, peer relationship problems, hyperactivity/inattention, conduct problems, and prosocial behavior. The SDQ is a 25-item parent and teacher report. There are additional materials (Goodman, 1999) that have parents report in addition to difficulties in the above listed domains. Parents report chronicity, distress, burden to others, and social impairment. The SDQ
was used to see how much of the sample was in the clinical range for attention deficit
hyperactivity disorder (ADHD) and emotional symptoms.

The Color Flanker Task (McDermott et al., 2007) was used to measure sustained and
executive attention. This task is completed using a computer. On the screen the child is shown a
row of five red and/or blue circles. Within this row the children must respond to the central target
circle. They press a button to indicate the color of the central target circle. The other four non-
target circles may either be the same color as the target (congruent), or the opposite color of the
target (incongruent); thus, these circles flank the target circle and participants must inhibit their
responses to accurately respond to the target circle’s color. The task has three blocks of 60 trials
(180 total); there were equal amounts of each trial type and these were presented in
pseudorandom order. A 24-trial practice round was administered, based on the accuracy in this
round, stimuli presentation length would change for each participant. Stimuli presentation
lengths possible were 250 ms, 400 ms, 550 ms, or 700 ms. During the task, feedback was
presented to children after each trial as either a smile face or a frown face.

**EEG and ERP Data Acquisition and Processing**

After consent and assent procedures, a 128 electrode Geodesic Sensor Net was applied to
the child’s head by a trained experimenter and the net was adjusted until all impedances were
below 100 kΩ. Netstation software was used to record continuous EEG during the Colors
Flanker Task. Trials during the task with no response were excluded, likely and non-responses
would be due to lapses of attention. All data were collected using a sampling rate of 500 Hz and
were referenced to Cz. A bandpass filter of .01-30 Hz was used before initial baseline correction
and segmentation. Segments that were stimulus locked ranged from -400 to 600 ms post
stimulus, and segments that were response locked ranged from -400 to 250 ms. Movement-
related artifacts and eye blinks were automatically removed by an automated artifact detection program. Trained research assistants visually reviewed all data files to ensure the automated program was accurate in its removal of artifacts, any manual edits deemed necessary were completed. Any segments with 15 bad channels or greater were removed. ERP averages for each participant were created, any bad channels were replaced with imputed waveforms, waveforms were re-referenced to the average of all channels. Stimulus locked waveforms were baseline corrected from -200 ms to stimulus offset. Baseline corrections were also completed for response-locked components from -300 ms to -100 ms before response. The average waveform of positive feedback and the average waveform for negative feedback trials were subtracted to create a difference waveform for feedback trials. These waveforms were assessed to make sure that these differences did not make any novel artifacts. All data were drawn from three channels all midline and frontal: 6 (CFz), 11 (Fz) and 16 (AFz). ERP components were drawn from specific time ranges; N2: 250-400 ms post-stimulus, and ERN: 0-100 ms post-response. An adaptive mean was computed, this is defined as the average amplitude for 25 ms on either side of the minimum value.

Data were lost for three participants due to a hardware failure. ERP data during the flanker task were removed because of behavioral performance (15.6%). After artifact scoring of the flanker task, 56% of stimulus-locked trials, 66% of response-locked trials were retained, and 36% of feedback-locked trials were retained for this task.
Data Analysis

All variables of interest were checked for normality, skewness, and kurtosis. If significant non-normality, skewness, or kurtosis were found, the data was evaluated and transformed to meet the needs of the assumption. Most analyses were Pearson correlations; therefore, in addition to normality, skew, and kurtosis, variables were checked for linearity, homoscedasticity, and outliers. For Specific Aim 2, one-way analysis of variance (ANOVA) was used. The data for this aim was assessed for independence, outliers, and homogeneity of variance. For Specific Aim 3 and 4, regressions were used and the additional assumptions of normality, linearity, and homogeneity of variance of the model residuals were tested. Finally, Specific Aim 6 used T-tests and had the same assumptions as correlation and therefore was already checked for the assumptions of this test. If transformation of the data was necessary, the specific transformation was determined by the severity of the assumption violation. After all assumptions were met, statistical analyses were run.

For Specific Aim 1, all hypotheses were concerned with the relationship of length of care and measures of attention. Therefore, Pearson’s correlations were run to assess whether a significant relationship exists between the variables of interest. Additionally, it was assessed if the correlation matches the hypothesized direction.

For Specific Aim 2, all hypotheses were concerned with the difference between children in foster care and in adoption facilities on measures of attention. However, the current study has children who, before placement, only received foster care, only received adoption agency care, children who had exposure to both, and children who had none of these. Therefore, for this analysis an ANOVA was used to determine if there was a significant amount of variance.
between each of these groups. Post-hoc contrasts can elucidate the differences that exist between groups, specifically, between children cared for in adoption facilities and foster care.

For Specific Aim 3, all hypotheses were concerned with the differential patterns of change for specific outcome variables. To conduct this analysis, regression models were created to see the overall relationship between variables of interest. Integral to this aim are the differences between these regressions. For this, Fisher’s Z transformation and critical limits of Z were used to assess significance of difference between each model.

For Specific Aim 4, the hypotheses were concerned with a moderation relationship between variables. To assess for moderation regression models were created between variables for each path of the moderation model to determine the significance of the moderation model as a whole.

For Specific Aim 5, the main hypothesis was concerned with the relationship between neural correlates and performance on measures of attention (HBQ, SDQ, flanker). This aim used Pearson’s correlation to see whether significant relationships exist between key variables.

Finally, for Specific Aim 6, an exploratory approach was used to assess differences between sexes on measures of attention (HBQ, SDQ, & flanker) and ERPs. To avoid confounds from the rates of sexes being adopted internationally from each country, countries with the most even distribution of sexes in the sample were explored for any group differences.
Results

Assumption Tests

All key study variables were assessed for normality, skew, and kurtosis. None of the key study variables were significantly kurtotic. Nine variables violated the assumption of normality when using Shapiro-Wilk’s Test: length of care in institutional care facilities, length of care in foster care, HBQ impulsivity subscale scores, HBQ attention subscale scores, SDQ scores, flanker accuracy for congruent trials, flanker accuracy for incongruent trials, flanker reaction time for correct congruent trials, and Flanker ERN amplitude.

However, Shapiro-Wilk’s Test when used in larger sample sizes is prone to be significant for small amounts of non-normality, for the current study this could be an issue ($n = 96$). We can instead use skew.2SE values to assess normality. Skew.2SE values are the skew divided by two times the standard error. This value is similar to assessing normality using z-scores with a z-score cutoff of 1.96 in either direction. Skew.2SE values greater than one, both positive and negative, are considered to be severely non-normal and should be considered for transformation (Field et al., 2012). All nine non-normal variables were further assessed by looking at skew.2SE values. Any variable that is not skewed by this criterion is not considered problematic and the raw data will be used in analyses.

After assessing skew.2SE values, three variables were considered to be non-normal and in need of transformation: length of care in institutional care facilities, length of care in foster care, and flanker accuracy for congruent trials. Length of care in institutional care facilities and length of care in foster care both passed the assumption of normality after logarithmic transformations. Within each analysis for the five specific aims these logarithmic transformed variables will be compared to the non-transformed variable to see if the significance of the test
changes with the transformed variable. If the significance is no different between these two, then raw data will be used for the analysis. Flanker accuracy for congruent trials was not able to become normal with either a square root or logarithmic transformation therefore raw data will be used.

Additional assumption testing is needed for each specific statistical test used in each aim. These additional tests and their results will be listed in the relevant aim below.

**Specific Aim 1**

The first aim was to examine the relationship between length of care and parent rating scores on measures of attention problems, impulsivity, and hyperactivity. Because this aim is correlative, the additional assumption of linearity was tested. Scatterplots with trend lines were created to assess the shape of the data and make sure there were no non-linear shapes. All variables were found to be linear.

The first hypothesis was that longer exposure to a care system would result in higher scores on measures of attention problems, impulsivity, and hyperactivity. Results showed that length of care in adoption care facilities was significantly related to scores of impulsivity on the HBQ ($r(79) = .22, p = .03$; see Figure 1). There were no significant relationships between length of care and the SDQ, or length of care and the other subscales on the HBQ.

The second hypothesis was that longer exposure to a care system would be related to faster reaction times on incongruent trials of the flanker task. Results showed there was no significant relationship between length of care and reaction time on trials of the flanker task in either care system.
The third hypothesis was that length of exposure to a care system would be related to lower accuracy of incongruent trials of the flanker task. Results showed no significant relationship for incongruent trials.

**Specific Aim 2**

The second aim was to examine the difference in parenting rating scores on measures of attention problems, impulsivity, and hyperactivity between children cared for in adoption agencies, children cared for in foster care, and children cared for in both. One-way analysis of variance (ANOVA) was used for this aim. The additional assumption of homogeneity of variance was assessed for key variables. Boxplots were created to visually compare variability of HBQ and SDQ scores by care type; none of the boxplots indicated a large difference in variability for any key variables. Levene’s Test was then conducted for all key variables; none of the variables violated the assumption of homogeneity of variance. It also necessary to make sure that all model residuals are normal. Several models came back with non-normal residuals: scores on the SDQ, flanker accuracy for congruent trials, flanker accuracy for incongruent trials, flanker reaction time for correct congruent trials, and flanker reaction time for correct incongruent trials. Each of these variables were transformed and retested to see if residuals became normal. Only two model residuals became normal after substituting with square-root transformed variables: flanker reaction time for correct congruent trials and for correct incongruent trials. However, neither model was significant before or after transformation.

The three hypotheses of this aim were that children cared for in adoption care facilities would be rated higher on measures of attention problems, have faster reaction times on incongruent flanker trials, and have greater errors (lower accuracy) on incongruent trials than children cared for in foster care. Results did not support any of these hypotheses; all ANOVA
models were not significant. Then, we conducted the same analysis with only two groups (i.e., children cared for in institutional care and children cared for in foster care. Those who received both were re-categorized to those two groups in which one was longer). None of the ANOVA were significant either. Overall, type of care did not show any effects on the attention measures.

Specific Aim 3

The third aim was to examine differential patterns of parent rating scores on measures of attention problems, impulsivity, and hyperactivity based on length of care by type of care. This aim used regression analysis and had the additional assumptions of normality, linearity, and homogeneity of variance of the model residuals. All model residuals were linear and had homogenous variance. Three model residuals were non-normal: the relationship between length in institutional care and the SDQ, length in institutional care and the attention subscale of the HBQ, and length in foster care and the SDQ. After substituting logarithmic transformed variables for length of care in each respective case the model residuals were able to become normal. However, each model before and after substitution was not significant. In addition to base regression models, this aim is concerned with the difference between each model. To assess significance of difference between regression models, a Fisher’s Z transformation and critical limits of Z-scores were used.

One model had a significant relationship; higher impulsivity ratings on the HBQ were related to greater length in institutional care \( (F(1, 93) = 4.77, p = 0.03, R^2 = 0.05) \). All other regression models were insignificant.

For Hypothesis 1, the differences between two models were significant. The two models showing the relationship of impulsivity ratings with institutional care and foster care, respectively, were significantly different. Impulsivity scores had a positive relationship with
institutional care while they had a negative relationship with foster care (institutional: \( r_1 = .22, n_1 = 95 \), foster: \( r_2 = -.16, n_2 = 94 \), \( z = 2.6, p < 0.01 \); see Figure 2). The two models showing the relationship of ADHD ratings on the HBQ with institutional care and foster care respectively were significantly different. ADHD ratings had a positive relationship with institutional care and a negative relationship with foster care (institutional: \( r_1 = .14, n_1 = 95 \), foster: \( r_2 = -.14, n_2 = 94 \), \( z = 1.91, p = .02 \); see Figure 3). A univariate understanding of these relationships from aim one would suggest that individuals who stayed in institutional care longer were rated higher for impulsivity and individuals who stayed in foster care longer showed no attention problems. When adding the understanding of the difference of trajectories between these groups, it suggests that individuals who stay longer in institutional care have higher ratings of impulsivity and ADHD than individuals who stay in foster care longer.

For Hypothesis 2 and 3 no models were significantly different for accuracy or reaction time on the flanker task.

**Specific Aim 4**

The fourth aim was to assess if type of care moderates the relationship between length of care and parent rating scores on measures of attention, impulsivity, and hyperactivity. Moderation analyses use regression models to understand if all paths of the moderation are significant. Therefore, the additional assumptions necessary for this aim are the same as regression: normality, linearity, and homogeneity of variance of the model residuals. All model residuals were linear and had homogenous variance. Five model residuals were non-normal: the relationship between length in institutional care and the SDQ, length in institutional care and the attention subscale of the HBQ, length in foster care and the SDQ, the model including the interaction term between length of care in institutional care and the SDQ, and the model
including the interaction term between length of care in foster care and the SDQ. All model residuals except one were able to become normal; however, all the models were not significant before and after transformation. The model that was not able to become normal was the model including the interaction term between length of care in foster care and the SDQ. This model before and after transformation was not significant.

Results showed that the overall moderation model was not significant.

**Specific Aim 5**

The fifth aim was to examine the relationship between ERP amplitudes (ERN, N2) and parent rating scores on measures of attention as well as accuracy on the flanker task. This aim used correlation and the additional assumption of linearity was tested. All variables were found to be linear.

Both hypotheses were not supported. No significant relationships were found between scores on measures of attention and ERP amplitudes or accuracy and ERN amplitudes.

**Specific Aim 6**

The sixth aim was to explore sex differences in parent rating scores on measures of attention, impulsivity, and hyperactivity, as well as reaction time and accuracy on the flanker task. T-tests were used to assess this aim, there were no additional assumption tests necessary.

For hypothesis one, when assessing all participants results showed that male children were rated significantly higher on the impulsivity, attention, and ADHD sub scale of the HBQ than female children (impulsivity: $t(82) = 2.32, p = .02$, attention: $t(65) = 1.97, p = .05$, ADHD: $t(72) = 2.37, p = .02$; see Figures 4-6).

All other hypotheses were not supported, all t-tests were not significant.
To address possible confounding from rates of sexes from each country of origin, further analyses were conducted on countries that had the most even distributions of sexes: Guatemala, Russia, and South Korea. These results were exploratory and should be taken with caution as each of these samples had a rather small sample size. Guatemala had the largest sample \((n = 21, \text{male} = 14, \text{female} = 7)\), followed by Russia \((n = 14, \text{male} = 6, \text{female} = 8)\), and then by South Korea \((n = 11, \text{male} = 5, \text{female} = 6)\). These three countries were also then pooled together and analyzed to assess a larger sample with a more even distribution of sexes \((n = 46, \text{male} = 25, \text{female} = 21)\).

For Guatemala, males were rated significantly higher on the SDQ than females \((t(18) = -2.97, p = .01; \text{see Figure 7})\). For Russia, males and females were not significantly different on any outcome variables. For South Korea, males were rated as significantly more inattentive than females \((t(8) = -2.58, p = .03; \text{see Figure 8})\). Males were also rated significantly higher on the SDQ than females \((t(5) = -6.27, p < 0.01; \text{see Figure 9})\). Finally, male’s reaction time on correct congruent trials of the flanker task were significantly shorter than females \((t(8) = 2.57, p = .03; \text{see Figure 10})\). For the pooled data from these three countries only one test was significant. Males were rated significantly higher on the SDQ than females \((t(38) = 2.83, p = .01; \text{see Figure 11})\).
Discussion

Length of Care

For Specific Aim 1, length of care and its relationships with reaction time, accuracy on trials of the flanker task, as well as parent rating scores on the HBQ and SDQ were examined. It was hypothesized that reaction time, as well as accuracy, on the flanker task trials would be related to length of care. Neither of these hypotheses were supported. The lack of relationship may be due to the fact that while we may see more impulsive responding for some participants which could lead to greater errors, we also see mastery of the task similar to the findings in McDermott and colleagues (2007). In their study, McDermott and colleagues (2007) found that for children ages 4 to 6 that they were responding faster on congruent trials than on incongruent trials, there was greater percentage error on incongruent trials, and that faster response was related to greater error. The authors discuss that this supports the idea that faster responding is both an indicator of mastery of the task (congruent trials) and impulsive responding (incongruent trials). Faster reaction times are not always linked to lower accuracy and therefore we may see a null result. Furthermore, the dataset provided for the current study only included reaction times for trials that were responded to correctly. The dataset did not include reaction times where errors were committed. Therefore, the lack of relationship could be due to the fact that for lower interference tasks (i.e., congruent trials) individuals may be less impulsive to respond because of the lower demand from that trial. Finally, it was hypothesized that parent rating scores on the HBQ and SDQ would be related to length of care. Ratings on the SDQ did not significantly relate to length of care. However, ratings on the impulsivity subscale of the HBQ did relate to length in institutional care. Previous studies showed that overall length in institutional care is related to greater deficits in multiple domains (Fjell et al., 2012; Govindan et al., 2010; Miller et
al., 2009; Nelson et al., 2011, Nelson et al., 2007). In particular they found that length of care is related to inattention/overactivity (Audet & Le Mare, 2010; Maclean, 2003) as well as ADHD symptoms (Beverly et al., 2008; Roskam et al., 2014). While previous studies have findings in these domains, the current study only supports relationships with impulsivity. This may be due to sample and methodological differences. Specifically, the studies listed above do not use the HBQ or SDQ and therefore may not be completely comparable. While all of the above studies use measures of attention, it is possible that variations in task type may not be as comparable for selective attention in the flanker task. Additionally, not all studies were assessing young children like the current sample (5-10 years) and a few included adolescents and adults (Beheh et al., 2009; Fjell et al., 2012; Govindan et al., 2010; Merz & McCall, 2010). Furthermore, some studies had samples from specific countries (e.g., Russia, Romania) whereas the current study has data from individuals from several countries. These sample and methodological differences may partially account for the deviation of results from the current literature.

Additionally, it is possible that the results for the impulsivity subscale may have higher overall scores than the inattention and ADHD subscale due to the nature of the items in the subscale. While speculation, it is possible that these items may map on to more typical child behavior and be more likely for parents to report a higher score. Parents are instructed to report the frequency of each behavior in the item, with higher numbers being a higher frequency. Items such as “Fidgets”; “Can’t stay seated when required to do so”; “Has difficulty awaiting turn in games or groups”; “Interrupts, blurts out answers to questions too soon”; “Has difficulty playing quietly”; and “Interrupts or butts in on others” seem like they could be common behavior for children even if they do not have prominent impulsivity problems. As discussed by Gualtieri and
Johnson (2005), parents may over report behaviors that are symptoms of ADHD including impulsivity as they are common in school aged children.

**Type of care**

For Specific Aim 2, group differences were examined between children exposed to adoption care facilities, foster care, or both of these. It was hypothesized that children cared for in institutional care facilities would have higher parent rating scores on the HBQ and SDQ, have faster reaction times on incongruent trials of the flanker task, and have lower accuracy on the flanker task than children cared for in foster care. However, no group significantly differed from the others. Previous studies demonstrated that individuals cared for in institutional/institutional care had greater inattention and hyperactivity as compared with both their peers in foster care and controls (Roy et al., 2000; Stevens et al., 2008). This was also supported in several different cognitive control tasks (McDermott et al., 2012) and in EEG recordings (Vanderwert et al., 2010). In the current sample, length of care had a large range. Length of care in foster care ranged from 1 month to 19 months and in institutional care ranged from 1 month to 48 months. It has been found that individuals who stayed in institutional care longer were rated higher on scores for impulsivity. Previous studies have also demonstrated that length of care is related to greater deficits in multiple domains in attention (Fjell et al., 2012; Govindan et al., 2010; Miller et al., 2009; Nelson et al., 2011, Nelson et al., 2007). Thus, it is possible that the lack of differences among children exposed to adoption care facilities, foster care, or both may be confounded by other factors, such as length of care.

Additionally, the lack of significance in the current study could partially be due to unequal sample size of each group. ANOVA is not robust to normality violations when there are unequal groups. For several of the ANOVA models, there were residual normality violations that
were not able to become normal even with transformation. In combination with unequal groups (institutional care \( n = 45 \), foster care \( n = 13 \), both \( n = 34 \)), it is possible that these results were affected. In addition, it would also follow that even without not being robust to normality violations, ANOVA models would not be significant because univariate relationships were not found in specific aim one. Additionally, the variability of length in each care type may be partially responsible for the lack of a significant difference.

**Interaction Between Length and Type of Care**

For Specific Aim 3, it was hypothesized that we would see a differential pattern of change between types of care groups based on length of care for their rated performance on measures of attention (HBQ, SDQ, flanker). It has been suggested that children cared for in institutional care have more attention deficits than their foster care peers (Roy et al., 2000), but both care systems have more deficits than their non-adopted peers (McDermott et al., 2012). One study has evidence to suggest that being placed in foster care could be used as an intervention for attention effects from institutional care. Vanderwert and colleagues (2010) found that when in institutional care children’s EEG alpha waves related to attention were subdued, but after being placed with a foster family these alpha waves increase. Therefore, there is reason to believe that over time in each type of care we will see different trajectories for children’s performance on measures of attention. While this was not supported for flanker accuracy or reaction time, it was supported for two of the HBQ subscales, impulsivity and ADHD. Interestingly, only the impulsivity rating scores were found to be a significant relationship with length of care in specific aim one, while ADHD scores were not. But in this aim, when considering the difference between type of care groups, the relationships for institutional care and foster care are significantly different. In both cases, a longer exposure to institutional care meant higher ratings
of impulsivity or ADHD, and longer exposure to foster care meant lower ratings. This finding was very exciting and the clinical implications of such a result is important when discussing planning and aid for IA children. It is our recommendation that early introduction of placement in a foster family can be beneficial for IA children. These results were also consistent with the existing literature (McDermott et al., 2012; Roy et al., 2000) and supported that over time children in foster care do better than their institutional care peers.

**Moderation Effect of Type of Care**

For Specific Aim Four, it was hypothesized that a moderation relationship would exist between type of care and length of care on attention as demonstrated on behavioral assessments and the flanker task. The literature showed support for greater length of care being related to more attention deficits (Audet & Le Mare, 2010; Beverly et al., 2008; Maclean, 2003; Roskam et al., 2014), and that being cared for in institutional care was related to more attention deficits (Roy et al., 2000; Stevens et al., 2008). But one study found that children in institutional care who were later placed in a foster home had increased alpha waves during EEG scans after placement which suggested they were previously subdued (Vanderwert et al., 2010). Therefore, the interaction effect between these two variables was important to understand the fuller picture. However, this hypothesis was not supported from the current study. This makes sense when considering univariate relationships assessed in specific aim one; only one relationship was significant. Therefore, when running regressions to understand significance in the paths of the moderation, it would make sense that moderation would not be supported.

**Behavioral Measures and Neural Correlates of Attention**

Specific aim five was concerned with the relationships that neural correlates (ERN, N2) might have with measures of attention (HBQ, SDQ). It was hypothesized that these neural
correlates would relate to measures of attention and accuracy on incongruent trials on the flanker task. Neither hypothesis was supported in the current study. ERN, in addition to accuracy in the flanker task, has been considered as a measure to reflect selective attention. It has been previously demonstrated that post-institutionalized children had smaller (less negative) ERNs than their non-adopted peers (Loman et al., 2013), suggesting impaired selective control in comparison to their non-adopted and foster care peers. In the current study, no ERN difference was found between institutional care and foster care. Additionally, there was no correlation between the ERN and the behavioral measures in flanker tasks. One main reason may be due to the developmental aspect. It has been found that ERN had greater amplitude for errors for older adolescents, but not for younger adolescents (Ladoceur et al., 2004). It has been argued that while early adolescents are able to be aware of error, the ability to monitor conflict created by error does not occur until later as a part of developing cognitive control. In the current study, the age for IA children was ranged from 5 years to 10 years old. Thus, it is possible that the age of the current sample could be a confounding factor for ERN.

N2 reflects a conflict between execution and inhibition (Nieuwhuis et al., 2003). In the flanker task, if participants struggle to attend and deal with the conflict incorporated, N2 can be used to assess conflict monitoring. It has been found that IA children had smaller (less negative) N2s than their non-adopted and foster care peers (Loman et al., 2013). In combination with ERN, the N2 incorporates the conflict portion of the task. Similar to ERN, there is an age-related change in N2, including latency, RT, and appearance of N2. Thus, it is not surprising that no differences were found between those with adopted care and foster care in the current sample.

Additionally, sample and methodological differences may be partially accountable for the lack of significance in comparison to previous literature. Specifically, for Johnstone and Clarke
(2009) the sample consisted of children with ADHD between the ages of 8 and 14. Furthermore, Loman and colleagues (2013) had a sample consisting of children ages 10 and 11 who were institutionalized for at least 75% of their pre-adopted lives. Furthermore, both studies used the go/no-go task whereas the current study used the flanker task.

**Sex Differences Effect on Attention Measures**

For Specific Aim 6, it was hypothesized that males would have higher rated scores on measures of attention (HBQ, SDQ), faster reaction times and lower accuracy on the flanker task, and lower ERP amplitudes (ERN, N2) than females. Males did not significantly differ from females on the flanker task or in ERP amplitudes. However, they did significantly differ from females on all subscales of the HBQ. Males were rated higher for scores of impulsivity, attention problems, and ADHD than females. Further analyses were conducted on countries with more even distributions of sexes. However, these countries had fairly small sample sizes and results should be taken with caution. These results supported results from the sample as a whole as well as results in the literature with males having more attention and impulsivity problems (Loman et al., 2013; Stevens et al., 2008; Ullebø et al., 2012).

**Limitations**

A major limitation of this study is that it is a secondary analysis of an existing dataset. As discussed by Cheng and Phillips (2014), it is possible that by not being involved in the original data collection, there may have been adjustments necessary during data collection and subtle nuances in data recording that may not be immediately evident even if there is thorough documentation. Subsequently, another limitation is that the dataset was not able to fully capture all the data points for the specific aims of the current study. Specifically, it would be interesting to understand reaction time on the flanker task for trials where the participant failed to respond
correctly and its relationship to other key variables of the current study. In Specific Aim 2, ANOVA models were not robust to non-normality due to uneven sample size which is a limitation for these results as they may have a higher likelihood of statistical error. Additionally, in Specific Aim 6 it is possible that general sample results for sex differences may be confounded by certain country’s rates of adoptions for each sex. Further, the results for specific countries with lower sample sizes are more susceptible to influential cases because T-tests are based on the mean of the data. Also, the results for these countries are not likely to be generalizable to the population due to the small sample size. Finally, internal validity may be a concern for the impulsivity subscale of the HBQ with regards to parent reporting.

**Future Directions**

The current study and the original study have both added information to the gap in the current literature that helps to elucidate the connection between internationally adopted children and outcomes for attention, impulsivity, and hyperactivity. Future studies could expand and improve this research by assessing the specific attributes of each type of care to assess what factors in each may be related to or causing noted differences for these groups. Further, future studies should expand the understanding of sex and gender differences for IA children with representative samples from multiple countries. Finally, future studies could improve reliability by using varied behavioral attention measures as well as assessing the internal validity of current measures.
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Figure 1

Correlation Between Institutional Care Length and Impulsivity Scores

Note. HBQ stands for Health and Behavior Questionnaire (Essex et al., 2002). Scores on the HBQ were parent report ratings.
Figure 2

Trajectory Difference Between Institutional Care and Foster Care for Impulsivity Scores

Note. HBQ stands for Health and Behavior Questionnaire (Essex et al., 2002). Scores on the HBQ were parent report ratings.
Figure 3

Trajectory Difference Between Institutional Care and Foster Care for ADHD Scores

Note. HBQ stands for Health and Behavior Questionnaire (Essex et al., 2002). ADHD stands for attention deficit hyperactivity disorder. Scores on the HBQ were parent report ratings.
Figure 4

Total Sample Gender Differences for Impulsivity Scores

Note. HBQ stands for Health and Behavior Questionnaire (Essex et al., 2002). Scores on the HBQ were parent report ratings.
Figure 5

*Total Sample Gender Differences for Attention Scores*

*Note.* HBQ stands for *Health and Behavior Questionnaire* (Essex et al., 2002). Scores on the HBQ were parent report ratings.
**Figure 6**

*Total Sample Gender Differences for ADHD Scores*

![Box plot showing gender differences in ADHD scores](image)

*Note.* HBQ stands for *Health and Behavior Questionnaire* (Essex et al., 2002). ADHD stands for attention deficit hyperactivity disorder. Scores on the HBQ were parent report ratings.
Note. SDQ stands for *Strengths and Difficulties Questionnaire* (Goodman, 1997). Scores on the SDQ were parent report ratings.
**Figure 8**

*Attention Score Differences for South Korean Children*

![Box plot showing attention score differences for South Korean children by gender. The plot displays a comparison between female and male scores on the Health and Behavior Questionnaire (HBQ). The scores indicate that male children have higher attention scores compared to female children.](image)

*Note. HBQ stands for Health and Behavior Questionnaire (Essex et al., 2002). Scores on the HBQ were parent report ratings.*
Figure 9

SDQ Score Differences for South Korean Children

Note. SDQ stands for *Strengths and Difficulties Questionnaire* (Goodman, 1997). Scores on the SDQ were parent report ratings.
Figure 10

Differences of Reaction Time on Correct Congruent Trials for South Korean Children
Figure 11

*SDQ Score Differences for Pooled Country Sample*

*Note.* Pooled country sample included only children from Guatemala, South Korea, and Russia. SDQ stands for *Strengths and Difficulties Questionnaire* (Goodman, 1997). Scores on the SDQ were parent report ratings.