INHIBITORY CONTROL AND WORKING MEMORY IN CHILDREN ADOPTED FROM PSYCHOSOCIALLY DEPRIVING INSTITUTIONS

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Children adopted internationally from institutions at older ages who were exposed to early psychosocial deprivation may have deficits in executive functioning (EF) which are related to their increased risk of attention and academic difficulties. This study examined inhibitory control and working memory in 8- to 17-year-old children adopted from psychosocially depriving Russian institutions after 14 months of age (*n*=34) and those adopted before 9 months (*n*=39). Children completed inhibitory control and working memory tasks, while their parents completed questionnaires on child attention problems and use of learning support services in school. Children adopted after 14 months of age were found to perform poorly on inhibitory control and working memory tasks relative to children adopted before 9 months of age after controlling for age at assessment. Significant group differences were found for the stop-signal, go/no-go, and spatial span tasks but not the spatial working memory, backward digit recall, or flanker tasks. Children adopted after 14 months also had significantly lower IQ than those adopted before 9 months, and they performed poorly on the stop-signal and spatial span tasks compared to never-institutionalized children from previous studies. Spatial span and stop-signal task performance was associated with parent-rated hyperactivity-impulsivity but not with inattention or the use of learning support services. These findings suggest that exposure to early psychosocial deprivation may be linked with deficits in inhibitory control and spatial working memory that are associated with persistent attention problems. These results may inform studies of neural development and the selection of services for children exposed to early deprivation.

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1.0 INTRODUCTION

In the past 20 years, more than 300,000 children were adopted internationally into the United States (US Department of State, 2009), most of them from countries that place children without permanent families in institutions. For these children, exposure to adverse circumstances during early childhood is followed by a transition into usually stable and well-educated middle-class families (Hellerstedt et al., 2008). Their life experiences provide the opportunity to study the effect of adversity limited to early childhood on development. Following adoption, marked improvements in physical, social, and cognitive development are generally observed (van IJzendoorn, Juffer, & Poelhuis, 2005), yet many post-institutionalized (PI) children display persistent behavioral, cognitive, and academic difficulties (MacLean, 2003). In particular, problems with inattention and hyperactivity-impulsivity have been observed across multiple samples of PI children and appear to persist years after adoption (Ames, 1997; Gunnar et al., 2007; Stevens et al., 2008). Indeed, rates of attention-deficit/hyperactivity disorder (ADHD) diagnosis are significantly elevated in PI children compared to never institutionalized children (Beverly, McGuinness, & Blanton, 2008; MacLean, 2003; Miller, Chan, Tirella, & Perrin, 2009), and researchers working on the English and Romanian Adoptees (ERA) longitudinal study have argued that inattention and hyperactivity are part of an "institutional deprivation syndrome" (Kreppner, O'Connor, & Rutter, 2001; Rutter, Kreppner, & O'Connor, 2001). Attention problems were also found to be related to elevated academic difficulties among PI children

(Beckett et al., 2007). Children who are older at adoption and who spend longer in an institution are at greater risk of attention and academic problems, while those adopted at younger ages do not tend to differ from children reared in their birth families (Stevens et al., 2008).

While the majority of PI literature to date has relied on parent and teacher reports, recent interest has turned toward examining the specific deficits underlying these problems including difficulties with executive functioning (EF), the higher order cognitive skills that facilitate goal-directed behavior and are mediated by the prefrontal cortex (PFC). Two core EF components are inhibitory control (also called response inhibition), or the ability to suppress automatic responses to extraneous information and goal-irrelevant stimuli (Schulz et al., 2005), and working memory, defined as the ability to store and update or process information in mind over brief periods of time (Baddeley, 1992; Just & Carpenter, 1992). These skills in particular are highly associated with attention functioning, in terms of being impaired in attention disorders (e.g., Nigg, 2001) as well as being "executive attention" processes (Posner & Rothbart, 2000; Rueda, Posner, & Rothbart, 2005). They are also found to support academic performance in never-institutionalized children (Alloway et al., 2009). While some research suggests that PI children may perform poorly on EF tasks (e.g., Pollak et al., 2010), little is known about inhibitory control and working memory in particular.

Institutions may be characterized by a variety of deficiencies, such as inadequate nutrition, health care, toys and stimulation, one-on-one interactions with caregivers, and changes in caregivers. A distinction has been made between globally or severely depriving institutions, such as Romanian institutions in the early 1990s, that are profoundly lacking in both physical and psychosocial resources (Rutter et al., 2007), and psychosocially depriving institutions that provide adequate physical resources but primarily lack a consistent set of responsive caregivers

(Gunnar, 2001). Under conditions of psychosocial deprivation, young children may not make the transition from caregiver- to self-guided regulation. In particular, the lack of response-contingent stimulation and opportunities to take an active role in problem-solving activities scaffolded by a familiar caregiver may disrupt EF development during early childhood (Bernier, Carlson, & Whipple, 2010). This theoretical link provides a basis for further investigating the association between early psychosocial deprivation and EF development in children.

As such, the purpose of the current study was to examine inhibitory control and working memory task performance as well as parent-reported attention problems in school-aged children adopted from psychosocially depriving institutions. PI children adopted after 14 months of age were compared to those adopted before 9 months of age, with the expectation that the former group would have greater deficits. PI children's performance on inhibitory control and working memory tasks was expected to be correlated with parent-reported attention problems and academic difficulties. This study was designed to expand our current understanding of the specific neurocognitive deficits related to attention and academic difficulties, areas of the brain that may be affected by early institutional deprivation, and the role of psychosocial deficiencies of institutions in producing poor outcomes.

1.1 OVERVIEW OF INHIBITORY CONTROL AND WORKING MEMORY

1.1.1 Development

EF skills and the underlying neural processes are shown to have a protracted developmental course that is largely postnatal. Early childhood constitutes a major period of transition in children's executive capacities (Garon, Bryson, & Smith, 2008). As connectivity between neural systems increases and particularly as the PFC develops, children progress in their ability to regulate their goal-directed behavior. There is evidence that inhibitory control and working memory skills emerge in the first year of life and develop rapidly over the course of early childhood. In early infancy, attentional control skills begin to emerge as infants learn to regulate distress, a process that may be fostered by the caregiver's use of orienting the child's attention. Young infants show increases in the ability to orient to and disengage from a stimulus by 3-4 months of age (Posner & Rothbart, 1998), and anticipatory looking has been shown in 6-7 month old infants, a process that involves voluntary control of attention (Sheese, Rothbart, Posner, White, & Fraundorf, 2008). Infants as young as 5 months are able to succeed on the object permanence task which requires them to inhibit their previously successful reach to location A (Baillargeon, Spelke, & Wasserman, 1985; Cuevas & Bell, 2010). On the detour-reaching task, a rudimentary ability to inhibit prepotent responses is clearly evident by 7-12 months (Diamond, 2002). More complex EF skills develop rapidly throughout early childhood forming a critical foundation for increasing refinement of EF abilities that proceeds through adolescence (Best & Miller, 2010; Luciana, Conklin, Hooper, & Yarger, 2005; Luna, Garver, Urban, Lazar, & Sweeney, 2004).

1.1.2 Measurement

Inhibitory control is divided into the suppression of a primary or prepotent response (i.e., a response that has been associated with reinforcement; go/no-go, stop-signal tasks) or a competing secondary response/distracting information (also called interference control and closely related to conflict monitoring and resolution; Stroop, flanker task). Inhibitory control is typically measured in older children using lab tasks that were originally designed for adult frontal lobe patients. For example, on the computerized go/no-go task, the child is required to respond as quickly as possible to a frequent "go" stimulus but not to respond to an infrequent "no-go" stimulus. The dominant tendency is to respond since most trials involve "go" stimuli. In the flanker task (Eriksen & Schultz, 1979), the child is required to respond as quickly as possible to a central target stimulus (e.g., an arrow) flanked by distractor stimuli that elicit either the same response as the target (congruent condition; e.g., arrows in the same direction) or an incorrect response (incongruent condition; e.g., arrows in the other direction). Thus, in the incongruent condition, the child must withhold responding to the distractor stimuli which trigger an incorrect response.

Similar to other EF tasks, these tasks are often classified as pure measures of a single EF component (inhibitory control) but may require multiple cognitive processes for successful performance (Nigg, 2000; Simpson & Riggs, 2005). For instance, while some inhibitory control tasks (e.g., go/no-go task) require a minimal amount of working memory, others (e.g., Stroop) place significant demands on working memory by requiring that the individual hold an arbitrary rule in mind (Cragg & Nation, 2008; Garon et al., 2008).

Working memory can be divided into two components: short-term storage/maintenance of information and updating/processing of information held in mind, and there are separate systems for verbal and visual-spatial information (Alloway, Gathercole, & Pickering, 2006). Working memory tasks that assess the storage component may place lower demands on executive control (or updating/processing) and the PFC (e.g., forward digit span, spatial span) than those that assess the processing component (e.g., backward digit span, self-ordered search; D'Esposito & Postle, 1999; Luciana et al., 2005).

Span tasks require the individual to remember the temporal order of multiple items presented in a sequence. For example, in the Cambridge Neuropsychological Test Automated Battery (CANTAB; Cambridge Cognition, United Kingdom) spatial span test, children view squares on a computer screen that light-up one by one and are then asked to reproduce the sequence in the same order that it was presented. The backward digit span task assesses the executive control system for verbal information and requires the participant to recall the digits presented by the examiner in reverse sequence. In the CANTAB spatial working memory test, a self-ordered search task, participants are required to search spatial locations to find tokens while remembering not to return to any locations where tokens were previously found. This task assesses the individual's ability to keep a rule in mind, update information in working memory, and develop and execute an organized search strategy (Luciana et al., 2005).

1.1.3 Association with attention

Inhibitory control is also an "executive attention" process reflecting its importance in supporting attention capabilities (Posner & Rothbart, 2000; Rueda, Posner, & Rothbart, 2005). There is also a substantial literature showing that school-aged children with ADHD perform poorly on tasks assessing inhibitory control, even after accounting for general cognitive ability (Nigg, 2001). Impairments are found on inhibitory control tasks assessing the suppression of both a primary and a competing secondary response. Findings consistently reveal that children with ADHD need significantly more time to inhibit a prepotent response on the stop-signal task (Chhabildas, Pennington, & Willcutt, 2001; Geurts, Vertie, Oosterlaan, Roeyers, & Sergeant, 2005; Rucklidge & Tannock, 2002; Scheres et al., 2004; Willcutt, Pennington, Olson, Chhabildas, & Hulslander, 2005). On the go/no-go task, children with ADHD incorrectly respond to no-go cues and show longer reaction times to go cues (Berlin, Bohlin, & Rydell, 2003; Durston et al., 2003; Happe, Booth, Charlton, & Hughes, 2006; Kerns, McInerney, & Wilde, 2001; Rubia et al., 2001). On the flanker task, children with ADHD show slower response times and more errors in the incongruent condition compared with the congruent condition, than typically developing children (Crone, Jennings, & Van Der Molen, 2003; Jonkman et al., 1999; Mullane, Corkum, Klein, & McLaughlin, 2009; Scheres et al., 2004).

Children with ADHD also perform poorly on tasks assessing short-term storage as well as storage plus updating/processing of spatial information even after accounting for general cognitive ability (Alloway, Rajendran, & Archibald, 2009; Martinussen, Hayden, Hogg-Johnson, & Tannock, 2005; Wilcutt et al., 2005). On the spatial span task, children with ADHD recall fewer items in order than typically-developing children (Corbett et al., 2009; Kempton et al., 1999). Children with ADHD also make more errors on the spatial working memory task than typically-developing children (Willcutt et al., 2005). Although effect sizes are smaller, children with ADHD are also found to be impaired on measures of verbal working memory, such as the backward digit span task (Rosenthal, Riccio, Gsanger, & Jarratt, 2006). Working memory impairments have been associated with the inattentive dimension of ADHD rather than hyperactive-impulsive symptoms (Alloway, Gathercole, Kirkwood, & Elliott, 2009). It has been suggested that inattention may stem from an inability to hold mental representations active and use them to guide behavior, a skill associated with working memory (Barkley, 1997).

1.1.4 Association with academic performance

Inhibitory control and working memory have been found to support academic achievement (Gathercole & Alloway, 2006; Gathercole, Brown, & Pickering, 2003; Jarvis & Gathercole, 2003). In several longitudinal studies, performance on working memory and inhibitory control tasks at age 4-7 years made unique contributions to math achievement at age 5-11 years after controlling for general cognitive ability and reading achievement (Bull, Espy, & Wiebe, 2008; Clark, Pritchard, & Woodward, 2010; Mazzocco & Kover, 2007). Inhibitory control also facilitates literacy, reading comprehension, and text generation abilities (Blair & Razza, 2007; Espy et al., 2004), and impaired inhibitory control is associated with increased difficulty in language and literacy (Passolunghi, Cornoldi, & De Liberto, 1999; St. Clair-Thompson & Gathercole, 2006). There is also evidence that children with poor working memory skills have an increased likelihood of learning difficulties (Alloway et al., 2009). Academic difficulties may occur because many typical school activities depend heavily on the ability to update and process information held in mind and to suppress task-irrelevant information.

1.1.5 Neural correlates

Inhibitory control is supported by regions of the PFC. Functional neuroimaging studies of adults have revealed that performance on the go/no-go task requires recruitment of the ventrolateral PFC (Chambers, Garavan, & Bellgrove, 2009). Similarly, response inhibition deficits on the go/no-go task in children with ADHD are likely to reflect impaired functioning of ventral frontostriatal circuitry (Booth et al., 2005; Durston et al., 2003; Durston, Mulder, Casey, Ziermans, & Van Engeland, 2006; Smith, Taylor, Brammer, Toone, & Rubia, 2006). Studies have also revealed activation of the anterior cingulate cortex (ACC) during the go/no-go, stop-signal (Dimoska, Johnstone, Barry, & Clarke, 2003; Pliszka et al., 2006; Rubia et al., 1999; Rubia, Smith, Brammer, Toone, & Taylor, 2005), and flanker tasks (Cabeza & Nyberg, 1997; Fan, Fossella, Sommer, Wu, & Posner, 2003).

Working memory is also associated with the PFC (Curtis & D'Esposito, 2003). For example, the CANTAB spatial span task is believed to activate the ventrolateral PFC in addition to sensorimotor brain regions that support the representation of the stimulus (D'Esposito & Postle, 1999; Petrides, 1995; Smith & Jonides, 1997). Performance on the CANTAB spatial working memory task is associated with the lateral PFC (Luciana & Nelson, 1998; Owen, Doyon, Petrides, & Evans, 1996; Owen, Morris, Sahakian, Polkey, & Robbins, 1996) and the striatum (O'Reilly & Frank, 2006).

1.2 ANIMAL MODELS OF EARLY DEPRIVATION

Studies of non-human primates have revealed that early maternal deprivation is associated with EF deficits and disrupted PFC development (Cirulli & Alleva, 2003; De Bellis, 2005; Sanchez, Ladd, & Plotsky, 2001; Suomi, 1997). For example, Sanchez, Hearn, Do, Rilling, and Herndon (1998) used magnetic resonance imaging (MRI) to study rhesus monkeys that were socially deprived for the first year of postnatal life and then returned to normal social groups. These monkeys exhibited poor performance on EF tasks which was correlated with decreased neuronal development of prefrontal, medial temporal, and amygdala substrates. Two years later, they exhibited increased abnormalities in the PFC that were related to their performance on learning and working memory tasks (Sanchez et al., 2001). In addition, Mathew et al. (2003) reported neuropathological alterations in the PFC of adult macaques with early adverse experience.

1.3 EXECUTIVE FUNCTIONING IN POST-INSTITUTIONALIZED CHILDREN

Consistent with the animal literature, recent studies show that older-adopted 6- to 11-year-old PI children perform poorly on EF tasks relative to children reared in their biological families and to children adopted at young ages from non-institutional settings (Bauer et al., 2009; Bos, Fox, Zeanah, & Nelson, 2009; Bruce, Tarullo, & Gunnar, 2009; Colvert et al., 2008; Pollak et al., 2010). On the go/no-go task, 10- to 11-year-old PI children demonstrated poor accuracy to go trials compared to never-institutionalized controls, but the groups did not differ in their accuracy to no-go trials (Loman, 2011). PI children were also found to perform poorly on complex inhibitory control tasks, such as the Stroop, knock and tap, and flanker tasks, reflecting deficits in their ability to inhibit a competing secondary response. Ten and 11-year-old PI children were found to demonstrate poorer accuracy to both congruent and incongruent flanker trials (Loman, 2011). However, reaction time on a flanker task was not found to differ between 6- to 11-year-old PI children and community controls (Chapman et al., 2009). Analyses of group differences in accuracy to congruent and incongruent trials were not reported in this sample. While research to date is suggestive of impairments in PI children's performance on complex inhibitory control tasks assessing the inhibition of a competing response, much less is known about PI children's ability to suppress a primary response. Further research is needed to more clearly elucidate the impact of early adversity on these skills.

PI children were also found to exhibit deficits on the CANTAB spatial working memory task. For example, in the Bucharest Early Intervention Project (BEIP), Romanian children with a history of institutionalization performed poorly on this task relative to Romanian children reared in their biological families (Bos et al., 2009). The ERA study examined verbal working memory in 11-year-old children adopted from severely depriving Romanian institutions. There was a trend ($p = .06$) for those adopted after 6 months of age to perform poorly on the backward digit span task relative to within-UK adopted children and children adopted from Romanian institutions before 6 months of age (Beckett, Castle, Rutter, & Sonuga-Barke, 2010). Based on these results, it is imperative that we further our understanding of the types of working memory tasks which pose challenges to PI children.

Across prior studies of EF in PI children, only PI children adopted after 6-12 months of age were found to have EF deficits, although younger-adopted PI children were less frequently studied. Findings from the ERA study suggest a step-like relation between age at adoption and EF deficits. Children adopted from severely depriving institutions after 6 months of age had greater inhibitory control (Stroop task) and verbal working memory difficulties than those adopted before 6 months who did not differ significantly from children adopted within the UK at young ages (Beckett et al., 2010; Colvert et al., 2008). Among the children adopted after 6 months of age, there was no association between EF task performance and age at adoption (Colvert et al., 2008).

The ERA study of children adopted from severely depriving institutions also found that deficits in inhibitory control were associated with attention problems. At 11 years of age, children who demonstrated parent- and teacher-reported inattention and hyperactivity had higher mean errors on the Stroop task relative to those without any "deprivation-specific" difficulties, such as problems with attention, attachment, quasi-autistic symptoms, and cognitive impairment (Colvert et al., 2008); this finding was replicated at 13 years of age in a pilot study using the go/no-go and stop-signal tasks, although between group differences did not reach significance (Sonuga-Barke & Rubia, 2008). These results provide a foundation for further examining the association between inhibitory control and working memory task performance and attention problems in PI children.

1.4 EARLY PSYCHOSOCIAL DEPRIVATION

Psychosocial deprivation, characteristic of nearly all institutions to some extent, would be theoretically expected to result in impaired EF development. Under typical family rearing conditions, caregivers are theorized to initially act as external regulators of the infant's functioning, gradually facilitating the child's increasing capacity to self-regulate (Kochanska, Coy, & Murray, 2001). Responsive caregiving practices provide young children with successful experiences of influencing the social environment and playing an active role in completing tasks which support their autonomy, goals, and sense of volition (Bernier, Carlson, & Whipple, 2010). Consistent with this theory, studies of non-adopted children have found that responsive caregiving during infancy is positively associated with children's EF development (e.g., Kochanska, Murray, & Harlan, 2000; Landry, Smith, & Swank, 2006; Olson, Bates, Sandy, & Schilling, 2002). There is also evidence that caregiver disruptions have negative effects on EF in general and foster care populations (Lengua, Honorado, & Bush, 2007; Lewis, Dozier, Ackerman, & Sepulveda, 2007). In studies of children adopted from globally depriving institutions or those exposed to an unspecified level of deprivation, the early factors that may have lead to later EF impairment are unclear.

School-aged children adopted from psychosocially depriving institutions after 2 to 3 years have been found to demonstrate more teacher-reported attention, externalizing, and peer problems than children reared in their birth families (Hodges & Tizard, 1989; Tizard & Hodges, 1978). In more recent studies, several institutions for infants to 4-year-old children in western Russia were found to provide adequate material resources, but nine or more different caregivers often worked with a group of 12 to 14 children in a given week, and children were periodically "graduated" to new groups with different caregivers. By 19+ months of age children had potentially experienced 60 to 100 caregivers (St. Petersburg-USA Orphanage Research Team, 2005). Caregivers rarely initiated social interactions, responded to infants' social bids, responded promptly to emotional distress, or provided warmth and affection (Muhamedrahimov, 1999; see also Tirella et al., 2008). Findings indicated that school-aged children adopted after 18 months of age from these psychosocially depriving institutions had high rates of parent-rated attention problems (Merz & McCall, 2010) and EF deficits (Merz & McCall, 2011). These problems were found to increase with age at assessment, such that they were not present in preschool-age children, and they increased in prevalence with age in the school-aged sample.

1.5 CURRENT STUDY

The purpose of the current study was to examine inhibitory control and working memory in 8- to 17-year-old children adopted from psychosocially depriving institutions as well as the predictors and correlates of these neurocognitive processes. Inhibitory control tasks assessed inhibition of both a dominant response (go/no-go, stop-signal tasks) and a competing secondary response (flanker task). Working memory tasks assessed short-term storage plus updating/processing of verbal (backward digit span) and spatial information (spatial span, spatial working memory). School-aged PI children were selected because they are old enough to demonstrate neurocognitive deficits and behavior problems based on prior studies (Gunnar et al., 2007; Pollak et al., 2010). The study had several specific aims.

The first aim was to compare children adopted from psychosocially depriving institutions after 14 months of age to those adopted before 9 months of age on inhibitory control and working memory task performance. Prior studies suggest that children adopted after 14-18 months of age display effects of early institutional deprivation while children adopted before 6-9 months of age do not differ from children reared in their biological families and children adopted from non-institutional settings on a range of outcomes (Rutter et al., 2007). As a comparison group, younger-adopted children also have the advantage of being similar to the older-adopted group on potentially confounding variables, such as genetic risk factors, prenatal care, birth circumstances, and the experience of adoption. Older-adopted children who were exposed to prolonged institutional deprivation were expected to show neurocognitive deficits relative to younger-adopted children. To examine their performance relative to non-institutionalized comparison groups, both the older- and younger-adopted PI groups were compared to control groups from previous studies and to the normative samples for the standardized assessments when available.

The second aim was to examine the specificity of inhibitory control and working memory deficits relative to lower general cognitive ability (IQ). Findings from prior studies showing older-adopted PI children to have lower IQ than comparison groups suggest that any group differences in inhibitory control and working memory could potentially be attributable to differences in overall IQ (Nelson et al., 2007). In one study, globally deprived children were found to show inhibitory control deficits above and beyond group differences in IQ (Colvert et al., 2008). Given that inhibitory control and working memory may also influence children's performance on IQ tests, analyses were conducted both covarying and not covarying IQ (Willcutt et al., 2005).

The third aim was to investigate the association between birth circumstances (birth weight, prematurity) and inhibitory control and working memory task performance. Poor birth circumstances are not usually found to be associated with outcomes among PI children (Bruce et al., 2009; Merz & McCall, 2010; Rutter et al., 2007). For example, one study found that despite not differing significantly in birth weight, PI children displayed greater EF deficits than children adopted at young ages from non-institutional settings (Pollak et al., 2010). However, in the BEIP study, birth weight significantly predicted spatial working memory total errors (Bos et al., 2009). Birth weight data from the BEIP study that came from institutional records in Romania may be more reliable than that of other studies using parent report data.

The fourth aim was to examine group differences in parent-reported inhibitory control, working memory, inattention, hyperactivity-impulsivity, and academic difficulties and whether parent ratings are associated with inhibitory control and working memory task performance. Tasks assessing inhibitory control and working memory were expected to be associated with rating scale measures of related skills after accounting for age at adoption and age at assessment. Task performance was also expected to be associated with parent-rated functioning above and beyond cognitive ability, but analyses were conducted with and without this covariate due to potential overlap in the skills assessed by these measures.

Findings from this study may shed light on the EF mechanisms underlying PI children's persistent attention problems and academic difficulties. Knowledge about the sources of these difficulties can be used by practitioners to determine appropriate support services for this population. Findings from this study may also highlight psychosocial inadequacies of the institutional rearing environment as potentially detrimental to neurocognitive functioning. Finally, results were expected to suggest neural circuitry that might be affected by early exposure to institutional deprivation thus providing a foundation for future neuroimaging studies.

2.0 METHOD

2.1 PARTICIPANTS

Participants in this study were 84 8- to 17-year-old children (48 adopted ≤ 9 months and 36 adopted ≥ 14 months) adopted from psychosocially depriving institutions primarily in St. Petersburg, Russia (68%); 54% came from the specific psychosocially depriving institutions described in the introduction (St. Petersburg-USA Orphanage Research Team, 2005). Although a narrower age range would have been preferable because inhibitory control and working memory (WM) improve with age (e.g., Brocki & Bohlin, 2004), children spanning a wide range of age at assessment were included in the study due to sampling constraints. Most of the PI children in both groups had been in institutions for their entire pre-adoption lives. However, seven children in the older-adopted group had also spent time in the care of their birth families prior to adoption. Children were excluded if they had spent ½ or more of their pre-adoption time with their birth family (2). The five remaining older-adopted children who had spent time in their birth families had been in an institution for 16 or more months prior to adoption. Children were also excluded from analyses if they had marked functional deficits (2), an autism spectrum disorder diagnosis (4), an IQ < 75 (1), a fetal alcohol spectrum disorder (FASD) diagnosis (1), or an age at adoption > 48 months (1).

The final sample consisted of 39 PI children adopted ≤ 9 months (range: 4-9 months) and 34 PI children adopted ≥ 14 months (range: 14-48 months). As shown in Table 1, there were no differences between the groups in terms of the number of boys versus girls and child's age at assessment. The adoptive families of the two groups were similar; most of the adoptive parents were married and had a high education and household income.

Table 1. Descriptive statistics for child and family characteristics

	Age at adoption (months)		
	≤9 (*n*=39)	**≥14 (*n*=34)**	**Statistical test**
Age (years)	13.04 (2.57)	12.69 (3.46)	$t(60) = .48$, *ns*
% Male	33%	38%	$\chi^2 = .19$, *ns*
Country of origin	Russia (35) Ukraine (1) Belarus (1) Uzbekistan (2)	Russia (29) Belarus (4) Uzbekistan (1)	
Age at adoption (months)	7.54 (1.45)	23.69 (9.38)	$t(34)=9.94$, $p<.001$
Time in an institution (months)	7.21 (1.45)	19.76 (8.14)	$t(35)=8.88$, $p<.001$
Time in adoptive home (years)	12.39 (2.57)	10.71 (3.49)	$t(60)=2.32$, $p<.05$
IQ[a]	106.92 (9.88)	99.68 (12.59)	$F(1,71)=7.58$, $p<.01$
% taking stimulant meds day of home visit	15%	18%	$\chi^2 = .07$, *ns*
% born prematurely	37%	41%	$\chi^2 = .08$, *ns*
Birth weight (lbs)	6.36 (1.36)	5.61 (1.59)	$t(49)=1.79$, $p=.08$
% LBW (< 5.5 lbs)	28%	42%	$\chi^2 = 1.05$, *ns*
Parent marital status (% married)	90%	82%	$\chi^2 = .84$, *ns*
Parent education (% with 4-year college degree)	95%	94%	$\chi^2 = .01$, *ns*
Household income (% earning > $100,000)	79%	74%	$\chi^2 = .22$, *ns*

[a]Estimated based on the Vocabulary and Matrix Reasoning subtests of the WISC-IV

2.1.1 Recruitment

Participants were recruited through the International Assistance Group (IAG), an adoption agency specializing in adoption from Russia. Most of the participants had also participated at one or more time points in our main study which examines behavior and development of all IAG children through parent-report questionnaires (Merz & McCall, 2010). Recruitment procedures, along with all other aspects of the study, were approved by the University of Pittsburgh Institutional Review Board (IRB). Parents received a letter of invitation and a follow-up phone call, during which they were asked screening questions to determine if they met the following criteria: child age at assessment between 8-17 years, child age at adoption either ≤ 9 or ≥ 14 months, and location within three hours driving distance of Pittsburgh, Philadelphia, or Washington D.C. Parents were also asked whether the child had a severe functional (sensory, motor, or cognitive) impairment that would make computerized tasks inappropriate for him/her but such children were not excluded if they were interested in participating. Parents of children who met the inclusion criteria and were willing to participate then scheduled a time when a researcher could conduct a home visit.

For children taking stimulant medications for ADHD (e.g., Ritalin, Concerta, Adderall), an attempt was made to schedule the home visit at a time when the child was not taking the medication because stimulant medication may improve task performance (Bedard et al., 2004; Elliott et al., 1997; Kempton et al., 1999; Zeiner et al., 1999). However, these children were included in the study regardless of whether such a time was available. In total, 20 child participants were taking stimulant medications; eight of these children were tested when they were not taking the medication, 12 of these children were taking their medication when they were tested. The percentage of children taking stimulant medication at the time of testing did not differ between groups (see Table 1).

The participation rate for the current study was about 44%. In total, 190 families received a letter and phone call of invitation; 163 families were reached via phone. Of these families, 157 met the inclusion criteria for the study (84 agreed to participate, 67 declined to participate, 6 agreed to participate but were not able to be scheduled). Primary reasons for declining participation included lack of interest and time demands. Analyses were conducted to examine whether the smaller sample that participated in this study involving a home visit differed in terms of parent-rated inhibitory control and WM from the larger sample that participated in the main study involving a questionnaire. Multivariate analysis of covariance (ANCOVA) was conducted to examine the effect of participation status (0= in the home visit; 1=in the main study) on Behavior Rating Inventory of Executive Functioning (BRIEF) Inhibit and Working Memory scale T scores after covarying age at assessment and age at adoption. There were no significant differences between home visit participants (n=65) and main study participants (n=143) on parent-rated inhibitory control or WM, Wilks' λ = .99, $F(2,203)=.55$, ns. This suggests that the children in the current study were similar to the larger sample of children in the main study in terms of inhibitory control and WM.

2.2 PROCEDURE

Parents and children were visited at their homes in Pittsburgh (66), Philadelphia (12), or Washington D.C. (6) one time for approximately two hours by a researcher. The researcher first explained the study procedures, obtained parent and child consent to participate, and set up the equipment needed for task administration on a large table, usually in the dining room. The computerized tasks were presented to the child on a touch screen attached to a laptop that faced the researcher. Depending on the task, the child used a keyboard, button box, or touch screen to input responses. The researcher administered the CANTAB motor screening task first followed by three inhibitory control tasks (go/no-go, flanker, and stop-signal), three working memory tasks (CANTAB spatial span and spatial working memory, AWMA backwards digit recall), and two IQ subtests (WISC-IV vocabulary and matrix reasoning) in a sequence which varied across children in the following manner. Each of the eight tasks was first paired with another task assessing a different construct (i.e., inhibitory control+WM, inhibitory control+IQ, or WM+IQ). Each combination of these four pairs formed a separate task sequence making 24 different task sequences in total. Children were assigned a task sequence such that once a particular sequence was randomly chosen for either a younger- or older-adopted child, the next child in the opposite group would be assigned the same sequence. Although these tests are usually administered in a lab setting, home visits were more appropriate for the current study to encourage the participation of adoptive families who live quite a distance from Pittsburgh.

While the child participated in these tasks, the parent completed the home visit questionnaire which consisted of a set of questions about family characteristics and the child's background, early development, medical history, academic performance, and service use as well as the Conners' Parent Rating Scale – Revised (CPRS; Conners, 2000). If the parent had not already completed the main study questionnaire, a more comprehensive battery that included the BRIEF and had been mailed to them, they were given the opportunity to do so during the home visit. While all parents completed the home visit questionnaire, 90% (76/84) completed the main study questionnaire. Therefore, analyses of the BRIEF were based on a slightly reduced sample. Parents and children were compensated $30 each for their participation.

Twenty home visits were conducted by a graduate student and 64 by a trained research assistant. The research assistant scheduled the home visits and assembled the documents for the home visit and was not blind to the group status of the participants or study hypotheses. However, the graduate student was blind to group status of the participant in the home visit because home visit documents did not list this status and this was not discussed prior to home visits conducted by the graduate student. The graduate student was not blind to study hypotheses. ANOVAs with home visitor (1=research assistant; 2=graduate student) and age at adoption group (1= ≤9; 2= ≥14 months) as between-group factors and age at assessment as a covariate were conducted to examine whether child inhibitory control, WM, or IQ task performance varied as a function of who conducted the home visit and administered the tasks. There were no significant effects of home visitor on WM, $F(1,68)=.01-.28$, ns, inhibitory control, $F(1,68)=.18-1.12$, ns, or IQ, $F(1,69)=.79$, ns.

2.3 MEASURES

2.3.1 Inhibitory control

Computerized tasks that assess suppression of both a primary or dominant response (go/no-go, stop-signal tasks) and a competing secondary response (flanker task) were administered. For each task, outcome measures (e.g., response errors, reaction time) were automatically generated by the computer. The stop-signal task came from the Cambridge Neuropsychological Test and

Automated Battery (CANTAB), a computerized battery of assessments of cognitive skills, and the go/no-go and flanker tasks were designed and presented using E-Prime Version 2.0 (PST, Pittsburgh, PA, USA).

2.3.1.1 Go/no-go task

White visual stimuli were presented on a computer screen with a black background, and children were instructed to respond as quickly as possible by pressing the spacebar with their dominant hand to go cues (circles) but not to respond to no-go cues (squares). The go target was presented in 75% of the trials, creating a prepotency toward responding. The stimulus duration was 300 ms, with a random interstimulus interval ranging from 1100 to 1900 ms. After a short practice session, there were two blocks of 100 trials for a total of 200 trials (50 total no-go trials). In each block the order of stimulus presentation was pseudo-random such that no two no-go stimuli occurred in succession. Scoring was based on accuracy to no-go trials, accuracy to go trials, and reaction time (RT) to correct go trials. No-go accuracy scores were negatively correlated with mean go RT ($r = -.36$, $p < .01$), indicating a speed-accuracy tradeoff in the sample, which is common.

2.3.1.2 Stop-signal task

In the stop-signal task (Logan, 1994; Logan, Schachar, & Tannock, 1997), equally probable visual stimuli (right- and left-pointing arrows) are presented on a computer screen, and the child is instructed to respond by pressing the corresponding keys as quickly as possible with his/her dominant hand. On 25% of the trials, an auditory “stop-signal” presented shortly after the go stimulus indicates that the child is not to respond. Each trial consists of a 500 ms fixation followed by an arrow appearing for one second and an inter-trial interval of 700 ms. The stop-signal consists of a 1000 Hz tone 100 ms in duration. Five blocks of 64 trials were administered following one practice block of 16 trials.

The stop-signal task utilizes a tracking procedure, in which the delay between the presentation of the visual stimulus and the onset of the stop-signal changes after every trial with a stop-signal. The task starts with a 250 ms delay. Following a successful stop, the delay is lengthened by 50 ms resulting in the next stop trial being harder. Following a failed stop, the delay is shortened by 50 ms resulting in the next stop trial being easier. This procedure converges on the stop-signal delay at which the child is able to inhibit on 50% of the trials.

Stop-signal RT (SSRT), the primary measure of inhibitory control on the stop-signal task, reflects inhibitory control speed or the time required to stop a response that is already in the process of being executed. It is computed as the difference between the mean stop-signal delay and the mean RT on trials without a stop-signal (e.g., Logan et al., 1997). Longer SSRT indicates poorer inhibitory control.

Checks on data integrity were conducted. The accurate estimation of SSRT relies on the tracking procedure converging on the stop-signal delay at which the child attained 50% accuracy. This was confirmed as the probability of inhibition was very close to 50% in each group. In addition, the PI groups did not differ significantly in terms of percentage of accurate inhibition or stop-signal delay. However, for two children, percentage of inhibition was < 13% potentially yielding questionable estimates of SSRT (Schachar, Mota, Logan, Tannock, & Klim, 2000). Main analyses were re-run omitting sub-blocks in which percentage of inhibition was < 13% (Nigg, 1999), with no change in results.

2.3.1.3 Flanker task

In the flanker task (Eriksen & Eriksen, 1974), a set of five arrows was presented in the center of a computer screen, and the child was instructed to press the ‘x’ key if the central arrow (target) was pointing left and to press the ‘m’ key if the central arrow was pointing right as quickly as possible. The target was flanked by two identical arrows on either side (distractors) that were either pointed in the same direction (i.e., a congruent trial, >>>>>) or in the opposite direction of the target arrow (i.e., an incongruent trial, >><>>). It takes longer to respond to incongruent trials than to congruent trials because in the first instance the flanker triggers a response that must be suppressed. After initial practice trials, the experimental trials consisted of two blocks of 80 trials in random order. Each block consisted of 40 congruent and 40 incongruent trials. Each stimulus was presented for 500 ms, with a fixed interstimulus interval of 1500 ms.

The dependent variables for this task were percent interference for RT and accuracy (e.g., incongruent RT - congruent RT /congruent RT). For percent interference for RT, larger scores indicate less efficient interference control. For percent interference for accuracy, larger scores indicate better interference control. These percentages control for individual differences in speed of responding and accuracy. Children who attained a congruent accuracy score < 60% (n=5) were omitted from analyses because this indicates a failure to understand or perform the task according to the instructions. As expected, all children attained higher accuracy scores for the congruent relative to the incongruent trials. While most children showed a faster RT to congruent compared to incongruent trials, three children exhibited the opposite pattern, which is not uncommon in studies using this task.

2.3.2 Verbal working memory

2.3.2.1 Backwards digit recall task

Children performed the backwards digit recall test, an assessment of the ability to store and process verbal items over short periods of time from the Automated Working Memory Assessment (AWMA; Alloway, 2007), a computerized, standardized battery of assessments. In this task, the computer presented a sequence of spoken digits to the child who was then required to recall them in the reverse order. The researcher manually recorded the accuracy of the child's answer by pressing designated keys. Practice trials were presented prior to test trials which began with a sequence of two numbers and increased to a maximum sequence of seven numbers based on child performance. The child had to pass three trials per level to move on to the next level of difficulty. The task ended when the child made three errors at a given level. Four-week test-retest reliability for the backwards digit recall task was .86 (Alloway, 2007).

Standard scores (M = 100, SD = 15) were generated automatically by the AWMA for each child on the basis of his/her age. Higher scores indicate more items stored and processed in verbal working memory. Values below 1 SD from the mean (standard scores < 86) are often considered to be indicative of mild deficit, with lower scores representing more severe deficits (Alloway et al., 2009). The nationally representative AWMA normative sample consisted of ethnically-diverse native-English speaking children in the UK (N = 746 4- to 11-year-olds; N = 351 12- to 18-year-olds). There were equal numbers of males and females, and sex was not found to lead to significant differences in test performance (Alloway et al., 2006).

2.3.3 Spatial working memory

CANTAB tasks were initially designed for adults based on tasks used in the animal experimental literature to investigate the functional impairments produced by lesions to specific brain areas. The CANTAB has since been extensively validated for children (Luciana & Nelson, 1998, 2002). There are age- and gender-based norms for each of the tests, and the scoring program automatically generates z scores and percentiles. The CANTAB standardization sample consists of primarily English-speaking UK residents age 4-90 (Strauss, Sherman, & Spreen, 2006). The CANTAB has been shown to possess acceptable to high levels of concurrent validity and test-retest reliability and to be differentially sensitive to disturbances in various brain systems (Fray, Robbins, & Sahakian, 1996; Lowe & Rabbitt, 1998). Proficiency in English does not impact performance, supporting its use with individuals who have compromised verbal skills (Luciana & Nelson, 2002).

2.3.3.1 Spatial span task

The spatial span task assesses the short-term storage/maintenance of spatial information. A set of 10 white boxes is displayed on the monitor and a specified number of boxes changes color for 3 seconds, one at a time. The participant is then signaled by a tone to reproduce the sequence by touching the same boxes in the same order on the monitor. If the participant touches the appropriate boxes in the correct order, he/she passes to the next level of difficulty. If the participant fails to give the correct response, two more attempts are allowed at each level. The task is discontinued after three failures at a given level. The task starts with a two-box sequence and it is possible to advance to a nine-box sequence. Prior to the start of test trials, the child is given two practice trials to ensure his/her understanding of the task. The score on this task is the number of items that can be remembered in the correct order.

2.3.3.2 Spatial working memory task

The spatial working memory task assesses the ability to store and process spatial information. The test begins with a number of colored squares ("boxes") displayed on a touch screen. The child is asked to find one blue token in each of these boxes and use the tokens to fill up an empty column on the right side of the screen. The child is instructed that after a token has been found in a box, that box will not contain any tokens in the future. Therefore, the child has to remember in which boxes tokens were found previously so as to not return to those boxes. There are three fixed levels of the task (4, 6, and 8 boxes) with four trials at each level. Outcome measures are the number of total errors (touching boxes that have already been found to be empty and revisiting boxes which have already been found to contain a token) as well as errors at the 4-, 6-, and 8-box levels.

2.3.4 General cognition

The home visitor administered the Vocabulary and Matrix Reasoning subtests of the Wechsler Intelligence Scales for Children – Fourth Edition (WISC-IV; Wechsler, 2003) to assess child cognitive skills. In the Vocabulary subtest, the child was required to define words, and in the Matrix Reasoning subtest, the child was required to choose a shape from a set of choices that completed a pattern. These two subtests were selected to provide a good estimate of full-scale IQ, which was used as a covariate to isolate inhibitory control and WM from general cognitive ability. This short form of the WISC-IV had high reliability (.92) and validity (.87) in the standardization sample (Sattler & Dumont, 2004).

2.3.5 Motor skills

The CANTAB motor screening test screens for visual, movement, and comprehension difficulties. A flashing cross was displayed on the screen in various locations, and children were instructed to touch it as quickly as possible. Accuracy and response latency measures were recorded.

2.3.6 Parent-rated attention problems

The long version of the Conners' Parent Rating Scale-Revised (CPRS; Conners, 2000; Conners, Sitarenios, Parker, & Epstein, 1998) has 80 items. Parents are asked to rate their 3- to 17-year-old child's behavior in the last month on a 4-point scale from 0 (not true at all) to 3 (very much true). Two CPRS scales were used in this study: the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) Inattentive and Hyperactive-Impulsive scales. The DSM-IV Inattentive scale (9 items) assesses poor attention to detail, careless mistakes on schoolwork, difficulty sustaining attention, failure to follow through on instructions, difficulty organizing tasks and activities, avoidance of tasks that require sustained mental effort, and distractibility. The DSM-IV Hyperactive-Impulsive subscale (9 items) assesses fidgetiness, difficulty remaining seated, excessive motor activity or restlessness, responding out of turn, and interrupting. High scores on the former scale indicate an above average correspondence with the DSM-IV diagnostic criteria for Inattentive type ADHD. High scores on the latter scale indicate an above average correspondence with the DSM-IV diagnostic criteria for Hyperactive-Impulsive type ADHD.

CPRS norms are based on a nationally representative standardization sample (N = 2,482). Separate norms are given for boys and girls, in three-year intervals, for ages 3 through 17. The CPRS yields T scores (higher scores indicate greater problems) which have a population mean of 50 (SD = 10). T scores of 65 and above indicate a clinically significant problem, with 61-64 considered mildly atypical and 56-60 considered borderline or slightly atypical. Adequate reliability and validity coefficients have been reported for the CPRS. Cronbach's alpha ranged from .73-.94 for CPRS scales in the standardization sample. Test-retest reliability coefficients over a span of 6-8 weeks ranged from .67-.85 for a sample of 50 children with a mean age of 11 years (Conners, 2000).

2.3.7 Parent-rated inhibitory control and working memory

The Behavior Rating Inventory of Executive Functioning (BRIEF; Gioia, Isquith, Guy, & Kenworthy, 2000) asks parents to rate 86 EF problems in their 5- to 18-year-old children as occurring never, sometimes, or often. Responses are summed to form eight scales; two of which were used in this study. The Inhibit scale (10 items) measures the ability to control impulses and to stop behavior at the appropriate time. The Working Memory scale (10 items) assesses the ability to hold information in mind to complete assignments and tasks. BRIEF scales yield T scores (with population M = 50, SD = 10) based on age and gender. Higher scores indicate more EF problems, with scores 1.5 SD above the normative mean of potential clinical significance. The BRIEF standardization sample (N = 1419) was 5–18 years at assessment (M = 11) and 43%

male. Given that children with any history of developmental delays were excluded from this sample, it is unlikely to have included any children adopted from institutions.

The BRIEF has adequate reliability and validity (Strauss, Sherman, & Spreen, 2006). The Cronbach alpha measure of internal consistency ranges from .80 to .98 for both clinical and normative samples, and the test–retest reliability correlation was .81 (range: .76–.85) for an average two-week interval (Gioia et al., 2000). However, some studies have failed to find significant associations between parent and teacher ratings on the BRIEF and children's performance on EF tasks (Mahone et al., 2002; see review McAuley, Chen, Goos, Schachar, & Crosbie, 2010) while others have found such relations (e.g., Toplak, Bucciarelli, Jain, & Tannock, 2009).

2.3.8 Academic difficulties

On the home visit questionnaire, parents were asked whether their child received special education services through an Individualized Education Plan (IEP), 504 service agreement, or a learning support or resource classroom (current or past). Parents whose child received special education services were asked to indicate the child's primary and secondary educational disability listed on his/her IEP from the following options: specific learning disability, emotional/behavioral disability, speech language impairment, autism spectrum disorder, physical impairment, other health impairment, deaf/hard of hearing, visual impairment, developmental delay, intellectual disability/mental retardation, severely multiply impaired, and other. Parents of children with 504 service agreements were asked to provide the diagnosis upon which the services are based. Parents of children using learning support or resource classrooms were asked to describe the services provided by the school. Parent responses to these questions were used to create academic difficulties, a dichotomous variable (1=using and 0=not using learning support services in school). If the parent indicated that the child was currently receiving any of the listed services, then the child was coded as receiving learning support.

2.3.9 Pre-adoption history

Age at adoption was defined as the age at which the child came into the parents' full-time care. Parent-reported time in an institution was strongly correlated with age at adoption, $r = .94$, $p < .001$, reflecting that most children were placed in institutions in the first few months of life. Age at adoption was used in analyses rather than time in an institution because it was more frequently and likely more accurately reported.

Parents provided their child's birth weight and whether their child's birth was premature. Birth weight was reported for 70% of the sample, and prematurity data was given for 79% of the sample. Low birth weight (LBW) was defined as weighing less than 5.5 pounds at birth; 32% (17/53) of the children with birth weight data were coded as LBW. As expected, prematurity was significantly associated with LBW, $\chi^2(1, N=53)=31.63$, $p<.001$. Conclusions regarding birth condition must be tempered by this sampling difference.

2.3.10 Post-adoption history

Parents indicated their level of education, family income, and marital status. Parents were asked to report the highest level of education completed: (a) less than high school degree; (b) high school or GED; (c) some college but no degree or associate degree (or other 2-year degree); (d) bachelor's degree; (e) master's degree; or (f) professional school and/or doctorate degree. These responses were dichotomized into those families in which at least one parent had a 4-year college degree or more vs. those with less education. Parents reported on family income before taxes in the year prior to the home visit in \$25,000 increments up to \$200,001+. Each income increment was assigned a numeric value from 1 for < \$50,000 to 8 for ≥ \$200,001. These responses were dichotomized into families with a household income of \$100,000 or more vs. those with lower income. Parents provided their marital status as married, partnered, separated, divorced, remarried, single, or widowed. These responses were dichotomized as married/partnered or not married/partnered.

3.0 RESULTS

3.1 PRELIMINARY ANALYSES

Prior to any inferential statistics, all dependent variables were examined for deviations from the required assumptions (e.g., normality), and transformations were made when necessary. Variables log-transformed included SSRT and go/no-go go accuracy. As expected, performance on inhibitory control and WM tasks improved with age at assessment for all scores, $r = .33\text{-}.58$, $p<.01$. There were no gender differences in task performance, $t(72)=.32\text{-}1.68$, ns. IQ was significantly higher in the PI group adopted ≤ 9 months (see Table 1) and was associated with performance on WM tasks but not inhibitory control tasks (see Table 2). There were no group differences on the CANTAB motor screening task error score, $F(1,72)=1.34$, ns, or latency score, $F(1,72)=1.28$, ns, suggesting that basic differences in motor skills may not confound any other differences found between the groups. Based on these preliminary analyses, age at assessment was included as a covariate in main analyses, and group differences in WM task performance were analyzed both covarying and not covarying IQ.

Analyses were conducted to examine the validity of the age at adoption groups. There were no significant correlations between age at adoption and inhibitory control or WM task performance within the PI group adopted ≤ 9 months ($r = .01\text{-}.26$, ns) or the PI group adopted ≥ 14 months ($r = .02\text{-}.27$, ns). In addition, age at adoption was not significantly correlated with parent-rated inhibitory control, working memory, inattention, or hyperactivity-impulsivity within either the PI group adopted ≤ 9 months (r = .01-.06, ns) or the PI group adopted ≥ 14 months (r = .02-.11, ns).

The potential influence of stimulant medication for ADHD on results was then examined by comparing inhibitory control and WM in three groups: children on stimulant medication during the home visit (*n*=12), children taking stimulant medication but not on the day of the home visit (*n*=8), children not taking stimulant medication (*n*=54). These groups did not differ significantly in inhibitory control (F(2,70)=.06-1.36, *ns*) or WM (F(2,70)=.17-.64, *ns*), although results were limited by low sample size within the groups taking medication.

3.2 CORRELATIONS ACROSS AND WITHIN INHIBITORY CONTROL AND WORKING MEMORY TASKS

Intercorrelations among outcome measures were conducted. WM tasks were expected to be highly intercorrelated, and simple inhibitory control tasks (stop-signal and go/no-go tasks) were expected to be highly intercorrelated. No predictions were made for the flanker task, a more complex inhibitory control task. It was also anticipated that there would be correlations across inhibitory control and WM because they are both EF components. As expected, the WM task scores were highly intercorrelated. Although not as strongly, the inhibitory control task scores were also intercorrelated (see Table 2). There were also significant correlations between inhibitory control and WM measures possibly reflecting the shared EF demands of the tasks.

Table 2. Bivariate correlations among inhibitory control, working memory, IQ, inattention, and hyperactivity-impulsivity

		1	2	3	4	5	6	7	8	9	10	11	12
1	Backward digit recall correct responses	--											
2	Spatial span (span length)	.40***	--										
3	Spatial working memory total errors	-.31**	-.50***	--									
4	Stop-signal RT (ms)	-.22[+]	-.19[+]	.34**	--								
5	Go/no-go task go accuracy	.28*	.36**	-.32**	-.29**	--							
6	Go/no-go task no-go accuracy	.11	.22*	-.15	-.13	.29**	--						
7	Go/no-go task mean go RT (ms)	-.50***	-.44***	.45***	.35**	-.26*	.26*	--					
8	Flanker task % interference for accuracy[a]	.12	.17	-.16	-.07	.13	.30**	.07	--				
9	Flanker task % interference for RT[b]	.19+	.40***	-.41***	-.32**	.19[+]	.24*	-.29**	-.04	--			
10	IQ	.30**	.28*	-.25*	-.13	.03	.01	-.14	-.03	.15	--		
11	CPRS Inattention *T* score	-.05	-.16	.17	.16	.01	.11	.07	.05	-.17	-.36**	--	
12	CPRS Hyperactivity-impulsivity *T* score	-.06	-.28*	.24*	.22*	-.16	.13	.20[+]	-.01	-.22*	-.33**	.57***	--

[+]*p*<.10; **p*<.05; ***p*<.01; ****p*<.001

Note. RT = response time; IQ was estimated based on the Vocabulary and Matrix Reasoning subtests of the WISC-IV; CPRS = Conners' Parent Rating Scale.

[a] high scores = less interference

[b] high scores = more interference

3.3 GROUP DIFFERENCES IN INHIBITORY CONTROL AND WORKING MEMORY TASK PERFORMANCE

Separate multivariate analyses of covariance (MANCOVA) were run to examine group differences in inhibitory control and working memory with one between-groups factor (group: adopted ≤ 9 or ≥ 14 months) and one covariate (age at assessment). Wilks' lambda was used as the overall test of significance and if the overall omnibus F was significant ($p < .05$), the subsequent univariate analyses were interpreted. The effect size partial eta-squared (η^2) was reported which indicates the percentage of variance accounted for by a factor in an analysis of variance type of model (Cohen, Cohen, West, & Aiken, 2003). The conventions for small, medium, and large effects are .01, .06, and .14, respectively.

The first MANCOVA revealed a significant main effect of group on WM, Wilks' $\lambda = .86$, $F(3,68)=3.66$, $p=.02$, $\eta^2= .14$. There were no significant interactions between age at adoption group and age at assessment. Univariate analyses indicated that PI children adopted ≥ 14 months recalled significantly fewer items on the spatial span task relative to PI children adopted ≤ 9 months (see Table 3), but there were no significant group differences for the spatial working memory or backward digit recall tasks. Group differences in working memory were then re-examined covarying general cognitive ability (IQ). The group effect was marginally significant after covarying IQ, Wilks' $\lambda = .90$, $F(3,68)=2.50$, $p=.07$, $\eta^2= .10$. There were no differences in results for individual WM variables after covarying IQ.

To further investigate group differences in performance on the spatial working memory task, the PI groups were compared on their errors at the three levels of the task (4, 6, and 8 boxes). The MANCOVA indicated a marginally significant omnibus effect, Wilks' λ = .91, $F(3,67)=2.14$, $p=.10$, $\eta^2= .09$. While there were no significant group differences at the 4 and 8 box levels, PI children adopted ≥ 14 months had marginally higher errors at the 6 box level than PI children adopted ≤ 9 months (see Table 3).

MANCOVA was conducted to examine group differences on the stop-signal and go/no-go tasks (SSRT, go/no-go go accuracy, go/no-go no-go accuracy, and go/no-go go RT). There was a significant main effect of group on these inhibitory control measures, Wilks' λ = .85, $F(4,65) = 2.78$, $p=.03$, $\eta^2 = .15$. Age at adoption group by age at assessment interaction effects were not significant and therefore were omitted from the final analysis of variance. As shown in Table 3, PI children adopted ≥ 14 months had a significantly higher SSRT than those adopted ≤ 9 months. On the go/no-go task, PI children adopted ≥ 14 months had significantly lower go trial accuracy than PI children adopted ≤ 9 months, but there were no significant group differences for no-go accuracy or go trial RT.

Table 3. Inhibitory control and working memory task performance in PI children adopted ≤ 9 months and ≥ 14 months

	Age at adoption (months)			
	≤9 (*n*=39)	**≥14 (*n*=34)**		
	***M* (*SD*)**	***M* (*SD*)**	*F*(1,70)	*p*
Backward digit span (correct responses)	15.47 (5.61)	14.44 (4.72)	.51	.48
Spatial working memory (total errors)	32.26 (17.17)	35.18 (18.27)	.26	.61
Errors at 4 box level	.79 (1.40)	1.18 (1.80)	.80	.41
Errors at 6 box level	7.34 (5.75)	10.29 (7.15)	3.47	.07
Errors at 8 box level	23.42 (11.71)	23.41 (11.94)	.16	.76
Spatial span (span length)	6.67 (1.58)	5.53 (1.44)	11.03	.001
Stop-signal RT (ms)	198.47 (69.43)	243.88 (95.20)	4.91	.03
Go/no-go go accuracy (% correct)	.97 (.04)	.94 (.06)	4.64	.04
Go/no-go no-go accuracy (% correct)	.59 (.21)	.60 (.18)	.95	.33
Go/no-go go RT (ms)	377.17 (43.90)	399.35 (69.78)	2.30	.13
Flanker task % interference for accuracy[a]	-.27 (.16)	-.33 (.18)	2.76	.10
Flanker task % interference for RT[b]	.18 (.09)	.16 (.08)	.53	.47

Note. Cases with congruent accuracy < 60% omitted from flanker task analyses, therefore error df=67

[a] high scores = less interference (better inhibitory control)

[b] high scores = more interference (poor inhibitory control)

Univariate analyses of covariance were conducted to test group differences on the flanker task. PI children adopted ≥ 14 months had marginally greater (*p*<.10) percent interference for accuracy compared to those adopted ≤ 9 months, but there were no significant group differences in percent interference for RT. Inspection of task scores revealed that the groups did not differ in their accuracy to congruent trials, but PI children adopted ≥ 14 months had marginally lower accuracy to incongruent trials than PI children ≤ 9 months (see Figure 1).

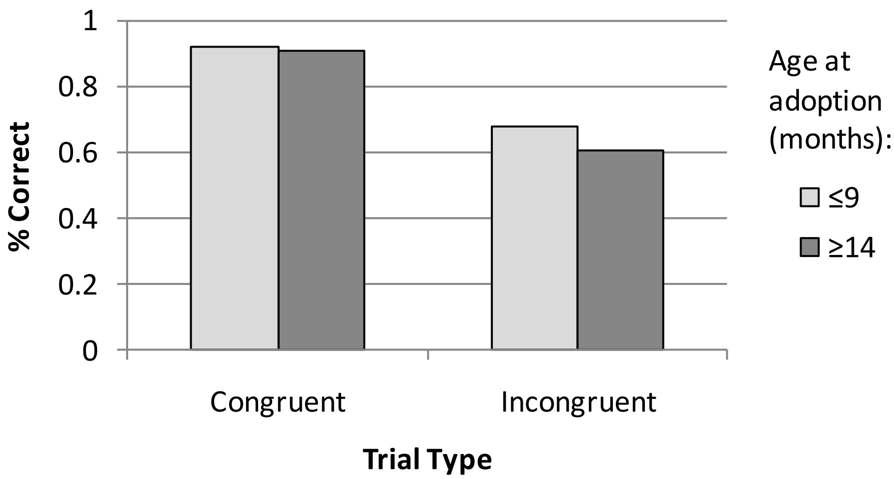

Figure 1. Flanker task performance in PI children adopted ≤ 9 months and ≥ 14 months

3.4 COMPARISON TO TYPICALLY-DEVELOPING CHILDREN REARED IN THEIR BIRTH FAMILIES

PI children's standard scores on the CANTAB and AWMA working memory tasks were examined. In addition, comparisons were made to typically-developing never-institutionalized children from previous studies. PI children adopted ≥ 14 months were expected to perform poorly relative to typically-developing never-institutionalized children but PI children adopted ≤ 9 months were not.

3.4.1 Standardization samples

For the CANTAB spatial span and spatial working memory tasks, *z* scores were calculated automatically indicating the differences between PI group scores and the mean scores of age-matched children in the standardization sample. It should be noted that the standardization samples for these tasks for the age groups in this study were quite small, approximately *N*=20-30. Scores on the spatial span task and the spatial working memory task did not differ significantly between either of the PI groups and the CANTAB standardization sample. On the spatial span task, PI children adopted ≥ 14 months obtained a span length *z* score of -.38 (*SD*=1.16) while those adopted ≤ 9 months achieved a *z* score of .56 (*SD*=1.15). On the spatial working memory task, PI children adopted ≥ 14 months obtained a total errors *z* score of -.12 (*SD*=.97) while those adopted ≤ 9 months attained a *z* score of -.08 (*SD*=.86).

The AWMA automatically generated standard scores for the backward digit recall task (*M*=100, *SD*=15). Standard scores on the AWMA backward digit recall task did not significantly differ from the normative sample for either PI children adopted after 14 months or those adopted before 9 months (*M*(*SD*) = 98.11(13.81) and 100.96(15.75), respectively).

3.4.2 Typically-developing comparison groups from previous studies

PI children's performance on the stop-signal, spatial working memory, and spatial span tasks was compared to that of normative control groups from previous studies. Among the inhibitory control measures, comparison to children reared in their birth families was only conducted for the stop-signal task because task specifications were identical to those used in previous studies. Because the go/no-go and flanker tasks were designed specifically for this study, the exact task specifications used here are not identical to those of tasks used in previous research. Therefore, it may be misleading to make comparisons to previous versions of these tasks.

For these analyses, each PI group (children adopted ≤ 9 and ≥ 14 months) was divided into 8- to 11-year-olds and 12- to 17-year-olds (see Table 4). Means and standard deviations of typically-developing comparison children in these age groups were obtained from several publications (Conklin, Luciana, Hooper, & Yarger, 2007; De Luca et al., 2003; Huang-Pollock, Mikami, Pfiffner, & McBurnett, 2009; Luciana & Nelson, 2002; Toplak et al., 2009). SSRT, spatial span length, and spatial working memory total errors were compared among PI children adopted ≥ 14 months, PI children adopted ≤ 9 months, and typically-developing children using *t* tests. On the stop-signal task, in the 8- to 11-year-old age group, there were no significant differences between either of the PI groups and typically-developing children, $t(46\text{-}52) = .67\text{-}.79$, *ns*. In contrast, 12- to 17-year-old PI children adopted ≥ 14 months had significantly higher SSRT scores than the typically developing comparison group from a previous study, $t(56) = 3.59$, $p=.001$, while those adopted ≤ 9 months were marginally higher, $t(65) = 1.94$, $p=.06$.

On the spatial span task, both 8- to 11-year-old, $t(153) = 2.14$, $p=.03$, and 12- to 17-year-old children adopted ≥ 14 months, $t(53) = 2.74$, $p =.01$, had a significantly lower span length than typically developing children, while children adopted ≤ 9 months in both age at assessment groups did not differ from the control group, $t(62\text{-}147) = .10\text{-}.19$, *ns*.

On the spatial working memory task, there were no significant group differences between either 8- to 11-year-old PI children, $t(39\text{-}45) = .04\text{-}.37$, *ns*, or 12- to 17-year-old PI children and typically developing children, $t(53\text{-}62) = 1.16\text{-}1.33$, *ns*, in terms of total errors. Similarly, at the 4-box level of the task, there were no significant group differences between either the 8- to 11-year-old PI children, $t(147\text{-}153) = 1.25\text{-}1.32$, *ns*, or the 12- to 17-year-old PI children and the typically developing comparison groups, $t(72\text{-}81) = .39\text{-}1.52$, *ns*. At the 6-box level of the task, there were no significant group differences between 8- to 11-year-old PI children and typically developing children, $t(147\text{-}153) = .56\text{-}.81$, *ns*, but both 12- to 17-year-old PI children adopted ≤ 9 months, $t(81) = 2.76$, $p = .007$, and ≥ 14 months, $t(72) = 3.23$, $p = .002$, had significantly more errors than typically developing children. At the 8-box level of the task, there were no group differences between 8- to 11-year-old PI children in either age at adoption group and typically-developing children, $t(147\text{-}153) = .23\text{-}1.46$, *ns*, but 12- to 17-year-old PI children adopted ≤ 9 months made significantly more errors than typically-developing children, $t(81) = 2.91$, $p = .005$, and those adopted ≥ 14 months made marginally more errors than typically-developing children, $t(72) = 1.90$, $p = .06$.

Table 4. Inhibitory control and working memory task performance in PI and typically-developing never-institutionalized children

	Age at assessment (years)					
	8-11			**12-17**		
	Age at adoption (months)			**Age at adoption (months)**		
	≤9 (*n*=12)	**≥14 (*n*=18)**	**TD**	**≤9 (*n*=25)**	**≥14 (*n*=16)**	**TD**
	***M* (*SD*)**	***M* (*SD*)**	***M* (*SD*)**	***M* (*SD*)**	***M* (*SD*)**	***M* (*SD*)**
Stop-signal RT (ms)	231.28 (87.13)	265.31 (85.37)	250.83 (69.87)[a]	180.89 (54.82)	**226.88** (100.14)	154.88 (52.04)[b]
Spatial span length	5.67 (.89)	**4.94** (1.31)	5.60 (1.22)[c]	7.19 (1.47)	**6.06** (1.24)	7.23(1.51)[d]
Spatial working memory total errors	45.54 (11.01)	43.94 (16.95)	44.10 (11.31)[e]	25.31 (15.46)	25.31 (14.58)	19.9 (16.19)[d]
Errors at 4 box level	1.67 (1.83)	1.61 (2.00)	1.08 (1.55)[c]	.38 (.94)	.69 (1.45)	.31 (.66)[f]
Errors at 6 box level	10.58 (5.57)	13.39 (6.90)	11.85 (7.62)[c]	**5.85** (5.29)	**6.81** (5.83)	3.25 (3.2)[f]
Errors at 8 box level	32.83 (6.46)	28.94 (11.66)	28.34 (10.43)[c]	**19.08** (11.07)	17.19 (9.01)	12.62 (8.39)[f]

Note. TD = typically-developing never-institutionalized children; RT = response time; bolded means differ significantly from typically-developing children in the same age range

[a] *N* = 36 8- to 12-year-olds from Huang-Pollock et al. (2009)
[b] *N* = 42 13- to 18-year-olds from Toplak et al. (2009)
[c] *N* = 137 8- to 12-year-olds from Luciana & Nelson (2002)
[d] *N* = 39 15- to 19-year-olds from De Luca et al. (2003)
[e] *N* = 29 8- to 10-year-olds from De Luca et al. (2003)
[f] *N* = 58 13- to 17-year-olds from Conklin, Luciana, Hooper, & Yarger (2007)

3.4.3 Spatial span task

Finally, PI children's performance on the spatial span task was compared to that of typically-developing children using data collected by the Lab of Neurocognitive Development (Asato, Nawarawong, Hermann, Crumrine, & Luna, 2011). There were approximately 133 8- to 17-year-old children with equal numbers of boys and girls. The groups did not differ significantly in terms of age at assessment, $F(2,203) = 1.22$, *ns*, or gender, $\chi^2(2,N=206) = 3.54$, *ns*. ANCOVA was conducted to examine group differences in spatial span length after covarying age at assessment. There was a significant main effect of group, $F(2,201) = 8.83$, $p<.001$, $\eta^2 = .08$. Pairwise comparisons indicated that the older-adopted PI group had a significantly lower span length than both the younger-adopted PI group and the typically-developing group, which did not differ significantly from each other.

3.5 INFLUENCE OF BIRTH CIRCUMSTANCES ON INHIBITORY CONTROL AND WORKING MEMORY

As shown in Table 1, there were no significant group differences in the percentage of children born prematurely, but PI children adopted ≥ 14 months had marginally lower birth weights than those adopted ≤ 9 months. There were no significant differences between PI children born and not born prematurely on any of the WM or inhibitory control measures, $t(56) = .13\text{-}1.09$, *ns*. The correlation between birth weight and span length on the spatial span task approached significance, r=.25, p=.08, n=51. Furthermore, categorical analyses of birth weight revealed that children with LBW had marginally lower span length on the spatial span task, $t(49) = 2.02$, p=.05, n=51, and higher total errors on the spatial working memory task, $t(49) = 1.73$, p=.09, n=51. Interpretation of these analyses should take into account the reduced sample size because birth data was not available for 39% of the total PI sample.

3.6 GROUP DIFFERENCES IN PARENT-RATED ATTENTION, INHIBITORY CONTROL, AND WORKING MEMORY PROBLEMS

As shown in Table 5, PI children adopted ≥ 14 months were found to have significantly higher *T* scores on the CPRS DSM-IV Inattentive and Hyperactive-Impulsive scales than those adopted ≤ 9 months. PI children adopted ≥ 14 months had higher inattention and hyperactivity-impulsivity than the CPRS normative sample, one-sample $t(34)$=3.88-5.42, p<.001. PI children adopted ≤ 9 months did not differ significantly from the normative sample on hyperactivity-impulsivity, one-sample $t(37)$=.67, *ns*, but had marginally higher inattention, one-sample $t(37)$=1.68, p=.10.

Similarly, the older-adopted PI group had significantly higher *T* scores on the BRIEF Inhibit and Working Memory scales than the younger-adopted PI group. While the older-adopted PI group had higher scores than the standardization sample, $t(26) = 4.19$-4.58, p<.001, the younger-adopted group did not, $t(36) = .04$-.36, *ns*.

Table 5. Parent-rated inhibitory control, working memory, and attention problems in PI children adopted ≤ 9 months and ≥ 14 months

	Age at adoption (months)							
	≤9 (*n*=39)		**≥14 (*n*=34)**		**Continuously-scaled variables**		**Categorically-scaled variables**	
	***M* (*SD*)**	***% T ≥ 65***	***M* (*SD*)**	***% T ≥ 65***	$F(1,70)$	p	$\chi^2(1)$	p
BRIEF Inhibitory Control *T* score[a]	49.32 (11.50)	14%	**61.67** (13.24)	41%	15.82	.000	6.17	.01
BRIEF Working Memory *T* score[a]	50.08 (12.98)	14%	**62.19** (15.11)	44%	11.81	.001	7.66	.01
CPRS Inattention *T* score	53.24 (11.88)	16%	**62.29** (12.88)	47%	9.64	.003	8.27	.004
CPRS Hyperactivity-Impulsivity *T* score	50.82 (7.57)	11%	**59.06** (13.83)	29%	10.12	.002	4.09	.04

Note. Bolded means are significantly higher than the standardization sample mean of 50 (*SD*=10); BRIEF = Behavior Rating Inventory of Executive Functioning; CPRS = Conners' Parent Rating Scale

[a] *N*=64 (37 adopted ≤ 9 months, 27 adopted ≥ 14 months)

3.7 ASSOCIATION BETWEEN INHIBITORY CONTROL AND WORKING MEMORY TASK PERFORMANCE AND PARENT-RATED ATTENTION, INHIBITORY CONTROL, AND WORKING MEMORY PROBLEMS

Table 2 gives the bivariate correlations between inhibitory control and WM scores and *T* scores on the CPRS DSM-IV Inattentive and Hyperactive-Impulsive scales. SSRT, spatial span length, and spatial working memory total errors were significantly correlated with hyperactivity-impulsivity, but none of the inhibitory control or WM task scores were significantly associated with inattention.

Because SSRT, spatial span length, and hyperactivity-impulsivity were significantly related to age at adoption group, it was important to ensure that the relations between SSRT/spatial span length and hyperactivity-impulsivity were not a result of age at adoption. Thus, multiple linear regression analyses were conducted. Hyperactivity-impulsivity was regressed on age at adoption group (entered first) and SSRT/spatial span length (entered second). In the first regression analysis, at the first step, age at adoption group accounted for a significant amount of the variability in hyperactivity-impulsivity, $R^2 = .06$, $F(1,77) = 4.53$, $p < .05$. At the second step, SSRT accounted for a marginally significant amount of variability in hyperactivity-impulsivity even after controlling for age at adoption group, $\Delta R^2 = .04$, $F(1,76) = 2.96$, $p < .10$. In the second regression analysis, at the second step, spatial span length accounted for a significant amount of variability in hyperactivity-impulsivity even after controlling for age at adoption group, $\Delta R^2 = .06$, $F(1,78) = 4.77$, $p < .05$.

Both WM and hyperactivity-impulsivity were associated with IQ. Therefore, hierarchical multiple regression was then conducted to examine whether WM outcome variables were associated with hyperactivity-impulsivity above and beyond IQ. In these models, hyperactivity-impulsivity was regressed on IQ (entered first) and spatial span length/spatial working memory total errors, respectively (entered second). In the first regression analysis, at the first step, IQ accounted for a significant amount of the variability in hyperactivity-impulsivity, $R^2 = .11$, $F(1,79) = 9.77$, $p < .01$. At the second step, the association between spatial span length and hyperactivity-impulsivity approached significance after controlling for IQ, $\Delta R^2 = .04$, $F(1,78) = 3.58$, $p = .06$. IQ and hyperactivity-impulsivity maintained a significant association with spatial span length in the model. In the second regression analysis, at the second step, spatial working memory total errors did not account for a significant amount of the variability in hyperactivity-impulsivity after controlling for IQ, $\Delta R^2 = .03$, $F(1,78) = 2.55$, $p = .12$.

Pearson correlations revealed significant associations between backward digit recall standard scores and *T* scores on the BRIEF Working Memory scale, $r = -.25$, $p<.05$, $n=64$, and between stop-signal RT and *T* scores on the BRIEF Inhibit scale, $r = .25$, $p<.05$, $n=64$.

3.8 ASSOCIATION BETWEEN IQ AND PARENT-RATED ATTENTION PROBLEMS

There were significant bivariate correlations between IQ and parent-rated inattention and hyperactivity-impulsivity (see Table 2). Multiple regression analyses were conducted in the same way as above to examine whether the relations between IQ and hyperactivity-impulsivity and between IQ and inattention held after accounting for age at adoption group. In the first regression, at the first step, age at adoption group accounted for a significant amount of the variability in hyperactivity-impulsivity, $R^2 = .05$, $F(1,79) = 4.41$, $p < .05$. At the second step, IQ accounted for a significant amount of variability in hyperactivity-impulsivity after accounting for age at adoption group, $\Delta R^2 = .08$, $F(1,78) = 7.14$, $p < .01$. In the second regression analysis, at the first step, age at adoption group accounted for a significant amount of the variability in inattentive symptoms, $R^2 = .06$, $F(1,79) = 5.21$, $p < .05$. At the second step, IQ accounted for a significant amount of the variability in inattentive symptoms after accounting for age at adoption group, $\Delta R^2 = .09$, $F(1,78) = 8.54$, $p < .01$.

3.9 GROUP DIFFERENCES IN ACADEMIC DIFFICULTIES

Group differences in academic difficulties (1=using and 0=not using learning support services in school) were investigated using chi-square tests. Descriptive data on academic difficulties in the PI sample are given in Table 6. Overall, a significantly higher percentage of PI children adopted ≥ 14 months than those adopted ≤ 9 months were reported to have academic difficulties. When broken down into the type of service received, the groups differed significantly in terms of percentage in a learning support classroom but not in terms of IEP special education services or 504 agreement services.

Table 6. Academic difficulties in PI children adopted ≤ 9 months and ≥ 14 months

	Age at adoption (months)			
	≤9 (*n*=39)	**≥14 (*n*=34)**	**χ^2(1, *N*=74)**	***p***
% with an IEP for learning support services	13% (5)	27% (9)	2.18	.14
# with the following primary educational disability:				
Specific learning disability	2	5		
Emotional/behavioral disability	1	1		
Speech language impairment	2	2		
Developmental delay	0	1		
% with a 504 service agreement	5% (2)	15% (5)	1.92	.17
# based on ADHD diagnosis	2	4		
% receiving learning support in a resource classroom	10% (4)	29% (10)	4.30	.04
Academic difficulties[b]	21% (8)	44% (15)	4.69	.03

Note. No children were reported to have the following IEP primary educational disabilities: physical impairment, other health impairment, intellectual disability/mental retardation, severely multiply impaired, Autism spectrum disorder, deaf/hard of hearing, visual impairment; IEP = individualized education program

[b]IEP learning support services, 504 service agreement, or in a learning support classroom

3.10 ASSOCIATION BETWEEN INHIBITORY CONTROL AND WORKING MEMORY TASK PERFORMANCE AND ACADEMIC DIFFICULTIES

There were no significant differences in inhibitory control and WM task performance between PI children with and without parent-reported academic difficulties. PI children with academic difficulties recalled marginally fewer numbers on the backward digit recall task, $t(71) = 1.91$, $p = .06$, and marginally fewer spatial locations on the spatial span task, $t(58) = 1.89$, $p = .06$, than those without academic difficulties. In addition, PI children with academic difficulties had significantly lower IQ, $t(71) = 3.06$, $p = .003$, higher parent-rated inattentive symptoms, $t(70) =$

5.42, p = .000, and higher parent-rated hyperactive-impulsive symptoms, $t(70) = 3.09$, p = .003, than those without academic difficulties.

4.0 DISCUSSION

The major purpose of this study was to compare inhibitory control and working memory task performance among school-aged children adopted from psychosocially depriving institutions at older and younger ages and never-institutionalized children from previous studies. Additional aims were to examine the predictors (e.g., birth circumstances) and correlates (e.g., parent-rated attention and academic difficulties) of these neurocognitive processes. Findings revealed that post-institutionalized (PI) children adopted at older ages performed poorly on inhibitory control and spatial working memory tasks compared to those adopted at younger ages and never-institutionalized children, who tended to not differ significantly. Significant group differences were found for the spatial span, stop-signal, and go/no-go tasks but not the spatial working memory, backward digit span, or flanker tasks. Given that older-adopted PI children did not significantly differ from comparison groups on some inhibitory control and working memory tasks, it is possible that they are vulnerable to deficits in these domains but able to overcome their difficulties under some conditions. Their performance across tasks may also reflect greater difficulty with some neurocognitive skills relative to others, which is discussed further below.

4.1 INHIBITORY CONTROL AND WORKING MEMORY

Older-adopted PI children performed poorly on the spatial span task relative to both younger-adopted PI children and never-institutionalized children, who did not differ significantly. For example, both 12- to 17-year-old children adopted from institutions before 9 months and never-institutionalized children recalled an average of 7 spatial locations in order, while those adopted from institutions beyond 14 months recalled an average of only 6 locations in order. Older-adopted PI children also needed significantly more time to inhibit a prepotent response on the stop-signal task relative to younger-adopted PI children, and those between 12-17 years of age performed poorly on this task relative to never-institutionalized children while younger-adopted PI children did not. On the go/no-go task, older-adopted PI children displayed significantly lower accuracy to go trials than younger-adopted PI children. Poor performance on these tasks may reflect difficulties with short-term storage/maintenance of spatial information, the suppression of an already-initiated response, and sustained attention.

In contrast, there were no significant group differences on spatial working memory total errors, backward digit recall correct responses, no-go accuracy, go response time, or flanker task accuracy or response time. The lack of significant group differences on these tasks may reflect intact executive skills in areas such as updating/processing of spatial information, verbal working memory, processing speed, suppression of a prepared response, and inhibition of competing or distracting information.

Taken together, these working memory results suggest that older-adopted PI children's working memory deficits may be more pronounced in the visual-spatial than the auditory-verbal modality consistent with previous findings (Pollak et al., 2010). However, older-adopted PI children were not impaired on the spatial working memory task despite showing deficits on the spatial span task. Based on this finding, it is possible that retention or maintenance of spatial information is impaired while updating/processing skills are intact. However, previous studies of PI children have indicated deficits on the spatial working memory task, and it is possible that our sample used compensatory strategies to perform at the same level as comparison groups on this task. Therefore, further studies are required to tease apart any specific difficulties PI children may be having within the domain of spatial working memory.

Findings for inhibitory control suggest that deficits may emerge in the context of increasing task demands. Although similar, the go/no-go task requires restraint or suppressing initiation of a prepared motor response while the stop-signal task requires canceling an already-initiated or ongoing motor response (Crosbie, Perusse, Barr, & Schachar, 2008; Rubia et al., 2001). Thus, the stop-signal task may place a higher load on inhibitory control processes compared to the go/no-go task because it involves the retraction of a response that has already been triggered by a go signal. On the other hand, given that older-adopted PI children were responding less consistently to frequent go trials (see Table 3), they may not have established a habit of responding making it easier for them to withhold a response to infrequent no-go trials. Nonetheless, based on these results, it is possible that PI children show inhibitory control difficulties when task demands are high but may be able to suppress goal-irrelevant responses when task demands are lower.

Finally, the flanker task is a complex inhibitory control task that requires the integration of multiple cognitive processes including attentional control and monitoring and resolution of conflict, defined as selecting a subdominant response in the presence of a competing dominant response (Rueda, Posner, & Rothbart, 2005). While it is difficult to ascribe children's performance to a specific skill, results for this task suggest that older- and younger-adopted PI children may not differ in the ability to suppress a response to competing or distracting information. Based on the results for other inhibitory control tasks, it is possible that PI children's deficits may emerge with increasing task demands, for instance, more significant distractions. It appeared as though the children responded to the task as expected given that performance was increased on the congruent relative to the incongruent condition of the task, but it is possible that the task was not sufficiently challenging to reveal existing difficulties. Results did follow the pattern of what would be expected of an executive deficit as the older- and younger-adopted PI children performed similarly to the congruent condition but older-adopted PI children's performance was lower to the incongruent condition; however, group differences were not significant. Thus, PI children's performance on this task should be explored further in future studies.

Findings from this study suggest that prolonged early exposure to institutional deprivation may result in impairment in inhibitory control and spatial working memory years after adoption. While the role of confounding risk factors cannot be ruled out, comparing older- and younger-adopted PI children provides some control of pre-institutional background such as prenatal care and characteristics of the birth parents. Furthermore, this study excluded PI children with pervasive developmental disorders and FASD diagnosis whose inclusion could have artificially inflated PI deficits. Analyses of the limited amount of birth data that was available for these children revealed trends for birth weight to be lower in the older-adopted PI group and associated with spatial working memory but not inhibitory control. Previous findings from the BEIP indicated that both low birth weight and a history of institutionalization explained unique variance in spatial working memory among PI children (Bos et al., 2009). Therefore, it is possible that poor birth circumstances operate in conjunction with early institutional deprivation to increase the risk of persistent spatial working memory difficulties.

While the attribution of age at adoption effects to the selective adoption of healthier children at younger ages cannot be ruled out in the current study, prior study designs suggest that selective adoption is unlikely to explain age at adoption effects. In particular, the BEIP randomly assigned institutionalized children to "care as usual" or foster care and yet found that children who were placed in foster care at older ages showed more cognitive deficits at 8 years of age (Fox, Almas, Degnan, Nelson, & Zeanah, 2011). In addition, the ERA study capitalized on rapid non-selective adoption occurring immediately following the collapse of the Ceausescu regime and the discovery of thousands of children languishing in Romanian institutions in the late 1980s (Rutter et al., 2007).

4.2 EARLY PSYCHOSOCIAL DEPRIVATION

The PI children in this study were adopted from psychosocially depriving institutions that provided adequate physical resources but failed to provide a consistent set of responsive caregivers. Therefore, their inhibitory control and working memory deficits may be attributable to early psychosocial deprivation consistent with previous findings showing that the early caregiving environment influences EF development in the toddler and preschool years (e.g., Valiente, Lemery-Chalfant, & Reiser, 2007) and that other forms of early psychosocial adversity (e.g., maltreatment, multiple foster placements) are associated with EF deficits (e.g., Lewis et al., 2007).

It is theorized that under typical family rearing circumstances, caregivers promote EF development during early childhood by providing external regulation of child functioning and gradually facilitating the child's increasing self-regulatory skills (Kopp, 1982). Specifically, they may promote EF development through caregiving practices termed "autonomy support" including response-contingent stimulation, scaffolding, and encouraging and responding to child-directed activities (Bernier, Carlson, & Whipple, 2010). Caregiver contingent responsiveness is thought to provide infants with successful experiences of influencing the social environment which promote the emergence of agency or self-efficacy and scaffolding to ensure that the child plays an active role in the successful completion of tasks which supports the child's autonomy, goals, choices, and sense of volition. Dramatic improvement in EF during early childhood may provide an important foundation for the refinement of these abilities that occurs through adolescence (Garon, Bryson, & Smith, 2008). For PI children, the lack of these caregiving practices in institutions may disrupt the development of EF skills during early childhood.

It is possible that other forms of early deprivation contributed to deficits in inhibitory control and working memory. For example, despite adequate nutrition provided by these institutions, iron deficiencies may have been present in these children, potentially disrupting the development of brain regions underlying EF (Fuglestad et al., 2008). However, in terms of examining the role of specific aspects of the early environment, the study of children adopted from psychosocially depriving institutions is an improvement over the study of children adopted from globally depriving institutions, who were exposed to inadequate physical resources as well as profound psychosocial deprivation. Results of the current study suggest that physical deprivation is unlikely to fully explain deficits in inhibitory control and working memory among PI children.

4.3 EFFECT OF EARLY DEPRIVATION ON NEURAL DEVELOPMENT

Findings from this study suggest that early institutional deprivation may disrupt the development of prefrontal circuitry and functional connectivity of the PFC with other neocortical and subcortical regions. Results are consistent with studies showing that nonhuman primates exposed to early maternal deprivation exhibit lower prefrontal activation along with poor performance on EF tasks (e.g., Sanchez et al., 1998) and with the few existing studies that have directly assessed brain development in PI children. For example, Chugani and colleagues (2001) used Positron Emission Tomography (PET) to examine brain development in a small sample of 8-year-old children exposed to Romanian institutions for an average of 38 months during early childhood. These PI children showed significantly reduced brain metabolism in regions of the PFC typically associated with EF relative to healthy adults and children with intractable epilepsy.

Older-adopted PI children's difficulties with spatial working memory and inhibitory control may reflect disrupted development of the PFC. In typically-developing adults, working memory utilizes an extended neural network that consistently includes the dorsolateral PFC (Carlson et al., 1998; D'Esposito et al., 1995; O'Reilly & Frank, 2006; Owen, Doyon, Petrides, & Evans, 1996; Owen, Morris, Sahakian, Polkey, & Robbins, 1996). In addition, widely distributed neural activation in the inferior parietal cortex, anterior cingulate cortex (ACC), basal ganglia, and cerebellum are associated with higher level components of spatial working memory (Casey et al., 1998; Curtis, Rao, & D'Esposito, 2004). Neuroimaging studies indicate that inhibitory control deficits in ADHD reflect abnormalities in frontal circuits including frontostriatal and frontoparietal circuitry (Booth et al., 2005; Rubia, Smith, Brammer, Toone, & Taylor, 2005; Suskauer et al., 2008). Performance on complex inhibitory control tasks (e.g., Stroop, flanker) is associated with the dorsolateral PFC and ACC (Banich et al., 2000; MacLeod

& MacDonald, 2000; Zysset, Muller, Lohmannn, & von-Cramon, 2001). It should be noted that firm conclusions about neural activity cannot be made based solely on behavioral data. Furthermore, as indicated, EF depends on the flexible use of integrated brain networks in addition to the PFC. Therefore, EF deficits may reflect more generalized brain abnormalities that undermine collaborative neocortical function and connectivity.

4.4 DEVELOPMENTAL TIMING OF DEPRIVATION

In the current study, there were no significant associations between age at adoption and inhibitory control/working memory within either the PI group adopted before 9 months or the PI group adopted after 14 months. Taken together with prior studies of EF in PI children (Beckett et al., 2010; Bos et al., 2009; Pollak et al., 2010), these findings suggest that the negative effect of early institutional deprivation on EF may occur very early in life (after 6-15 months depending on the severity of deprivation) and there may be no further impact with greater exposure at older ages. In particular, the ERA study has consistently found a threshold effect at 6 months for school-aged children exposed to early global deprivation (Colvert et al., 2008). There may be a sensitive period during early childhood when the experience of a consistent set of responsive caregivers who scaffold engagement in developmentally-appropriate tasks is essential to the development of EF and underlying prefrontal circuits. Rapid brain development of areas essential to EF during this time may depend on having opportunities to exert control over the environment and actively engage in tasks with the support of a nurturing caregiver. Although speculative, this would be consistent with theories of experience-expectant brain development which posit that brain development depends on certain types of environmental stimulation provided at certain times (Marshall & Kenney, 2009). However, this study was unable to specify whether age at adoption effects were caused by the duration of time spent in the institution or the chronological age at which children were exposed to the institution.

4.5 GENERAL COGNITIVE DEFICITS

Consistent with previous studies (van IJzendoorn, Luijk, & Juffer, 2008), older-adopted PI children had significantly lower IQ scores than younger-adopted PI children, although both means were in the average range. Further, IQ was significantly associated with working memory but not inhibitory control task performance. Older-adopted PI children had marginally greater working memory difficulties than younger-adopted PI children after accounting for group differences in IQ. In the ERA study of children adopted from severely depriving institutions, deficits in complex inhibitory control remained after accounting for IQ (Colvert et al., 2008), but other studies of EF in PI children have not examined this relation. Results from the current study suggest that inhibitory control deficits in older-adopted PI children may not be solely accounted for by IQ and may instead represent institutional effects distinct from general cognitive impairment. Working memory deficits may be partially accounted for by lower overall cognitive problem-solving skills. However, children's IQ scores may partially reflect their working memory skills because working memory is required to perform IQ tests. Further examination of the specificity of working memory deficits relative to impairment in general cognitive ability is warranted.

4.6 CORRELATES OF INHIBITORY CONTROL AND WORKING MEMORY TASK PERFORMANCE

4.6.1 Parent-rated attention problems

As expected, older-adopted PI children had significantly greater parent-rated inattention and hyperactivity-impulsivity than younger-adopted PI children who did not differ from the standardization sample. In particular, almost half of the older-adopted PI group had clinical-range problems with inattention, and approximately 30% were reported to have clinical-range hyperactivity-impulsivity. Heightened parent-rated hyperactivity-impulsivity but not inattention symptoms were associated with decreased performance on inhibitory control and spatial working memory tasks, even after accounting for age at adoption. This is consistent with ERA study results indicating a significant association between parent- and teacher-reported attention problems and performance on the Stroop task among 11-year-old children adopted from severely depriving institutions (Colvert et al., 2008; Sonuga-Barke & Rubia, 2008). While inhibitory control and impulsivity reflect similar behaviors related to the ability to withhold automatic responses to goal-irrelevant stimuli, working memory and impulsivity are not as similar in their definitions. It is possible that parents were better observers of hyperactive-impulsive behaviors.

These results suggest that attention-related executive problems are shown in task performance in addition to rating scale measures, which may reflect bias based on the nature of the rater's relationship with the child. Decreased task performance argues against the view that PI children's deficits are attributable to biased reporting by adoptive parents.

Furthermore, deficits in spatial working memory and inhibitory control may represent specific processes related to PI children's risk of clinical-range inattention and hyperactivity-impulsivity. Most of the studies to date have used broad measures of attention problems reflecting a combination of both inattention and hyperactivity-impulsivity. This study extends past findings by revealing that PI children's attention problems are characterized by both inattentive and hyperactive-impulsive symptoms, and may be characterized by specific deficits in the ability to suppress a dominant response, to sustain attention and ignore distractions, and to maintain and update spatial information in mind over short periods of time.

IQ also showed a strong association with parent-rated inattention and hyperactivity-impulsivity, even after accounting for age at adoption. It is possible that PI children's performance on this measure of general cognitive skills was influenced by persistent difficulties with attention. Prior studies have found that attention training produces increases in overall IQ in children (Klingsberg, Forssberg, Westerberg, 2002; Rueda, Rothbart, McCandliss, Saccamono, & Posner, 2005). Or, attention problems could be part of a set of cognitive difficulties resulting from early institutional deprivation consistent with findings from the ERA study suggesting that both cognitive impairment and attention problems are part of an institutional deprivation syndrome (Kreppner, O'Connor, & Rutter, 2001).

4.6.2 Academic performance

Results revealed that older-adopted PI children were significantly more likely to use learning support services in school than younger-adopted PI children consistent with prior studies of academic performance among PI children (Beckett et al., 2007). However, the use of learning support services was not significantly associated with poor inhibitory control or working memory task performance, although the association with working memory approached significance. It is possible that this is due to the use of learning support services as a measure of academic difficulties. If academic achievement had been directly assessed, then variation in academic performance across the normal range may have led to significant results. Furthermore, some of the children were receiving support for specific learning difficulties whereas working memory deficits would be more likely to produce more general academic difficulties. In addition, PI children receiving learning support services had a significantly lower IQ and higher attention problems than those not receiving such services, suggesting that perhaps cognitive and attention deficits made academic tasks more difficult.

4.7 LIMITATIONS

Several limitations of the current study should be noted. The study had a relatively small sample especially within each PI group which precluded conducting some more advanced statistical methods (e.g., factor analysis) and suggests the possibility that low power might have restricted the ability to detect statistically significant results. Nonetheless, the sample size is within the range of studies using neurocognitive measures. Like other studies of internationally adopted PI children, this study was unable to rule out the influence of potentially confounding risk factors. A challenge to research with this population is the lack of information regarding their pre-adoption life. Adoptive parents often have limited information regarding genetic risk factors (e.g., family history of medical and/or psychological problems), prenatal care, stress, and exposure to substances, and experience of birth complications. PI children have been found to demonstrate greater EF difficulties than non-institutionalized adopted children who are relatively similar to them in terms of potentially confounding risk factors, increasing the likelihood that effects are attributable to early institutional deprivation. In the current study, comparison to younger-adopted PI children provided some control for other risk factors, and examining birth circumstances was helpful in examining the possible role of pre-adoption factors.

Because this sample was adopted solely from Russia/former Soviet Union, the results may not be representative of children adopted from institutions worldwide. In particular, children adopted from this region may have an increased likelihood of prenatal alcohol exposure (PAE), which is linked with EF deficits in non-adopted children (e.g., Rasmussen & Bisanz, 2009). However, prior studies also included PI children adopted from other areas of the world (e.g., Asia, Latin America) and/or excluded children with indicators of PAE and still found EF deficits (Bauer et al., 2009; Bos et al., 2009; Pollak et al., 2010).

In addition, the cross-sectional study design does not allow inferences as to the direction of causality. Like most other studies of PI children, this study could not measure inhibitory control and working memory prior to placement in an institution. Therefore, the alternate direction of association, with child inhibitory control and working memory predicting placement in an institution, cannot be ruled out. However, given that the vast majority of PI children in this study were placed in institutions at birth, it is unlikely that children were placed in an institution due to pre-existing inhibitory control and working memory problems. In addition, because inhibitory control, WM, IQ, and academic difficulties were all measured at the same time, it should not be concluded that any one problem pre-dated any other.

There were also procedural limitations. Administration of the tasks in the child's home rather than in a lab setting may have influenced their task performance. Further, the home visitors were not blind to the hypotheses of the study and, for most home visits, the group status the participant. However, because all of the EF tasks were computerized, it is unlikely that home visitor expectations influenced the results.

Despite being classified by a single cognitive construct, complex tasks like the flanker task likely require the coordination of multiple cognitive processes (e.g., Asato, Sweeney, & Luna, 2006; Huizinga, Dolan, & van der Molen, 2006; Miyake et al., 2000). Therefore, PI children's poor performance on these tasks may reflect impairment in multiple EF skills. Future studies should employ simple EF tasks that isolate specific skills to pinpoint areas of difficulty for PI children. It is also important to examine different stages of EF task performance to discover which aspects of the task are difficult for PI children.

The sensory modality of the EF task (cue and response) may influence performance and possibly be a confounding factor in results. The tasks varied in their use of visual (e.g., spatial working memory, go/no-go task) versus auditory cues (e.g., backward digit span, stop-signal task). Pollak et al. (2010) suggest that PI children may show impairment on neurocognitive tasks that involve visual but not auditory stimuli, but this pattern has not been replicated in other studies in this literature (e.g., Beckett, Castle, Rutter, & Sonuga-Barke, 2010). There were no group differences on the CANTAB motor screening task, suggesting that group differences in EF were not due to poor motor skills. Nonetheless, future studies should take into consideration the possibility that PI children's performance on EF tasks could be influenced by the perceptual modality of the task.

4.8 FUTURE DIRECTIONS

There are many unanswered questions for future studies to pursue. It is important that we continue to employ a variety of neuroimaging tools to examine brain structure and function among PI children, particularly PFC regions associated with EF components. To date there are no functional neuroimaging studies of PI children that have examined their neural activity while performing EF tasks. Moreover, future research on neural mechanisms should test the link between HPA axis dysregulation and development of PFC networks given that this stress system has been found to be sensitive to early adversity and linked with brain systems supporting EF (Loman & Gunnar, 2010). This is an important step in terms of investigating the neurobiological underpinnings of negative outcomes in PI children.

4.8.1 Executive functioning in the context of emotion

Future studies should explore PI children's performance on "hot" EF tasks, which are motivational in nature or assess EF in the context of emotionally significant consequences (i.e., meaningful rewards and/or losses). A recent study by the ERA group used a task designed to measure the response of brain regions underlying reward processing to the anticipation of monetary reward. Findings revealed that adolescents adopted from severely depriving Romanian institutions did not recruit the ventral striatum during reward anticipation despite task performance that was comparable to that of non-adopted children (Mehta et al., 2010). It is important to pursue this line of research to tease apart which neural networks are affected by early institutional deprivation and to further specify the particular conditions under which EF deficits may be exhibited.

Future studies should also examine whether older-adopted PI children's EF difficulties may be particularly heightened in emotional contexts based on recent evidence of poor inhibitory control in the context of emotional stimuli (Tottenham et al., 2010). PI children's cognitive resources may be captured by emotionally salient stimuli such that they have difficulty directing attention away from irrelevant emotional information. Inhibitory control difficulties under emotional conditions may reflect less effective top-down regulation from ventral prefrontal regions combined with heightened amygdala reactivity (Hare et al., 2008). Similarly, recent MRI studies of PI children have highlighted amygdala structural differences (Mehta et al., 2009) underscoring the importance of investigating this pathway and its behavioral correlates. Moreover, in another MRI study, PI children were found to have diminished white matter connectivity in the uncinate fasciculus region of the brain compared with controls (Eluvathingal et al., 2006). The uncinate fasciculus connects brain areas involved in EF and emotion (e.g., amygdala and frontal lobe). Self-regulatory difficulties under emotional circumstances may underlie school-aged PI children's poor social and emotional outcomes.

4.8.2 Change in executive functioning over time

Future studies should examine EF components in preschool-aged PI children. Preliminary findings suggest that preschool-aged PI children do show performance-based EF deficits shortly following adoption (Hostinar et al., 2011). Based on results of the current study, the performance of PI adolescents on EF tasks should be further investigated using a larger sample. Longitudinal designs and methods such as trajectory analysis would help us to understand patterns of change in EF over time. The ERA longitudinal study of globally deprived children has shown persistence in cognitive deficits even after many years in adoptive homes, but the course of cognitive functioning is less well-understood for children exposed to early psychosocial deprivation (Beckett et al., 2006).

4.8.3 Predictors of executive functioning in post-institutionalized children

Future studies should also explore the sources of heterogeneity of EF outcome among older-adopted PI children. In addition to early deprivation, multiple factors, such as birth circumstances, may influence EF among older-adopted PI children. In particular, research with monozygotic and dizygotic twins suggests that genetic factors make important contributions to flanker task performance (Fan, Wu, Fossella, & Posner, 2001). Polymorphisms in genes associated with dopamine (e.g., COMT, DRD4, MAOA, and DAT1 genes) are associated with EF task performance (e.g., Diamond et al., 2004). Moreover, genetic moderation of institutional deprivation effects has been shown in a few quantitative and molecular genetic studies (see review, Sheridan, Drury, McLaughlin, & Almas, 2010). For example, a recent study from the ERA group demonstrated that the DAT1 haplotype moderates the influence of early institutional deprivation on attention problems (Stevens, Kumsta, Kreppner, Brookes, Rutter, & Sonuga-Barke, 2009). BDNF genotype has also been found to be related to EF problems in PI children (Gabbitas, Thomas, & Gunnar, 2011). It is possible that genotype may modulate children's vulnerability to institutional caregiving deficiencies, such as frequent changes in caregivers or the lack of caregiver responsiveness, leading to variable EF outcomes among PI children.

In addition, future studies should disentangle the relative influences of psychosocial and other institutional deficiencies (e.g., nutritional) in producing EF deficits as well as examine the combined effect of inadequate nutrition and psychosocial deprivation. One way in which this could be further explored is by examining the association between the level and quality of particular caregiving features in the institution, such as caregiver responsiveness and scaffolding of active engagement in developmentally-appropriate tasks, and EF development in PI children.

Such a study would add greatly to our understanding of the ways in which caregiving deficiencies in institutions may disrupt the development of EF.

4.8.4 Developmental timing of institutional deprivation

Future studies should explore the effect of age at adoption or the timing of exposure to institutional deprivation on EF skills. Consistent with the idea of a sensitive period, exposure to psychosocial deprivation at specific ages during early childhood may be particularly detrimental to EF development. While most studies to date have had a limited range of age at adoption represented in their samples (adopted after 9-12 months), future studies should recruit children adopted at a wide range of ages. Researchers should also investigate whether a step function or dose-response relation best characterizes the association between age at adoption and EF deficits, and whether the age after which children are at risk of EF deficits might vary as a function of the level of deprivation to which they were exposed.

4.8.5 Role of executive functioning in academic outcomes

It is important to increase our understanding of the role that EF deficits may play in PI children's academic difficulties. Academic performance has broad implications for future educational and career opportunities as well as children's social and emotional functioning. In particular, researchers should use longitudinal designs to investigate the mediating effects of EF on later academic outcomes. In a recent study, inhibitory control was found to partially mediate the association between family environment and academic performance in a sample of children in foster care who had been exposed to maltreatment (Pears, Fisher, Bruce, Kim, & Yoerger, 2010).

Identifying specific areas of difficulty that lead to poor outcomes can inform the development and selection of interventions that will be effective in improving PI children's long-term outcomes. Several interventions have been found to be effective in improving EF in non-institutionalized children (e.g., Tools of the Mind; Diamond, Barnett, Thomas, & Munro, 2007). It is possible that these interventions could improve PI children's EF and in turn reduce their academic difficulties allowing them to be more successful in school.

5.0 CONCLUSION

In summary, this study examined inhibitory control and working memory in 8- to 17-year-old children adopted from psychosocially depriving institutions. Results indicated that post-institutionalized children adopted at older ages performed poorly on inhibitory control and spatial working memory tasks compared to those adopted at younger ages and never-institutionalized children after accounting for age at assessment. Deficits in inhibitory control and spatial working memory task performance were correlated with parent-rated hyperactivity-impulsivity. Older-adopted PI children had an increased likelihood of using learning support services in school, which was associated with lower cognitive skills and attention problems. These findings suggest that the early lack of a consistent set of responsive caregivers who encourage active engagement in tasks tailored to the abilities of the child may increase the risk of executive functioning deficits. It is critical that we apply this information by educating parents and professionals who see these children about the possible sequelae of early institutionalization. We should also use this knowledge of factors that promote early childhood development to influence policies dictating care settings of orphaned or abandoned children worldwide.

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