

MILLER, STEPHANIE E., Ph.D. The Relationship between Executive Function and Joint Attention in the Second Year of Life (2012)
Directed by Dr. Stuart Marcovitch. 105 pp.

Several theories of cognitive control or executive function (EF) propose that EF development corresponds to children's ability to form and reflect on represented stimuli in the environment. However, research on early EF is primarily conducted with preschoolers, despite the fact that important developments in representation (e.g., language, gesture) occur within the first years of life within a social context (e.g., to share, communicate, and collaborate, see Tomasello, Carpenter, Call, Behne, & Moll, 2005). In the current study, children's EF performance and the relationship between EF and early representation (i.e., joint attention, language) were longitudinally examined in 47 children at 14 and 18 months of age. Results provided support for a unidirectional relationship in which earlier joint attention behavior at 14 months was related to better EF at 18 months. Specifically, higher level initiation of joint attention behaviors at 14 months (e.g., pointing to manipulate another's attention) were related to stronger, more cohesive EF performance at 18 months. Children's performance on EF tasks was low at 14 months and improved from 14 to 18 months. Although EF performance during this period revealed patterns dissimilar to later EF development in preschool (e.g., low inter-task correlations, few significant relations to language), by 18 months of age a subset of children consistently passed the majority of EF tasks, possibly indicating the emergence of a unified EF in the second year of life. These results provide evidence that preverbal means of representation (i.e., initiation of joint attention) are related to early EF (e.g., Zelazo, 2004). Further, early representation that emerges within a social context (e.g., to

communicate information to another person) may underlie the emergence of a unified EF ability, as only children demonstrating higher-level initiation of joint attention behaviors were able to guide behavior across multiple EF contexts.

THE RELATIONSHIP BETWEEN EXECUTIVE FUNCTION AND JOINT
ATTENTION IN THE SECOND YEAR OF LIFE

by

Stephanie E. Miller

A Dissertation Submitted to
The Faculty of The Graduate School at
The University of North Carolina at Greensboro
in Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

Greensboro
2012

Approved by

Committee Chair

APPROVAL PAGE

This dissertation has been approved by the following committee of the Faculty of The Graduate School at The University of North Carolina at Greensboro.

Committee Chair _____
Stuart Marcovitch

Committee Members _____
Rob Guttentag

Alan Kamhi

Michael Kane

Date of Acceptance by Committee

Date of Final Oral Examination

TABLE OF CONTENTS

	Page
LIST OF TABLES	iv
LIST OF FIGURES	v
CHAPTER	
I. INTRODUCTION	1
II. METHOD	31
III. RESULTS	46
IV. DISCUSSION	62
REFERENCES	82
FOOTNOTES	98
APPENDIX A. TABLES	99
APPENDIX B. FIGURES	104

LIST OF TABLES

	Page
Table 1. Descriptive Statistics of All Measures at 14 and 18 Months	99
Table 2. Correlations Among All Measures at 14 Months	100
Table 3. Correlations Among All Measures at 18 Months	101
Table 4. Longitudinal Correlations from 14 to 18 Months of Age	102
Table 5. Summary of Hierarchical Regression Analysis for Variables (14 months) Predicting Number of EF Tasks Passed (18 months)	103

LIST OF FIGURES

	Page
Figure 1. IJA-ratio (i.e., percentage of IJA behaviors that are higher level behaviors) at 14 months by EF pass/fail behavior at 18 months	104
Figure 2. IJA-ratio (i.e., percentage of IJA behaviors that are higher level behaviors) at 14 months by number of EF tasks passed at 18 months.....	105

CHAPTER I

INTRODUCTION

Early childhood is not conventionally perceived as a period during which children demonstrate great control. However, if you consider the growth from dependent infant to more autonomous preschooler, issues in regulation (e.g., waiting, controlling emotion, sharing) may seem less like shortcomings and more like expected missteps in children's impressive first attempts to control thought and behavior independently. The development of cognitive and behavioral control, termed executive function (EF), has emerged as a major focus in cognitive development (for a review see Garon, Bryson, & Smith, 2008), with many theories of EF explaining development in terms of the types of representation children can form and use to control behavior (see Jacques & Marcovitch, 2010). For example, toddlers and preschoolers perform better on EF tasks when they have linguistic means to represent information in the task (e.g., Kirkham, Cruess, & Diamond, 2003; Miller & Marcovitch, 2011; Müller, Zelazo, Hood, & Leone, 2004). Although EF development is well documented in the preschool years, there is not as much work capturing the transition from early behavioral control in infancy to more complex EF in preschool. This is unfortunate, as various frameworks propose that important developments in EF occur before 3 years of age (e.g., Diamond, 2002, 2006; Garon et al., 2008; Marcovitch & Zelazo, 2006, 2009; Zelazo, 2004). Further, many theorists hypothesize that the key to developing higher cognition is in our social nature as

humans (e.g., Tomasello & Herrmann, 2010), which begins very early in life and provides the context for the development of higher representations central to EF and problem-solving (e.g., symbols, gesture, and language). The goal of the present research is to examine the emergence of EF during the second year of life by examining how EF is related to children's representational ability developing within a social context.

Executive Function

Although there is no universally accepted definition of EF, characterizations of EF typically refer to processes involved in the conscious control over thought and behavior directed toward a goal. This conscious control may be most noticeable in its absence. For instance, in our daily lives we likely rely on a combination of controlled and automatic processes. Take the example of typing in your email password. Although you may initially need to recall and type the password consciously, this behavior typically becomes automatic (i.e., a login screen prompts the habit of typing in the code). A lapse in EF could occur when you are required to execute a behavior that conflicts with this automatic process. For example, if the old password was reset and you habitually entered the old code at the prompt, this would demonstrate a failure in thought and behavioral control required to type in the new correct password. Experimental EF tasks capitalize on this premise by assessing EF through a problem-solving framework. In typical EF tasks, participants are presented with a problem where the control of behavior is challenging due to a conflicting prepotent way of thinking or responding to a problem (see Carlson, 2005). The problem-solving framework (Zelazo, Carter, Reznick, & Frye, 1997) provides

a structure where failures in EF are demonstrated by an individual's inability to solve the problem.

EF Development.

The development of EF in preschool. The study of early EF typically focuses on the rapid development demonstrated within the 3 to 5 year age range (e.g., Zelazo et al., 1997), which does not incur the challenges associated with examining EF in younger preverbal children (e.g., comprehension of complex instructions). During this period, children improve in their working memory (i.e., WM or the ability to hold and manipulate increasing amounts of task relevant information in mind over longer delays that can be used to guide behavior), inhibition (i.e., suppressing prepotent or affectively driven behaviors), and shifting abilities (i.e., flexibly switching responses and attention between task relevant information; see Garon et al., 2008; Jacques & Marcovitch, 2010 for reviews). One frequently used EF task that demonstrates all of these achievements is the Dimensional Change Card Sort (DCCS; Zelazo, Müller, Frye, & Marcovitch, 2003). In this task, children sort cards that vary on two dimensions (e.g., color and shape) to conflicting target cards of the same dimensions. Thus, if children are asked to sort red triangles and blue squares, they match them to target cards that are blue triangles and red squares. In the first part of the game, termed the preswitch phase, children sort according to one dimension (e.g., shape). After sorting successfully on one dimension the experimenter switches to the postswitch phase and asks children to sort according to the other dimension (e.g., color). Three-year-olds typically have difficulty in the postswitch phase and perseverate on the previously correct rule. There is marked improvement from

3 to 5 years of age, with the majority of 5-year-olds correctly sorting all postswitch trials. This developmental shift has been taken as evidence that preschoolers improve in EF abilities and begin to integrate all components of EF (e.g., maintaining the sorting rule, inhibiting pre-switch sorting, and switching attention to the postswitch rule, see Garon et al., 2008).

The early development of EF. The study of EF in children younger than 3 years of age is limited, primarily because it is difficult to translate complex EF tasks into age-appropriate versions for linguistically challenged toddlers and infants. However, there are indications that children begin to demonstrate controlled, goal-directed behavior during the first years of life. The earliest displays of this behavior are demonstrated in the delayed response task, where children search for a desirable object that is hidden in one of two (or more) locations after a delay. Children succeed on this task around 6 months of age (Pelphrey & Reznick, 2002) and improve in the amount of information they can hold in mind (Pelphrey et al., 2004) and the length of the delay they can tolerate before search (Diamond, 1985; Diamond & Doar, 1989). Performance on this task has been linked to development in the dorsolateral prefrontal cortex, which is also implicated in later EF behavior (e.g., Diamond, 2006). In addition, there are several other cognitive and social achievements emerging during this period that likely require controlled behavior (see Wiebe, Lukowski, & Bauer, 2010 for a discussion of related behaviors), although they are not always studied as “EF” tasks. For instance, during the first few years of life children regulate emotions (Mangelsdorf, Shapiro, & Marzolf, 1995), delay gratification (e.g., Kochanska, Tjebkes, Forman, 1998), imitate complex sequences (e.g., Alp, 1994;

Wiebe & Bauer, 2005), begin to demonstrate means-end behavior (e.g., Chen, Sanchez, & Campbell, 1997; Willatts, 1990), and control motor behavior and action (e.g., Adolph, Joh, Franchak, Ishak, & Gill, 2009).

Later in the first year, children begin to succeed on a more difficult search task, the A-not-B task. In the classic A-not-B task (Piaget, 1954), children observe a toy hidden at one location (location A) and subsequently retrieve it. After they retrieved the object at location A many times, they watch as the object is hidden at a new location (location B), and must shift their search response to the new location to retrieve the object. Many factors influence search behavior in the A-not-B task (see Marcovitch & Zelazo, 1999), but by 12 months of age the majority of children retrieve the object at location B and begin to tolerate increasing delays between hiding and search (Diamond & Doar, 1989; Diamond & Goldman-Rakic, 1989). The A-not-B task is also hypothesized to measure processes involved in cognitive control, such as the ability to hold the hiding location in mind over a delay, inhibit behavior toward the previously correct A location, and flexibly shift search response between the A and B location (see Marcovitch & Zelazo, 2009). The A-not-B task (and related variants) is perhaps the most widely examined measure of early EF (e.g., Diamond, 2006; Diamond, Prevor, Callender, & Druin, 1997; Garon et al., 2008; Marcovitch & Zelazo, 2009, Wiebe et al., 2010) and has also been adapted to investigate EF in a less linguistically demanding manner for older children (e.g., Espy, Kaufmann, McDiamid, & Gilsky, 1999; Miller & Marcovitch, 2011; Schutte & Spencer, 2002; Spencer, Smith, & Thelen, 2001; Zelazo, Reznick, & Spinazzola, 1998).

A few researchers have linked the early study of EF to later developing abilities in preschoolers by examining EF in the second year of life. Diamond et al. (1997) investigated cognitive control at 15, 18, and 21 months as part of a longitudinal study on the cognitive functioning of children treated for PKU through 7 years of age. This study also examined matched controls longitudinally and a cross sectional sample from the general population for comparison. Diamond et al. found that performance on a modified A-not-B task (i.e., A-not-B with invisible displacement, where the object was moved to the A or B location out of the direct sight of the infant) did not begin to improve until after 21 months. The study also included performance on the 3-boxes task, designed to measure WM. In this task, children watched as the experimenter placed three toys in three different colored boxes, one toy per box. They were then allowed to search for the toy at one location. After they retrieved the toy there was a brief delay in which the boxes were covered, then revealed again to children. Correct performance on this task involved holding in mind the location where children had previously searched. Two versions of the task were given. In the 3-boxes scrambled version, the location of each box during the delay was moved. Diamond et al. found that children were able to open all boxes in 4 to 5 reaches and needed fewer reaches as they got older. In the 3-boxes stationary version the boxes remained in the same location each time they were presented to children for search, and children tended to exhibit more perseveration, presumably because motor perseveration to a previously correct location would lead to an empty box if they were unscrambled. The number of reaches back to the same box declined across the age range, especially in children from 15 to 18 months of age.

Wiebe et al. (2010) also examined individual task performance, longitudinal stability, and interrelations between several EF tasks (i.e., involving control in reaching or imitation) longitudinally at 15 and 20 months of age. They found evidence for growth in performance in both the A-not-B invisible displacement task and 3-boxes task scrambled. Wiebe et al. also demonstrated improvement from 15 to 20 months in a task where children had to remember a sequence of actions to achieve a goal (related to holding information in mind). Interestingly, although there were developmental improvements across all these tasks, individual differences in task performance were not stable from 15 to 20 months (i.e., performance at 15 months was not well correlated with performance at 20 months). Further, performance across different EF tasks was generally not correlated concurrently at 15 or 20 months of age (but see Wiebe et al., 2010 for a few exceptions), which conflicts with perspectives suggesting that performance across EF tasks should show some degree of overlap in childhood and into adulthood (e.g., Lehto, Juujarvi, Kooistra, & Pukkinen, 2003; Miyake et al., 2000; Miyake & Friedman, 2012; Wiebe, Espy, & Charak, 2008; Wiebe, Sheffield, Nelson, Clark, Chevalier, & Espy, 2011).

Structure of EF. Theorists typically hypothesize that performance should be related across different EF assessments (e.g., Lehto et al., 2003; Miyake et al., 2000; Miyake & Friedman, 2012; Wiebe et al., 2008, 2011). Unitary accounts propose that a single control mechanism (usually related to attention) is responsible for cognitive control across a variety of EF tasks (e.g., Baddeley, 1992; Norman & Shallice, 1986). In contrast, dissociable or componential accounts propose that many separable subprocesses

contribute to EF (e.g., Carlson & Moses, 2001; Diamond, 2002; Lehto et al., 2003; Miyake et al., 2000). In adulthood, Miyake et al. suggested that EF could be separated into three distinct component processes that were also related: updating (or WM), inhibition, and shifting. Miyake and Friedman (2012) recently updated their framework, now termed the unity/diversity framework, and shifted their focus to examining common EF (i.e., maintenance of task relevant information which guides lower level processes toward executing a goal) that is shared across all component processes. They suggest that EF components are composed of common EF and component specific abilities (i.e., WM and shifting specific abilities), and that individual differences in performance in the inhibition component can be entirely explained by common EF.

Although support for the unity/diversity framework exists in adulthood, similar approaches examining EF in early childhood support unity but not necessarily diversity in EF. Wiebe and colleagues (2011) suggested that EF in preschool is best explained by a unitary EF factor, which may reflect Miyake and Friedman's (2012) common EF. EF structure may not be differentiated in preschool because common EF guides behavior across all tasks for preschoolers, as shifting and WM specific abilities have not yet emerged (Wiebe et al., 2011). This is consistent with developmental data and Garon et al.'s (2008) theory that the ability to hold relevant information in mind (related to common EF) develops first, followed by the emergence of more complex abilities in shifting and updating later in preschool (see also Wiebe et al., 2011). However, there is little work extending this study of the structure of EF to children younger than 2 years of age. Wiebe et al. (2010) demonstrated that there is growth in EF performance from 15 to

20 months of age; however, correlations were not strong between EF tasks, and children performed poorly at the 15-month time point. Wiebe et al. suggested that poor performance at 15 months of age could reflect an absence of common EF guiding behavior in children this young. Further, the authors suggested that general improvement across the 5 month time period could reflect the emergence of strategic goal-directed behavior, possibly related to maintaining task-relevant information and goals, similar to Miyake and Friedman's (2012) description of common EF.

Thus, early evidence points to complex developments in EF structure across the lifespan. Performance on EF tasks within the first year of life is poor, but improves across the second year, suggesting that a common EF ability related to maintaining task relevant information and goals may emerge late within the second year of life (Wiebe et al., 2010). The correlation between performance on EF tasks is generally low, but steadily improves across preschool years (Carlson, Mandell, & Williams, 2004; Hughes & Ensor, 2005, 2007). Results in EF may be best explained by a unitary latent general EF factor that underlies performance on all tasks in preschool (Wiebe et al., 2008; 2011). This may reflect development in "common EF", related to goal formation, maintenance, and execution across multiple contexts. Finally, developments in shifting and updating result in further differentiation of EF (Lehto et al., 2003; Miyake et al., 2000; Miyake & Friedman, 2012), resulting in 3 component abilities that share "common EF" but are differentiated by shifting and updating specific abilities that contribute to performance (Miyake & Friedman, 2012).

Theories of EF development.

Neurological models of EF development. Garon et al (2008) suggested that the attention network (i.e., the anterior cingulate) plays a critical role in EF development. In this model, basic EF components (i.e., WM, inhibition, and cognitive flexibility) are initially influenced by an environmentally driven orienting attention system, responsible for orienting to and exploring objects (see Ruff & Rothbart, 1996). External factors may influence control of behavior early in life (e.g., infants may only hold in mind what is immediately relevant to the external situation). In the second year a newfound control emerges when children begin to control attention endogenously (i.e., voluntary attention). This allows initially separable lower level components of EF to become related, integrated, and more complex. For example, voluntary attention becomes integrated with WM and the ability to hold *and* manipulate information in mind emerges around 15 months and improves into the preschool years (e.g., Diamond et al., 1997; Hughes, 1998). In this model, neural developments and interconnectivity in attention systems (e.g., anterior cingulate, dorsolateral prefrontal cortex, Rothbart & Posner, 2001) are responsible for EF development, which appears broadly consistent with the changing structure of EF in childhood, moving from initially unrelated EF abilities early in life (e.g., environmentally driven attention), to an EF that becomes more interrelated through the development and integration of voluntary attention.

Reflection based representational accounts. Although evidence supports a link between EF and neurological development, these models do not typically focus on cognitive mechanisms for change. Several developmental accounts focus on the critical

role that representational abilities have on the emergence and development of EF. For example, the Hierarchical Competing Systems Model (HCSM: Marcovitch & Zelazo, 2009) suggests that two foundational systems interact to influence behavior from infancy to adulthood. The habit based system influences behavior unconsciously through previous experience, whereas the representational system impacts behavioral control through conscious representation and reflection on the environment and rules to guide behavior. In many contexts, these systems work together, and repeated practice allows individuals to rely less on the effortful conscious representational system when habitual responding would suffice. For example, in infant EF measures (i.e., the A-not-B task), repeated retrieval at location A strengthens the habit-based system (up to a certain point, see Marcovitch & Zelazo, 2006, 2009), which gradually increases the likelihood that the habit based system will guide behavior, and children may search at location A without conscious awareness of the hiding location or controlling search behavior. Although it is appropriate (though not equally efficient) to rely on either system in this example, circumstances arise in which the two systems conflict and conscious representation is necessary to control behavior. For example, after the object is hidden in a new location (location B) the prepotent response of searching at location A conflicts with the representation of the new hiding location B, and young children tend to search habitually and incorrectly at location A. In this instance, controlled behavior can be achieved by representing the new hiding location consciously to guide behavior. This model accounts for many findings in early EF and provides a novel framework emphasizing the role of representation and reflection in the development of EF (see Marcovitch & Zelazo, 2009).

The HCSM and additional representational models proposed by Zelazo and colleagues suggest that development in a single representational mechanism is related to EF development (e.g., Zelazo, 2004; Zelazo & Müller, 2002; Zelazo et al., 2003). The Levels of Consciousness model (LoC model, Zelazo, 2004) details development in children's representational ability by describing how children become more conscious of relevant stimuli and actions in their environment. For example, at the lowest level of consciousness (i.e., minimal consciousness) infants are aware of objects in their environment but this awareness is automatic and unreflective (e.g., they may respond automatically to a bottle by sucking on it). At the end of the first year of life, recursive consciousness emerges when the lowest level of consciousness (e.g., the bottle) now becomes the contents of children's awareness. It is during this period that children are able to reflect upon objects in consciousness (e.g., pointing and labeling allows children to represent an object and link a semantic memory to current experience). Children continue to develop and reach higher levels of consciousness by incorporating multiple levels of reflection (i.e., reflecting on their reflections). In the related Cognitive Complexity and Control theory (CCC, Zelazo et al., 2003), higher LOCs are directly related to children's ability to create and reflect on plans and rules which aid in controlling behavior. Zelazo concludes that development in EF is related to overarching developments in reflection and rule-based abilities.

Active-latent representational accounts. Munakata (1998) also proposed a model focusing on the influence of representational strength on EF. EF is supported by active representations, which are more abstract, actively maintained in memory, and related to

prefrontal cortical regions of the brain. Latent representations, on the other hand, are tied directly to environmental stimuli, strengthened through repeated experience with stimuli, and related to posterior cortical and subcortical regions of the brain. For example, on the critical B trial of the A-not-B task, a strong active representation maintained of the object hidden at location B would override a latent representation formed from repeated search at location A that biases search toward the previously correct location. In situations requiring cognitive control these two representations compete, and active memory traces are necessary to overcome habitual responding driven by the latent representations. Further, as active and latent processing mechanisms are tied to neurological systems, increases in the control of thought and behavior are related to development in the prefrontal cortex, which allow children to form stronger, active representations to guide behavior.

Support for Representational Models of EF. Evidence for representational models comes from work demonstrating that linguistic representation is related to improvement in EF. Numerous studies demonstrate that EF is correlated with language ability in the preschool years (e.g., Carlson & Moses, 2001; Hughes, 1998; Hughes & Ensor, 2007). However, representational frameworks are more clearly supported by experimental work demonstrating that language manipulations typically improve EF in preschoolers (for a review see Jacques & Zelazo, 2005). For example, Kirkham et al. (2003) demonstrated that 3-year-olds asked to label the relevant sorting dimension on the DCCS performed better than those who did not label (see also Towse, Redbond, Houston-Price, & Cook, 2000). Linguistic manipulations are also beneficial to

performance in interference control tasks (Müller et al., 2004), in which labeling the non-dominant correct response improved preschoolers' ability to resist a prepotent response. In addition, introducing relevant relational language (e.g., describing object relations) helps preschoolers' control their behavior in relational search tasks, where children have to find an object based on the relationship between items (e.g., Lowenstein & Gentner, 2005; Rattermann & Gentner, 1998). However, there are issues with the reliability of labeling effects across EF tasks (see Müller, Zelazo, Lurye, & Liebermann, 2008), which may have to do with the amount of linguistic support available within a task. Jacques and Zelazo (2005) suggested that labeling effects might be less consistent in deductive measures (i.e., tasks where children are told how to solve the task) because there already exists some labeling support from the experimenter compared to inductive tasks (i.e., children are not told how to solve the task).

Reflection based theories (Marcovitch & Zelazo, 2009; Zelazo, 2004) suggest that providing or encouraging labels increases the likelihood that children will generate (i.e., either overtly or covertly) higher order representations they can reflect upon to guide behavior. These higher order representations can be fairly complex for older preschoolers (e.g., labeling information relevant to a hierarchical rule structure for guiding behavior in multiple contexts) or more simplistic for younger children (e.g., labeling a novel search location for a desired object). The key is that independent generation of a label for the appropriate representation should result in controlled behavior. However, not all representational theories equate generation of higher order representations (e.g., labels) with success on the task. Munakata's (1998) active-latent approach would suggest that

generation of relevant linguistic information strengthens active representations necessary for cognitive control, but is not paramount as it is in reflection models. For instance, if children and the experimenter both label task relevant information, active representations should be further strengthened (Kharitina, Chien, Colunga, & Munakata, 2009; Miller & Marcovitch, 2011). These distinctions may be critical as we move into studying representation and EF in even younger children. Given that the active nature of representation may be emerging within the first 3 years of life (e.g., active pointing and labeling within a social context), reflection based theories would hypothesize a critical development in representation and EF during this period. Active-latent representational theories may not necessarily target a key EF transition with the development of generating independent representations.

It is clear that representations influence cognitive control in verbal children, however there is limited research in the development of representation and EF in prelinguistic children in the second year of life, commonly referred to as the “dark ages” of cognitive development (e.g., Hughes & Ensor, 2007; Meltzoff, Gopnik, & Repacholi, 1999). Although infants in the first year can control behavior (as seen in laboratory demonstrations, e.g., delayed response task, A-not-B task), early control does not necessarily entail internal representations guiding behavior (see Jacques & Marcovitch, 2010). For instance, children may search correctly in the A-not-B task because they internally represent the location and reflect upon it to guide behavior, or because seeing the object hidden at location B automatically inhibits the response to location A (see also Perner, Strummer, & Lang, 1999). Examining the development of EF in the second year

of life is critical because it focuses on a time when representation emerges (e.g., precursors to language like declarative pointing), a time when children may first engage in generating and reflect on task relevant representations to control behavior consciously. Therefore, representational theories may suggest that the emergence of internally generated representations in the second year of life lay the foundation for consciously controlled behavior.

The Development of Representation and EF in a Social Context

Although preschoolers are very familiar with the idea that language and symbols represent their environment, representational ability is difficult to examine in children younger than 2 years of age. As EF research begins to explore representations of language novices, it becomes important to consider that advanced representations emerge because they are socially constructed (e.g., Tomasello, 2003). In fact, many theorists propose that the key to complex, uniquely human cognition (e.g., language, symbols, advanced problem solving) lies in our social, communicative, and cooperative nature as humans (e.g. Nelson, 1996; Tomasello, 1999; Tomasello & Herrmann, 2010, Vygotsky, 1978). Thus, examining the early development of representation and EF may necessitate considerations of how the social environment contributes to these abilities.

Linguistic Representation and EF in a Social Context. Representational theories emphasize the importance of language in the control of behavior, but empirical research typically decouples language from its pragmatic or communicative context and focuses on how the semantic meaning influences problem solving (e.g., Lowenstein & Gentner, 2005; Rattermann & Gentner, 1998). This focus is warranted in research with

preschool aged children, as it is likely that any presentation of familiar language is automatically associated with the semantic meaning that children can reflect upon to guide behavior (e.g., Zelazo, 2004). However, Vygotsky (1934/1986) suggested that linguistic meaning may initially be dependent on the social context of language, and young children must speak language aloud to another for language to have meaning (i.e., external speech). Miller and Marcovitch (2011) supported Vygotsky's theory and demonstrated that 2.5-year-olds performed best in an A-not-B task when they generated a relevant label in response to an experimenter's question. Thus, the social context in which language was generated was critical to forming representations to guide behavior in young language novices. As children transition to external speech (i.e., speech spoken aloud to oneself to have meaning) and finally inner speech (i.e., covert linguistic representations), the overt generation of linguistic information for another may become less essential in controlling behavior.

Social Interaction, Scaffolding, and EF. In line with the premise that the early social environment shapes children's EF, more attention has focused on the role of social interaction in EF (e.g., Bibok, Carpendale, & Müller, 2009; Carlson 2009; Hammond, Carpendale, Bibok, Müller, & Liebermann-Finestone, 2012; Hughes & Ensor, 2009; Lewis & Carpendale, 2009). This research has its foundations in Vygotsky and Luria's early work (e.g., Luria, 1979; Vygotsky, 1934/1986, 1978), suggesting that the social environment helps children internalize socially presented strategies for behavioral and cognitive control (e.g., inner speech). As more studies emerge, it is clear that the relationship between children's social interactions and the development of EF is complex.

For instance, Hammond et al. (2011) investigated the relationship between scaffolding and EF growth in a longitudinal study with children at 2, 3, and 4 years of age.

Scaffolding, typically defined as guidance within learning situations (e.g., Vygotsky, 1978; Wood, Bruner, & Ross, 1976), was examined by observing parents' tailored support of children's behavior during a difficult puzzle task (e.g., allowing errors, guiding and maintaining attention when frustrated, offering escalating levels of assistance). Their work demonstrated that parental scaffolding in a puzzle task at age 3 was related to EF at age 4, and scaffolding at age 2 was indirectly related to EF at age 4 through language. These results suggest developmental timing is critical when examining the role of the social context in EF and that the influence of scaffolding may change across the lifespan (e.g., Bibok et al., 2009; Hammond et al., 2011). More specifically, scaffolding may be more important early in life, and influence important contributors to EF (e.g., language) later in life.

Social Cognitive Understanding and EF. Another relevant aspect of children's early social environment (and perhaps one of the most studied social-EF relationships in preschool) is the relationship between social cognitive understanding and EF. Studies with preschoolers demonstrate that performance on EF tasks relates to performance on theory of mind (ToM) tasks, which assess the understanding that other individuals have their own mental states that guide behavior (e.g., Carlson et al., 2004; Carlson, Moses, & Claxton, 2004). One of the most widely studied ToM task is the false belief task (e.g., Gopnik & Astington, 1988; Wellman, Cross, & Watson, 2001; Wimmer & Perner, 1983), which assesses whether children can explicitly predict the behavior of a character in a

story with a false belief about reality (e.g., if they believe a treat is hidden in a cupboard, the character will search in the cupboard even if the treat is moved unbeknownst to the character). Several theorists hypothesized that mastery of this task demonstrates children's ability to form theories about other people based on how unobservable mental states (e.g., desires, knowledge, beliefs) guide behavior (e.g., Gopnik & Meltzoff, 1997; Wellman, 1990). Although children commonly pass the false belief task by 4 years of age, the appreciations of mental states that do not conflict with children's knowledge of a situation (e.g., others' true beliefs, desires, and knowledge) typically emerge earlier in life (e.g., Repacholi, & Gopnik, 1997; Wellman & Liu, 2004). The robust relationship between EF and ToM in preschool suggests that understanding behavioral control in others is related to behavioral and cognitive control in oneself.

Various theories explain the relationship between EF and ToM in preschoolers. Moses (2001) proposed that EF may play a role in ToM expression (e.g., children need WM to hold multiple perspectives in mind) and emergence (i.e., children must first be able to inhibit their own more salient mental states to have an understanding of others' mental states, Russell, 1996). Empirical support for this unidirectional EF → ToM account demonstrates that EF at 24 months predicts later ToM across the preschool period (Carlson et al., 2004; Hughes & Ensor, 2005, 2007). In contrast, Perner and Lang (2000) suggested a unidirectional account in which ToM is necessary for the emergence of EF. They propose that understanding that mental states guide behavior allows children to recognize problems in behavioral control (e.g., the natural tendency to produce prepotent responses) and inhibit habitual responding in EF tasks. Further supporting this

hypothesis, Carruthers (2009) suggested that ToM deficits in children with Autism (i.e., specifically related to impairments in social understanding) contribute to EF problems in this population.

Conflicting support for these two unidirectional theories suggests that the EF-ToM relationship is likely more complex. For instance, the CCC theory, originally described as a reflection based representational account for the development of EF, has also been applied to the EF-ToM relationship (Frye, Zelazo, & Burack, 1998). Frye et al. demonstrated that children's ability to use and understand embedded rules in the DCCS was related to children's performance on ToM tasks. The authors did not hypothesize a unidirectional relationship; rather they suggested that performance was related in both tasks because an underlying ability in the representation of rules was necessary to guide behavior in both tasks. Given the complex nature between social understanding and EF, the most likely explanation of this relationship is that the abilities are interdependent and contribute to the development of the other. However, research on the ToM-EF relationship is limited because the majority of studies are restricted to preschool-aged children. Miller and Marcovitch (2010) proposed that reflection based representational accounts of EF (e.g., Frye et al., 1998; Marcovitch & Zelazo, 2009; Zelazo, 2004) provide a framework for understanding the complex relationship between EF and ToM from infancy to school age. Namely, the strength of the relationship between ToM and EF should be related to the extent that performance draws on the same representational abilities and may change with age. It is likely that social understanding in the first couple years of life may contribute to representational ability (and indirectly later EF) because

early social understanding likely supports communication and representational abilities like language, which influences EF. However, later in preschool, EF may contribute to social understanding because advanced social cognitive tasks often require domain-general EF abilities (e.g., inhibiting one's own beliefs to appreciate others' beliefs) in addition to social cognitive understanding. More research is necessary in the critical second year of life to determine the accuracy of the hypothesis that early representations developing within a social context (e.g., language and gestures used to communicate) support EF.

Early Examinations of Social Factors in the Development of Representation and EF. Social interaction and understanding appears to be important to the development of EF, with many studies focusing on the role that social factors play in the development of representation to support EF. Although reflection based theories provide a mechanism for development across early childhood, they do not necessarily explore the impetus for change. Examining how the representational abilities that guide EF develop within a social context may provide a more complete account of EF development, elucidating the nature of the changes within children's representational ability (e.g., representation driven by early scaffolding and social interaction) that underlie cognitive control.

Very few studies have investigated the development of EF and representation within a social context during the first few years of life, because these concepts have traditionally been measured starting in preschool. One promising avenue for this representational framework is to focus research on the relationship between EF and joint attention. Joint attention is a social cognitive and communicative hallmark that emerges

in infancy and refers to the behaviors that describe infants' and agents' shared reference to objects or events (Carpenter, Nagell, & Tomasello, 1998). Although children in the second year may not yet be proficient in language or social understanding, joint attention is related to later development in these abilities and may provide a means for examining early representation, EF, and the social environment.

Carpenter et al. (1998) proposed that three joint attention abilities develop across infancy. First, between 9 and 12 months children first check attention (e.g., look to adult). At 11 to 14 months children follow attention (e.g., follow and share adult gaze to an object), followed by children's directing attention (e.g., gesture to objects to get adult's attention) from 13 to 15 months. Mundy and colleagues (e.g., Mundy & Gnomes, 1998) also note a sequence of abilities in joint attention: responding to joint attention (RJA; i.e., following others attention) emerges before initiating joint attention (IJA; i.e., directing attention). Mundy and colleagues (Mundy & Newell, 2007; Mundy et al., 2007) suggested that RJA and IJA are distinct processes in infancy driven by separate attentional systems (Ruff & Rothbart, 1996). RJA is guided by a more primitive attention system (i.e., the orienting attention system) based on attention to novelty, and IJA (similar to directing attention) is supported by a later developing anterior attention system responsible for higher levels of internal control of attention. Both theories distinguish between the less active demonstrations of joint attention (i.e., checking, following, and RJA) compared to more active joint attention (i.e., directing and IJA), and argue for the importance of examining these different joint attentional abilities.

Joint attention, EF, and language. Joint attention may be one of the best ways to understand developing representation in the first few years of life. For example, a robust relationship has been documented between joint attention and language development (e.g., Colonnaesi, Stams, Koster, & Noom, 2010; Markus, Mundy, Morales, Delgado, & Yale, 2000; Tomasello & Farrar, 1986; Tomasello, Mannle, & Kruger, 1986; Tomasello & Todd, 1983). Studies demonstrate that children and parents who maintained joint attentional episodes longer resulted in better vocabularies in the second year of life (Tomasello & Todd, 1983; Tomasello et al., 1986). Tomasello and Farrar (1986) suggested that interactions in joint attention scaffold children's linguistic development because it provides an ideal setting for children to pick up parent provided language for entities that are currently in attention. Although studies tend to focus on the scaffolding role of the parent in guiding children's attention in linguistic exchanges, Mundy and Gnomes (1998) also suggested that individual differences in children's joint attentional abilities play a role in language acquisition. They demonstrated that 14 to 17 month old children's ability to respond to joint attention uniquely predicted receptive language, whereas the ability to initiate joint attention predicted expressive language. These results also support the argument that RJA and IJA are distinct processes that need to be examined separately.

One aspect of joint attention that has been widely studied in the relationship to language is pointing (for a review see Colonnaesi et al., 2010). Pointing occurs when children extend their hand and index finger to an object or event in the environment (Butterworth & Morissette, 1996; Colonnaesi et al., 2010). This behavior can serve several

different functions. For instance, researchers have drawn distinctions between imperative pointing (i.e., pointing to control behavior of another such as requesting an object) and declarative pointing (i.e., pointing to direct and share attention with another, see Bates, 1976). Many theorists consider declarative pointing as a higher level of joint attention, because it involves children's intentional action with the goal of initiating and directing the attention of another to a third entity (e.g., Mundy & Newell, 2007; Tomasello, Carpenter, & Liszkowski, 2007). Although Colonnesi et al. provided support for a robust relationship between all forms of pointing and language when examined concurrently, declarative pointing is more predictive of later language as compared to imperative pointing. Further, age moderated this relationship and suggested that the longitudinal relationship between earlier pointing and later language development became stronger when declarative pointing was measured later in life (i.e., 15 to 20 months of age) compared to earlier assessments. Colonnesi et al. suggested that these results provide support that pointing is the first instance of referential and intentional communication that contributes to language.

Few studies have actually investigated the relationship between precursors to language and EF. Theoretically, representational accounts suggest that early forms of both verbal and nonverbal representation provide the impetus for internally controlled behavior. For example, Zelazo (2004) proposed that declarative pointing may be the first evidence that young children develop higher levels of consciousness or awareness of their environment (Zelazo & Zelazo, 1998). When children point to manipulate another's attention, it provides the opportunity for children to appreciate the fact that they can have

and compare multiple representations (i.e., the act of pointing and the object pointed to). It is hypothesized that this behavior, prompted by the desire to share with others, is one of the first instances that children begin to form representations of objects in their environment. This advancement in representation allows children to hold and manipulate information in mind, which is a key development in emerging cognitive control.

Joint attention, EF, and scaffolding. Models of joint attention and language suggest that parent behavior in joint attentional episodes scaffold early word learning (e.g., Tomasello & Farrar, 1986), and work has demonstrated that parent behavior may help guide more focused attention as well. For example, Bono and Sifter (2003) found that parental guidance in shared attention episodes at 10 and 18 months combined was related to control of attention in a separate task at 18 months. Children with parents who attempted to maintain attention (e.g., verbal and nonverbal actions to keep attention engaged) had better focused attention (i.e., sustained looking and interacting with an object with an intent expression) compared to children with parents who attempted to redirect attention (e.g., verbal and nonverbal actions to change attention to new object). Further, more focused attention was related to higher general cognitive development scores (i.e., Bailey Mental Development Index, MDI) at 10 and 18 months of age. These results suggest that joint engagement with parents has an important influence on the development of the control of attention and cognition. Proponents of this perspective suggested that parents first help control attention within these episodes of joint engagement, and joint attention episodes may aid in the transition from other directed attention to self directed attention.

Joint attention, EF, and social understanding. Examining joint attention and EF may help clarify the relationship between EF and social understanding or ToM. Social-cognitive views of joint attention propose that engaging in collaborative communication is evidence of early social cognitive understanding. For example, Carpenter et al. (1998) suggested that joint attention abilities increase in complexity (e.g., passive gaze following is less socially demanding than the more active manipulation of others' attention) and correspond to an increasingly complex understanding of others. Tomasello, Carpenter, Call, and Behne (2005) proposed that although the ability to check and follow attention is important, directing attention falls within a higher level of collaborative engagement and demonstrates children's abilities to participate actively in and understand their own role and others' roles in an episode involving joint intentions. For example, Tomasello et al. suggested that declarative pointing (a means for directing attention) is more advanced because the goal of this act is to share attention with others for the sake of sharing attention and to initiate an episode of shared goals and plans (i.e., they do not get a physical reward as they would when obtaining an object). Further, Tomasello et al. (2007) argued for a rich social interpretation of pointing in children, suggesting that pointing is evidence of children's attempts to share and understand a common social ground, to communicate and influence the mental states of others, and to understand intentional actions of the self and others. The authors hypothesized that the production of declarative pointing indicates that infants are aware that others have a separate understanding about the world that includes their own attention and intentions that can be

shared (Camaioni, Perucchini, Bellagamba, & Colonnese, 2004; Tomasello & Camaioni, 1997; Tomasello et al., 2005).

The relationship between joint attention and EF. Despite the strong theoretical support for the examination of joint attention and EF in infancy, few empirical studies have examined this relationship. The majority of this work has been conducted by assessing joint attention and EF in children with autism, and it has been suggested that children with autism's impairment in social understanding is related to a general EF impairment (e.g., Ozonoff & McEvoy, 1994; Rumsey & Hamburger, 1990). In support of this hypothesis, Dawson et al. (2002) found a relationship between the delay nonmatch to sample task (DNMS, a task hypothesized to require EF abilities) and joint attention abilities in children with autism. Further, Griffith, Pennington, Wehner, and Rogers (2001) demonstrated that EF at an earlier time point (mean age of 51 months) was correlated with IJA one year later, while the reverse correlation was not significant. The study of the EF-joint attention relationship has also been extended to typically developing children. Nichols, Fox, and Mundy (2005) demonstrated that improvement in the DNMS from 14 to 18 months of age predicted IJA abilities at 18 months. However, these studies generally examine atypically developing populations, focus on the unidirectional link between early cognitive control and joint attention, and typically administer relatively few EF tasks. There are no studies approaching this relationship from a representational framework, where the social context is hypothesized to play a major role in EF development.

The Present Study

In the current study, I examined the longitudinal relationship between EF and joint attention in 14- to 18-month-olds. There were two major goals to this study. First, I sought to describe EF abilities during the second year of life by observing EF task performance, coherence between EF measures, longitudinal stability, and the relationship between EF, language, and parent report measures of self-control temperament. Four EF tasks were given to children at both their 14 and 18 month visits. A more difficult version of Piaget's (1954) A-not-B task was included as a measure of response shifting (Garon et al., 2008) because it requires multiple components of EF, such as holding the hiding location in mind, inhibiting the prepotent response to search at location A, and shifting to a new response set (see Marcovitch & Zelazo, 2009). Although 12-month-olds can tolerate up to 10 second delays between hiding and search on the A-not-B task with two hiding locations (Diamond, 1985), the version in the current study implemented a 10 second delay with 5 hiding locations to make the task appropriately challenging for 14- to 18-month-olds. A delay of gratification task similar to tasks used with preschoolers (Carlson, 2005; Garon et al., 2008) was also included as a measure of inhibition (e.g., inhibiting a desirable action such as eating a snack when asked to wait). Although delay of gratification has rarely been studied in children younger than 2 years of age, Kochanska et al. (1998) examined behavior in contexts of prohibition in children as young as 8 months. In Kochanska et al.'s tasks, parents prohibited (e.g., said 'no' or 'don't') 13- to 15-month-old children from playing with attractive objects across several situations (e.g., snack time, free play) that totaled 25 minutes. Internalization of this rule

was measured when children were left alone with the toy in an eight minute free-play session. In the current study, children were presented with an abbreviated version of this task in which they were prohibited from playing with a toy by the experimenter for 3 minutes, and their behavior was immediately observed during an unsupervised 2 minute free play to determine if they played with the forbidden toy. The 3-boxes task was included as a measure of complex WM because the task required children to hold object locations in mind and update this information throughout the task (Diamond et al., 1997). The 3-boxes stationary version was used (in which the boxes remained in the same location after each search) and no additional modifications were made to the original task, as it was originally designed to assess EF in the second year of life. Finally, the Imitation Sorting Task (IST; Alp, 1994) was administered as a simple WM span task that primarily measures the ability to hold information in mind over a delay. WM span tasks are not typically administered to children younger than 3, because they require children to repeat a list of numbers or words. Alp (1994) proposed the IST as a non-verbal measure for 12- to 36-month-olds that measures WM span by children's ability to imitate an experimenter sort increasing numbers of items into two containers. An abbreviated version of the task was used in which children were presented with an increasing number of items to sort until they answered incorrectly on 3 trials.

The second goal was to investigate the relationship between developing representation and EF within a social context. Given that children are not fully competent in language during this period, joint attention was selected as the primary measure of representation (although parent report measures of children's developing language

abilities were also collected). I hypothesized that engaging in higher level IJA behaviors (e.g., declarative pointing) should be related to stronger EF concurrently and longitudinally, because IJA prompted within a social context may be the first instance that children label and reflect on stimuli in the environment, which is a representational skill critical to developing EF. Further, I hypothesized that a higher-level IJA-EF relationship would provide support for an extension of the EF-ToM relationship to even younger, 1-year-old preverbal children. More specifically, if declarative pointing reflects children's understanding that others are intentional agents with internal mental states that can be manipulated (e.g., Tomasello et al., 2005), this behavior should be related to EF as a precursor to ToM. Finally, I also measured less active measures of joint attention (e.g., RJA). If these aspects of joint attention are distinct as many theorists suggest (Mundy & Gnomes, 1998; Mundy & Newell, 2007; Mundy et al., 2007), they should be less important in the development of EF at this stage, because they are not hypothesized to reflect children's representational and ToM abilities.

CHAPTER II

METHOD

Participants

The final sample included 47 children (25 boys, 22 girls) who participated in the longitudinal study at 14 and 18 months of age. Participants were recruited from childcare centers and preschools or from a database of parents interested in participating in studies on cognitive development. Parents received a \$5 gift card for each visit, and children received a snack and toy for participation. From the original sample of 52, $n = 4$ children were not included in the final sample because they failed to return for the second visit at 18 months, and $n = 1$ child was removed due to excessive parent involvement throughout the tasks.

At time 1, the mean age was 14.38 months ($SD = .34$, range = 13.77 – 15.10 months). The average length of time between the first and second visit was 4.12 months ($SD = .28$, range = 3.57 – 4.79 months). At time 2, the mean age was 18.48 months ($SD = .35$, range = 17.84 – 19.25 months).

Materials and Procedure

Children were tested on the same EF and joint attention battery at the 14 and 18 month visit. Because the focus was on individual differences, the same female experimenter presented tasks to children in a fixed order (object spectacle task 1, A-not-B, gaze following, book presentation task, forbidden toy task, object spectacle 2, 3-boxes

task, object spectacle 3, IST) to equate experimenter and order effects. Four 14-month olds and two 18-month-olds were administered the A-not-B task later in the visit because they were initially not compliant. The order of the joint attention tasks (i.e., object spectacle, gaze following, and book presentation tasks) was also administered flexibly. For example, if children did not attend to the experimenter during the gaze following task, they were presented with the next task and received the gaze following task later. This is recommended because the experimenter must be responsive to children's communicative bids for the items presented (see Mundy et al., 2003). Testing sessions took place in a University laboratory and lasted approximately 30 minutes to 1 hour. Children were permitted to sit on the parent's lap or to the left and in front of the parent in a separate chair. Parents remained in the testing room for all children except for two 18-month-olds, whose parents watched tasks from a separate room. Parents were informed that the interactions of interests would occur between the experimenter and child, and if children attempted to interact with the parent they could respond in a natural manner and redirect attention to the experimenter. All sessions were videotaped.

EF Measures

Children were presented with four EF tasks designed to assess 14- and 18-month-olds' abilities in different components of EF typically correlated in older children and adults (i.e., set-shifting, WM, and inhibition, see Carlson et al., 2003; Garon et al., 2008; Miyake et al., 2000). Performance on each task was scored from the video by a primary coder. A second coder scored 10 videos randomly selected for each 14 and 18 month visit. For the 14 month visit, measures of interrater reliability for categorical variables

(kappa) were all equal to 1.0 and measures of reliability for continuous variables (intraclass correlations) were greater than .99. For the 18 month visit, measures of interrater reliability for categorical variables (kappa) were all equal to 1.0 except for behavior on the forbidden toy task (Kappa = .73), which reflected disagreement on one out of the 10 cases. In instances of disagreement coding from the primary coder were considered. Measures of reliability for continuous variables (intraclass correlations) were greater than .92. At 14 months, one child had missing data for the forbidden toy task, 3-boxes task, and IST task, one child had missing data for the 3-boxes task, and one child had missing data for the IST. Missing data was handled in a pairwise deletion fashion where all available information was used for each case (e.g., if the child had missing data for the 3-boxes task, they were still included in other analyses for tasks which they had data). A brief description of each task in the EF battery is provided below.

A-not-B with multiple hiding locations (response switching). The hiding apparatus consisted of five shallow wells (7 cm depth, 9.5 cm diameter of well opening) used as hiding locations embedded within a wooden box (43 cm length X 56 cm width X 7 cm height). Hiding locations were arranged in a semi-circle configuration, such that each hiding location was 16 cm from the point where the box would be placed in front of children to search. Each hiding location was covered by blue felt that sealed and opened with Velcro at the center to reveal the contents of the hiding location.

In the training phase, children were familiarized with the task of retrieving a toy hidden in a well. Children chose the desired toy from a set of three and watched as the experimenter broke the Velcro seal and placed the chosen toy conspicuously inside the

center well. A 56 cm X 43 cm white poster board occluded all but the center well during training. The hiding box was then placed immediately (i.e., no delay) in front of children and they were encouraged to retrieve the toy. Children were praised and got to play with the toy after retrieval on this training trial, and all subsequent training trials. Next, the box was moved out of reach and children watched again as the experimenter placed the toy inside the well and sealed the Velcro cover to the well. This time, there was a ten-second delay in which the experimenter covered the hiding box with a 76 cm X 50 cm foam poster board and counted aloud to ten. After the ten second delay, children were presented with the hiding box and encouraged to search for the toy. Children had to break the Velcro seal at the center hiding location after the ten second delay to move on to the testing phase.

In the testing phase, the A and B trials were similar to those administered in the training phase except all five hiding locations were visible. Children had to retrieve the toy at location A correctly 3 times before they saw the object hidden at a new location (location B). Hiding locations were counterbalanced with the stipulation that the center well was never used as a hiding location and location B was located on the opposite side of the midline as location A (see Marcovitch & Zelazo, 2006). At the beginning of each test trial, children's attention was brought to the center of the testing apparatus, and children watched as the experimenter hid the toy in one of the hiding locations (location A). The experimenter then sealed the Velcro and covered all 5 hiding locations simultaneously (see Diamond, Cruttenden, & Niederman, 1994) with the white poster board and counted to ten. The hiding apparatus was then presented to the children and

they were encouraged to search for the object. The first location at which they broke the Velcro seal was counted as their response on any given trial¹. If children refused to search the trial was considered incorrect. Children who searched correctly were rewarded with praise and permitted to play with the toy. Children who searched incorrectly were shown the correct location of the object, but were not rewarded with praise nor permitted to play with the toy. B trials were repeated until children retrieved the object correctly at location B twice or refused to continue search.

On A trials, pass/fail performance was measured. Children unable to complete three A trials or who failed to search at one location (i.e., always produced simultaneous search at two locations, n=1) were assigned a 0, whereas those who completed three A trials successfully were assigned a 1. On B trials, performance was only assessed if children were successful on the A trials. I measured pass/fail performance on the first B trial (0 = incorrect/fail, 1=correct/pass) and the error run on the first B trial, defined as the number of errors committed before children retrieved the object at location B correctly. Error run ranged from 0 – 5, and children who withdrew from the task were assigned a score of 6 to permit their inclusion in the analyses, resulting in a final range of 0 – 6².

Forbidden Toy (inhibition). In the current study, a shortened version of the prohibition task was created to examine 14- and 18-month-olds' performance on an inhibition task similar to the delay of gratification tasks used in preschool. First, the experimenter and children shared 3-minutes of free play where children were invited to play with an available toy (a multicolored Fisher-Price[®] Stack 'n Surprise Blocks Blockity-Pop Caterpillar) but told not to touch an appealing toy train (Fisher Price[®]

GeoTrax™ train) that was out of close reach. The train was activated (i.e., drove around a circular train track) for 15 seconds at the 45-, 105-, and 165-second mark during free play. Each time children touched or attempted to reach for the toy the experimenter prohibited children from playing with it (e.g., said we can't play with this toy now, we will play with it later) and redirected attention to the available toy. Supervised free play was conducted to ensure that children understood the prohibition before examining their behavior in a delay of gratification setting where the ability to resist the prepotent response of playing with a forbidden toy was observed. At the end of the supervised free play session, the experimenter repeated the prohibition, and suggested that children continue to play with the available toy while she left the room for 2 minutes. The parent remained in the room, but was instructed not to respond to children's inquiries about the train and not to prohibit them from touching it. The train was activated for 20 seconds at the 0- and 60- second mark during unsupervised play. During unsupervised play, children's pass/fail behavior (0 = touched toy/fail, 1 = did not touch the toy/pass,) and the latency (amount of time children waited to touch the forbidden toy) were measured. Children who did not touch the toy were assigned the maximum latency score of 120 seconds.

Three boxes task (WM + attention). Three distinct boxes were used as hiding locations (blue box with a star handle, yellow box with a circle handle, and red box with a square handle, all handles were approximately 6 cm by 6 cm). Each box was affixed with velcro to a foam base (47 cm length X 16.5 cm width X 4.5 cm height) that presented boxes toward children at a slight downward angle. All boxes were 12 cm

length X 11 cm width X 3.5 cm height and were 7.5 cm apart once affixed to the foam base. Notably, each location could be distinguished by spatial location, color, and/or shape of the handle. The location of the boxes was counterbalanced across children.

Children watched as the experimenter lifted the lids of all three boxes and placed an attractive toy (i.e., a pink plastic rattle that made noise) inside each box. The experimenter then simultaneously replaced the lids and occluded the hiding apparatus with a white foam poster board for 5 seconds. After the delay, the experimenter presented children with the search display and encouraged children to search at one location. On the few instances where children lifted two lids simultaneously, children's responses were determined based on eye gaze or the location children continued to open. Children rarely (n=2) simultaneously lifted lids to both an incorrect and correct location. On correct searches children were praised and briefly played with the toy while the boxes remained out of reach with the chosen box open. On incorrect searches children were told the toy was not in that box while the hiding apparatus was tilted toward children with the incorrect box open so children could observe the empty hiding location. After each search trial the lid was replaced, removed from children's reach, and occluded for five seconds. After the delay the hiding apparatus was again presented to children and they were encouraged to search again. Searching continued until children retrieved all three objects, or until they failed to find a toy for 4 consecutive trials. Children were considered to pass the task if they retrieved all three toys (0 = fail, 1 = pass). In addition, I measured the error run, or number of errors children made before finding all 3 toys. Children who failed to find a toy were assigned a 5. Thus, children who failed to find the second toy

were assigned a 5 for both the second and third toy and received the maximum error run of 10.

Imitation Sorting Task (WM). In the current study, children were administered an abbreviated version of the IST where the experimenter sorted objects into two containers and subsequently invited children to imitate the sort. Children were presented with increasingly difficult levels (i.e., more objects to sort) as the task progressed. Two clear plastic sorting containers (8 cm in height with a 10.5 cm diameter) were mounted on a 47 cm X 14 cm foam base with Velcro that kept the containers 23 cm apart. Each container was designated with a brown or green ribbon glued 1.5 cm below the opening of the container. Forty distinct toys (e.g., toy cars, balls, plastic animals) ranging in size from approximately 10 cm X 6 cm to 5 cm X 5 cm were used for sorting.

In level 1, the sorting bucket was always placed to the right, and children watched as the experimenter sorted one toy into the right bucket. The ribbon color of the first sorting bucket was counterbalanced across children. A typical trial began with the experimenter telling children “The frog goes in this bucket. Hop, hop, hop.” The toy was tapped on the foam base each time the experimenter uttered “hop”, and then the toy was dropped in the container. The toy was removed from the bucket, placed in the center of the foam base, and then presented to children. The experimenter then invited children to imitate by saying “Now, you try”. Children were considered to pass the first level if they correctly placed the toy in the bucket three times and, they were rewarded with praise and clapping to encourage imitation. This level was considered the training phase of the task,

as children had to demonstrate they could imitate the experimenter's action with one object before they moved on to sort multiple objects.

Alp (1994) states that imitation sorting begins in level 2 with the introduction of a second sorting bucket added to the left hand side of children. The experimenter asked children to imitate sorting two distinct toys, one in each bucket. In the first set, two distinct toys were selected from the 40 toys. Once toys were sorted, they were not used again in later trials. The experimenter noted the addition of the new bucket, sorted the first toy in the left container and the second toy in the right container, then removed the toys and placed them in the center of the foam base for children to sort. Toys were sorted in a manner similar to the first trial by saying: "Now there are two buckets. The ball goes in this bucket (left) hop, hop, hop. The car goes in this bucket (right) hop, hop, hop. Now you try". Sorting was counted as correct if children put each toy in a separate bucket (i.e., children did not have to put the toy in the same bucket as the experimenter as long as the items were sorted into separate buckets). Once all toys were placed in a container the sorting behavior was scored (e.g., children could change initial sorts by removing the toy and placing it in the other bucket, but once both toys were placed in a container the trial was considered complete and scored). If children sorted incorrectly (e.g., both toys in one bucket) or refused to complete the sort, the experimenter showed them the sorting process again with the same toys. If children failed to imitate the sort after they were shown a second time, the experimenter selected two new toys and moved on the new set. In all levels children were given a maximum of 5 sets, and were designated as passing and moved on to the next level as soon as they sorted 3 sets correctly. Children who were

unable to sort 3 sets correctly did not pass the level and did not participate in the task further.

Level 3 followed the same procedure as the previous level, except now three toys were introduced and sorted in the two buckets. The experimenter sorted the first two toys individually in the bucket on children's left, and the third toy in the bucket on the right. Toys were selected from the set of 40 toys so that the pairs sorted were arbitrarily related to each other (e.g., pairs were not consistently conceptually or perceptually related). Children's imitation sorting was counted as correct if children kept the pair of toys together and isolated the third toy, regardless of the buckets they were placed in. In Level 4, four toys were introduced and the experimenter sorted the first two toys into the bucket on the left and the second two toys in the bucket to the right. No child made it past level 4. For this sample, children were considered to pass the task if they passed level 2 (i.e., were able to sort at least 2 items correctly). Because Alp (1994) suggested that the IST begins at level 2, the number of correct sorts was also measured beginning with level 2 (i.e., once children begin to sort more than one object).

Joint Attention Measures

All joint attention measures were taken from the Early Social Communication Scale (ESCS, Mundy et al., 2003) constructed to measure early social understanding of children from 8 to 30 months of age. In this measure, Mundy and colleagues demonstrated that joint attention can be separated into distinct dimensions (e.g., Mundy et al., 2007) hypothesized to have different underlying processes and developmental progressions. Because active sharing joint attention behaviors (e.g., protodeclarative

pointing) were hypothesized to be most strongly related to EF (e.g., Zelazo, 2004), a subset of tasks designed to elicit IJA behaviors were chosen for inclusion in this battery. In addition, RJA behaviors (i.e., behaviors related to *sharing* attention in response to an adult) and initiating behavioral response behaviors (i.e., IBR, behaviors related to requesting an object *initiated* by the child) were measured to determine whether any sharing or child initiated behavior was related to EF, or whether there was something particular to child initiated sharing behaviors critical to the development of representation and EF. Finally, because self-initiated gesture was hypothesized to encourage stronger representations used to guide EF (e.g., Zelazo, 2004), the IJA-higher subscale was examined. This subscale included measures of protodeclarative pointing and showing gestures toward adults. Global measures of each dimension of joint attention (IJA, IJA-higher, RJA, and IBR) consisted of frequency scores counting every time one of these behaviors occurred within the joint attention tasks, coded according to the guidelines specified by Mundy and colleagues (2003).

EF and joint attention coding was always conducted during separate coding sessions. Joint attention behaviors were coded from videos of each session and reliability for coding these behaviors occurred in two phases. First, the primary coder rated joint attention on 10 tapes provided with the ESCS manual, which was compared to provided coding scores to establish reliability with coding described in the manual. Intraclass correlations were calculated between the primary coder's behavioral ratings and the manual's established coding. All correlations for IJA, IJA-higher, RJA, and IBR were significant at the .005 level or below and were .93, .91, .81, and .72, respectively. Next, a

secondary coder examined 10 randomly selected tapes from the current study for each time point and was compared to the primary coder's ratings. At 14 months all correlations were significant at the .005 level or below and were .96 for IJA, .82 for IJA-higher, .84 for RJA, and .80 for IBR. Finally, at 18 months all correlations were significant at the .005 level or below and were .95 for IJA, .73 for IJA-higher, .80 for RJA, and .92 for IBR. There was no missing data for joint attention measures at either time point. A brief description of each task in the joint attention battery is provided below.

Gaze following task. This was the only measure of RJA and measured children's ability to respond or follow the experimenter's request to share attention with children. In this task, four posters in the room were located to the left, right, behind left, and behind right of children. The experimenter called children's name and touched their own nose to direct children's attention to the experimenter. The experimenter then turned their entire torso and visually oriented to the poster to children's left while pointing at the poster with a "short arm point" (i.e., elbow in contact with side) to reduce influence of arm movement on children's behavior or block the video recording of the children. The experimenter said children's name three times increasing in force with approximately two seconds in between each enunciation, and then looked back to children after the third enunciation. On trials with the poster behind children, the experimenter leaned forward to the left or right of children as if they saw something interesting and pointed to the poster behind the children. After each trial the experimenter commented on the target (e.g., "Did you see the Dog?") to acknowledge or encourage action in children. Children's behavior

in terms of following the experimenter's line of regard was measured. Children received credit for responding to joint attention if they turned their eyes or head to indicate they were looking in the intended direction of the experimenter. In addition, children received credit for IJA and IJA-higher behaviors if they pointed to the poster to direct the experimenter's attention before the experimenter showed children the posters (i.e., children demonstrated that they were not just imitating the experimenter's pointing action).

Object spectacle task. This task was administered three times throughout the study and was the main measure of IJA and IBR in children. In this task, the experimenter activated a toy (i.e., a wind up seal, hand puppet, or wind up caterpillar) on the table just out of direct reach of children and let it remain active for at least six seconds or until children requested the toy. The experimenter remained silent but attended to children while the toy was active, which allowed children to initiate joint attention (e.g., alternate gaze between toy and experimenter, point to the active toy) or request the toy (e.g., reaching for the toy). If children attempted to initiate joint attention with the experimenter, the experimenter provided children with a brief natural response (e.g., "I see!"). If they requested the toy by attempting to obtain it, the experimenter moved the toy within reach of the children. At the end of the trial, the toy was given to children and they were permitted to play with it. Each toy was activated and presented to children three times in a row. Behaviors reflecting child initiated joint attentional episodes with the experimenter were measured. It was considered a bid for joint attention when children alternated looking between an active toy and the experimenter's eyes, or if children

looked to the experimenter while they were playing with an inactive toy. In addition, IJA-higher behaviors (a subscale of total IJA) was coded when children pointed to an active toy or held the toy to show the adult. IBR requests were scored when children requested the toy or action from the adult (e.g., reaching/pointing to obtain the toy, giving the toy to the experimenter so they would reactivate it).

Book presentation task. The book presentation task provided children with an opportunity to exhibit IJA behavior. In this task, the experimenter presented a picture book to children with several distinct pictures displayed on the pages and said, “What do you see?” The experimenter waited 20 seconds, in which children could initiate episodes of joint attention by pointing to pictures in the book to share attention with the experimenter. If children pointed spontaneously during this time the experimenter responded naturally (e.g., “I see”). After 10 seconds, the experimenter prompted children again, asking them what they saw in the book. An IJA-higher behavior was considered to occur when children pointed to a picture to during the 20 seconds of the task.

Parent Report Measures

Early Childhood Behavior Questionnaire (ECBQ) – Self-control subscales (Putnam, Gartstein, & Rothbart, 2006). The ECBQ is a large parent report measure of toddler temperament typically administered in 18- to 36-month-old children. A subset of temperament measures related to self-control (i.e., attentional focus, attentional shifting, impulsivity, and inhibitory control) were selected to create a 46-question measure completed by caregivers within approximately one week of each visit. Questions included parent report measures of attentional focus (e.g., When playing alone how often does

your child become easily distracted?), attentional shifting (e.g., When you were busy, how often did your child find another activity to do when asked?), impulsivity (e.g., When offered a choice of activities, how often did your child stop and think before deciding?), and inhibitory control (e.g., When told “no”, how often did your child stop an activity quickly?). The average score for each subscale was calculated. Higher scores reflected better self control abilities.

MacArthur-Bates Communicative Development Inventories (CDI; Fenson et al., 2007). Caregivers also completed the “words and gestures” MacArthur-Bates Communicative Development Inventory parent report. This measure is typically administered to parents of 8- to 18-month-old children and asks parents about children’s understanding of early vocabulary and symbolic gestures. The vocabulary production and vocabulary comprehension subscales were used in the present study and were calculated by summing the total number of words that parents identified that their children could produce and understand. Higher scores reflected better language ability.

CHAPTER III

RESULTS

EF Abilities in the Second Year of Life

To address EF abilities in the second year of life, EF task performance, developmental change from 14 to 18 months, and the relationship to language and parent reports of children's self-control temperament were examined. Descriptive statistics for performance on EF measures at 14 and 18 months are displayed in Table 1. For a given task, children were only included in longitudinal analyses if they had data at both time points. EF performance was not significantly related to sex at either age, $r_s < .26$, $p_s > .09$, therefore sex was not further considered as a variable in the analyses for EF. Correlations between parent report measures of children's abilities (i.e., language and self-control temperament) and EF task performance were conducted on quantitative ratio scaled variables of EF performance (i.e., reverse scored A-not-B error run, Forbidden Toy latency, reverse scored 3-boxes error run, IST Number Correct Trials).

A-not-B task. The majority of children passed the A trial phase (i.e., completed 3 A-trials successfully) with minimal errors. The percentage of children who passed the A trial phase significantly increased from 14 (72%) to 18 months of age (96%), McNemar $\chi^2(1, n=47) = 6.67$, $p = .01$, and the number of errors committed on A-trials marginally decreased, $t(31) = -3.87$, $p = .10$.

Performance on B trials was the primary measure of interest. Children who did not pass the A trial phase were not considered in this analysis. The percentage of children who searched correctly on the first B trial was low at both 14 months (9%) and 18 months of age (29%), and although performance improved across this age range this increase was not significant, McNemar $\chi^2(1, n=32) = 2.50, p = .11$. The error run was also measured. B trials were administered until children searched correctly twice; however, a large number of 14-month-olds (43%) and fewer 18-month-olds (13%) withdrew from the task before ever retrieving the toy at location B. I therefore focused on the number of errors committed before *one* correct search, so as not to exclude children who did not continue to the second B trial. Because the error runs were not normally distributed, a Wilcoxon Signed-ranks test was conducted on the performance of the 32 children that had error runs at both 14 and 18 months of age. The error run significantly decreased from 14 ($Mdn = 4.0$) to 18 months of age ($Mdn = 1.0$), $z = -2.84, p = .005$.

Forbidden toy task. The majority of children did not inhibit playing with the forbidden toy during unsupervised play. The percentage of children who refrained from play did not significantly change from 14 (26%) to 18 months of age (28%), McNemar $\chi^2(1, n=46) = 0.00, p = 1.0$. Further, although 18-month-olds waited longer before touching the forbidden toy compared to 14-month-olds, this difference was not significant, $t(45) = 1.08, p = .29$.

Three boxes task. By 18-months, the majority of children were able to pass the 3-boxes task and correctly retrieved the 3 toys with no more than 4 errors at each location. The percentage of children who passed the 3-boxes task, significantly increased

from 14 (22%) to 18 months of age (66%), McNemar $\chi^2(1, n=45) = 13.89, p < .001$. In addition, the error run significantly decreased from 14 ($Mdn = 6.00$) to 18 months of age ($Mdn = 2.00$), $z = -3.93, p < .001$.

Imitation sorting task. The percentage of children that passed the IST (i.e., children who completed level 2 and sorted at least 2 toys correctly) significantly increased from 14 (22%) to 18 months of age (62%), McNemar $\chi^2(1, n=45) = 16.06 p < .001$. Further, there was a significant increase in the number of correct sorting trials from 14 ($M = 1.31$) to 18 months of age ($M = 2.95$), $t(38) = 5.01, p < .001$.

Relations between EF and parent report of children's language. There did not appear to be any relation between EF and language ability in the second year of life, as no correlation between any of the EF tasks and parent report of language was significant, $r_s < .25, p_s > .11$ (see Table 2 and Table 3). Further, language comprehension and production at 14 months was not related to any of the EF tasks at 18 months, $r_s < .23, p_s > .11$. Finally, no correlations between EF measures at 14 months and language at 18 months were significant, $r_s < .24, p_s > .14$, with the exception of the marginal relationship between the forbidden toy task at 14 months and CDI comprehension at 18 months, $r(41) = .27, p = .08$ (see Table 4).

Relations between EF and parent report of children's self-control temperament. Unlike behavioral measures of EF, there was little growth in self-control temperament as reported by parents. Although caregivers reported that children's self-control temperament improved from 14 to 18 months of age, only parent's ratings of inhibitory control revealed a significant increase, $t(39) = 3.76, p = .001$, and attention

focusing revealed a marginal increase, $t(39) = 1.84, p = .07$. Parent rating of attention shifting and impulsivity did not significantly differ across this age range, both $t(39) < 1.33, ps > .19$.

There was limited evidence that parent report measures of self-control temperament were related to EF task performance. At 14 months, no correlation between any behavioral measures of EF and parent reports of self-control was significant, $rs < .25, ps > .12$ (see Table 2). At 18 months, 3 of the 16 correlations between EF and parent report measures of self-control were either significant or marginally significant (see Table 3). However, counter to my predictions, performance on the Forbidden Toy task was significantly negatively correlated with attention shifting, $r(41) = -.41, p = .01$ and error run on the A-not-B task was marginally negatively correlated with attention focus, $r(40) = -.28, p = .07$. Finally, error run on the 3-boxes task was marginally related to attention focus, $r(41) = .26, p = .09$. Longitudinally, no correlation between any EF measures at 14 months and parent report measure of self-control at 18 months was significant, $rs < .28, ps > .13$. Further, no parent report measure of self-control at 14 months was correlated with EF at 18 months, $rs < .15, ps > .19$ (see Table 4).

Relations between parent reports of children's self-control temperament and language. Although there was little evidence that language was related to behavioral measures of EF, there was evidence for a relationship between parent reports of language and parent reports of self-control. At 14 months, language comprehension was significantly correlated with attention focus and inhibitory control, $rs(41) = .39, .40$, respectively, both $ps = .01$ (see Table 2). At 18 months, language comprehension was

significantly correlated with inhibitory control, $r(41) = .51, p < .001$, and language production was marginally correlated with inhibitory control, $r(41) = .27, p = .08$ (see Table 3). Longitudinally, language comprehension at 14 months was significantly correlated with inhibitory control at 18 months, $r(38) = .34, p = .03$ and marginally correlated with attention shifting at 18 months, $r(38) = .30, p = .06$. No other correlation between early language and later parent report measures of self-control was significant, $r_s < .24, p > .15$. Only CBQ ratings of inhibitory control at 14 months was significantly related to language comprehension at 18 months, $r(39) = .49, p = .001$ (see Table 4).

Cohesion in EF Measures and Longitudinal Stability

I examined the correlations between EF tasks at each age to address issues related to the structure underlying EF (e.g., could EF be described by a unitary structure in which EF abilities are interrelated, similar to later models of EF in preschool, Wiebe et al., 2008). I also investigated the stability of individual differences in EF by determining whether EF at 14 months of age was related to later EF at 18 months of age. For these analyses as well, only quantitative variables measured on a ratio scale were included (i.e., reverse scored A-not-B error run, Forbidden Toy latency, reverse scored 3-boxes Error Run, IST Number Correct Trials), because they are better suited for Pearson product moment correlations³.

Correlations between EF Measures. There were no significant correlations between the 4 EF measures (A-not-B, Forbidden Toy, 3-boxes, IST) at 14 months, $r_s < .20, p_s > .23$, (see Table 3) or 18 months, $r_s < .21, p_s > .17$, (see Table 4). Because of this

lack of cohesion in EF, it was inappropriate to construct an EF composite score so each measure of EF is considered separately.

Longitudinal stability. Table 4 displays the correlations between EF performance at 14 months and 18 months of age. There was no stability in EF performance across the 4 month period $r_s < .26$, $p_s > .12$. I also examined whether performance on earlier EF tasks was related to later performance on a different EF task. Again, EF at 14 months was typically not predictive of EF at 18 months. Performance on the forbidden toy task at 14 months was marginally correlated with performance on the 3-boxes task at 18 months $r(44) = .27$, $p = .07$. In addition, performance on the IST at 14 months was marginally correlated with performance on the Forbidden Toy task at 18 months, $r(38) = .30$, $p = .06$. No other correlation between EF at 14 months and EF at 18 months was significant.

Parent reports of self-control temperament demonstrated longitudinal consistency from 14 to 18 months of age. Reports of attentional focus, inhibitory control, and impulsivity at 14 months were significantly related to ratings at 18 months, $r_s(38) = .57$, $.64$, and $.55$ respectively, all $p_s < .001$. Parent reports of attention switching was the only aspect of self-control temperament that did not exhibit longitudinal stability, $r(38) = .21$, $p = .20$.

Joint Attention Abilities in the Second Year of Life

Descriptive statistics for performance on joint attention measures at 14 and 18 months are displayed in Table 1. The correlations between joint attention measures are displayed in Table 2 (14 months) and Table 3 (18 months). Joint attention performance

and developmental change from 14- to 18-months of age on each joint attention task were examined. Children were only included in longitudinal analyses if they had data at both time points. Several joint attention measures were related to sex, and sex differences are discussed for individual measures.

IJA measures. IJA-total behaviors (i.e., child-initiated sharing attention behaviors like alternating gaze and pointing) marginally decreased from 14 to 18 months of age, $t(46) = -1.76, p = .09$, and IJA-higher behaviors (i.e., only the most active IJA behaviors, specifically protodeclarative pointing and showing behaviors) did not significantly change, $t(46) = .21, p = .83$. In addition to the amount of IJA-higher behaviors produced, the IJA-higher ratio (IJA-higher behaviors/total number of IJA behaviors) was examined because it was recommended by Mundy and Gomes (1998) to measure children's tendency to use higher-level IJA behaviors. The IJA-ratio did not change from 14 to 18 months, $t(46) = .58, p = .57$. There were no significant sex differences for any IJA measures at 14 months, $ts(45) < 1.07, ps > .29$. There was a marginally significant sex difference for IJA-higher behaviors, such that 18-month-old girls ($M = 1.50, SD = .37$) demonstrated more IJA-higher behaviors than 18-month-old boys ($M = .72, SD = .16$), $t(28.76, \text{due to unequal variances}) = 1.96, p = .06$. There were no other sex differences for IJA measures at 18 months, $ts(45) < 1.34, ps > .18$.

RJA and IBR measures. RJA behaviors (i.e., behaviors related to sharing attention initiated by and adult, such as following adults' gaze) significantly increased from 14 to 18 months of age, $t(46) = 5.64, p = .00$. Total measures of IBR behaviors (i.e., behaviors related to requesting an object initiated by the child) did not significantly

change from 14 to 18 months of age, $t(46) = -1.05, p = .30$. There were no significant sex differences in measures of RJA or IBR at 14 months, $ts(45) < 1.45, p > .15$, or 18 months, $ts(45) < 1.50, p > .15$.

Correlations between joint attention measures. Relationships between joint attention measures demonstrated that dimensions of joint attention were relatively distinct and unrelated, similar to previous studies of joint attention using the ESCS (e.g., Mundy et al., 2007). At both 14 months (Table 3) and 18 months (Table 4), the majority of IJA measures (i.e., IJA-total, IJA-higher, and IJA-ratio) were unrelated to RJA and IBR, $rs(45) < .07, ps > .11$. The only measure of IJA that was related to another measure of joint attention was IJA-higher, which was significantly negatively correlated with IBR at 14 months, $r(45) = -.37, p = .01$, and marginally negatively correlated with IBR at 18 months, $r(45) = -.25, p = .10$. RJA was not correlated with IBR at 14 months, $r(45) = -.03, p = .85$, or 18 months, $r(45) = -.17, p = .25$.

Longitudinal stability. There was modest stability in joint attention measures from 14 to 18 months (see Table 7), which is also consistent with previous studies (e.g., Mundy et al., 2007). IJA-total at 14 months was significantly correlated with later IJA-total scores 18 months, $r(45) = .46, p = .001$. However, neither IJA-higher measure (i.e., IJA-higher, IJA-ratio) demonstrated stability across the 4 month period, $r(45) = -.02, .03, p = .88, .84$, respectively. RJA at 14 months was significantly related to RJA at 18 months, $r(45) = .29, p = .04$, however measures of IBR did not display the same longitudinal stability, $r(45) = .12, p = .41$. I also examined whether performance of joint attention at 14 months was related to later performance on a different measures of joint

attention task (e.g., whether IJA at 14 months was related to RJA at 18 months), and no correlation was significant, $r_s(45) < .14, p_s > .16$, further demonstrating that dimensions of joint attention were distinct.

Relation to parent report of language. There were few significant correlations between joint attention and language. At 14 months (see Table 3), only language production and IBR behavior were correlated, $r(41) = .39, p = .01$. No other correlation between language (comprehension and production) and joint attention at the 14 month time point was significant, $r_s(41) < .16, p_s > .32$. At 18 months (see Table 4), language comprehension was related to IJA-higher and IJA-ratio, both $r_s(42) = .32, p_s = .04$. In addition, language production was marginally correlated with RJA, $r(42) = .27, p = .08$. No other correlation between language and joint attention at the 18 month time point was significant, $r_s(42) < .23, p_s > .11$. Further, language comprehension and production at 14 months was not related to joint attention at 18 months, $r_s < .25, p_s > .11$. Finally, no joint attention measures at 14 months was significantly related to language measures at 18 months, $r_s < .23, p_s > .15$, although IBR behavior at 14 months was marginally related to language production at 18 months, $r(42) = .27, p = .07$.

Correlations Between EF and Joint Attention

One major focus of this study was to examine the relationship between EF and joint attention. More specifically, it was hypothesized that higher behaviors of IJA (i.e., IJA-higher and IJA-ratio, which measures pointing and showing objects to others to share attention) would be related to stronger EF because they are indicative of the formation of strong representations that can guide the control of behavior. The EF-joint attention

relationship was examined both concurrently (i.e., at 14 months and 18 months separately) and longitudinally. Only simple bivariate correlations between joint attention and EF were conducted and I did not conduct partial correlations controlling for language and gender, because these variables were not related to EF and were not consistently related to joint attention.

Correlations between EF and joint attention at 14 months. The correlations between EF and joint attention at 14-months of age are displayed in Table 2. At 14 months, five of the 20 EF-joint attention correlations were significant or marginally significant, but no systematic relationship between joint attention and EF emerged. Contrary to my hypothesis, results did not reveal a relationship between higher behaviors of IJA (i.e., IJA-higher and IJA-ratio) and better EF at this age, $r_s < .18$, $p_s > .23$. IJA-total was actually negatively related to performance on two EF tasks, the Forbidden Toy task, $r(44) = -.27$, $p = .08$, and the 3-boxes task, $r(43) = -.25$, $p = .10$. Finally, although I hypothesized that it was unlikely that non-initiating joint attention behaviors would be related to EF (e.g., see Nichols et al., 2005), RJA was significantly related to performance on the IST, $r(38) = .32$, $p = .05$, and IBR was significantly related to performance on the 3-boxes task, $r(43) = .31$, $p = .04$. Further, RJA was marginally correlated with performance on the A-not-B task, $r(32) = .33$, $p = .06$. No other measure of joint attention (i.e., IJA-total, RJA, and IBR) was related to EF, $r_s < .22$, $p_s > .14$. Thus, although there was no evidence of a concurrent relationship between EF and higher behaviors of IJA at 14 months, there was evidence that lower behaviors of joint attention (i.e., RJA, IBR) were related to performance on a few EF tasks.

The correlations between parent report of self-control temperament and joint attention were also examined. Again, there was little evidence for a relationship between EF and higher behaviors of IJA for parent report of children's self-control measures. At 14 months, only one of the 16 correlations was marginally significant. IJA-ratio was marginally correlated with parent reports of attention shifting, $r(41) = .26, p = .09$. No other measure of joint attention was related to parent report measures of self-control temperament, $r_s < .22, p_s > .16$

Correlations between EF and joint attention at 18 months. The correlations between EF and joint attention at 18-months of age are displayed in Table 3. At 18 months, three of the 20 EF-joint attention correlations were significant or marginally significant, and again no systematic relationship between joint attention and EF emerged. My hypothesis that measures of higher IJA behaviors (i.e., IJA-higher or IJA-ratio) would be related to better EF was again not supported, $r_s < .13, p_s > .18$. Only one relationship between IJA-total and EF emerged, IJA-total was marginally negatively correlated with performance on the 3-boxes task, $r(45) = -.26, p = .08$. Finally, despite my hypothesis that non-initiating joint attention behaviors would not be related to EF, RJA was significantly related to performance on the A-not-B task $r(43) = .34, p = .02$ and the 3-boxes task, $r(45) = .36, p = .01$. IBR total was not significantly related to performance on any EF task $r_s < .02, p > .12$. No other measure of joint attention was related to EF, $r_s < .20, p_s > .12$. In sum, at 18 months there was no evidence of a concurrent relationship between EF and higher behaviors of IJA at 18 months. However, RJA, was significantly related to performance on two EF tasks.

The correlations between parent report of self-control temperament and joint attention were also examined. At 18 months, only one of the 16 correlations was significant. IJA-total was negatively correlated with parent reports of inhibitory control, $r(41) = -.33, p = .03$. No other measure of joint attention was related to parent report measures of self-control temperament, $r_s < .24, p_s > .12$.

Correlations between joint attention at 14 months and EF at 18 months.

Correlations between joint attention measures at 14 months and EF measures at 18 months are displayed in Table 4. Six of the 20 correlations between joint attention at 14 months and EF at 18 months were significant or marginally significant. Data supported the hypothesis that IJA-higher behavior at 14 months would be related to better EF at 18 months, as significant correlations primarily existed between measures of higher IJA at 14 months and EF at 18 months. IJA-higher behavior at 14 months was significantly correlated with performance on the IST at 18 months and marginally correlated with the 3-boxes task at 18 months, $r_s(42) = .31, .25, p_s = .04, .09$, respectively. In addition, the IJA-ratio at 14 months was significantly correlated with performance on the IST at 18 months, $r(42) = .39, p = .01$, and marginally correlated with performance on the A-not-B task and the 3-boxes task at 18 months, $r_s(43, 45) = .25, .25, p_s = .10, .09$, respectively. Only one other correlation between joint attention at 14 months and EF at 18 months was marginally significant, as IBR at 14 months was negatively correlated with IST at 18 months, $r(42) = -.28, p = .07$. No correlation other between IJA-total, RJA, and IBR at 14 months and EF at 18 months was significant, $r_s < .23, p_s > .13$.

In sum, results from the EF-joint attention longitudinal analysis suggest that although EF and higher behaviors of IJA were not related concurrently at 14 or 18 months of age, children who engage in higher IJA behaviors at 14 months had better EF at 18 months.

Correlations between EF at 14 months and joint attention at 18 months.

Correlations between EF measures at 14 months and joint attention measures at 18 months are displayed in Table 4. There was not much evidence that EF at 14 months was related to joint attention at 18 months, only one of the 20 correlations between EF at 14 months and joint attention at 18 was significant or marginally significant. IST performance at 14 months was significantly negatively related to IBR at 18 months, $r(38) = -.34, p = .03$. No other correlations between EF at 14 months and joint attention measures at 18 months were significant $r_s < .27, p > .13$. Notably, no EF measures at 14 months were related to IJA behaviors at 18 months and results suggest a unidirectional relationship in which IJA higher behaviors predict later EF, but EF does not predict IJA higher behaviors.

Follow up Analyses Supporting the Joint Attention→EF relationship

One of the main findings to emerge from examining the concurrent and longitudinal relationship between EF and joint attention was that higher IJA behavior at 14 months was related to better EF performance measured quantitatively (e.g., error run) at 18 months. EF performance in infancy and preschool-aged children often naturally follows a dichotomous distribution, and thus is frequently examined in terms of pass/fail performance (e.g., Carlson, 2005). Thus, I also examined higher IJA behaviors with

regard to pass/fail EF performance. For brevity, only the relationship between IJA-ratio and pass/fail EF performance is reported because IJA-ratio was recommended by Mundy and Gomes (1998) to measure the tendency to use higher-level IJA behaviors and results were nearly identical when the IJA-higher variable was analyzed.

Figure 1 displays the IJA-ratio at 14 month by pass/fail EF behavior at 18 months. Mann-Whitney *U*-tests revealed higher IJA-ratios at 14 months in children who passed the 3 boxes task, $U(n = 47) = 152.5, p = .02$, and IST at 18 months, $U(n = 47) = 192, p = .10$. Children who passed the A-not-B and Forbidden Toy task at 18 months did not demonstrate significantly higher IJA-ratio at 14 months, $Us(n = 47) > 179, ps > .43$. Thus, results based on passing behavior on EF tasks revealed a pattern similar to analyses conducted on quantitative measures of EF performance: higher IJA behavior at 14 was related to better performance in the 3-boxes tasks and IST at 18 months. The one discrepancy between analyses (i.e., dichotomous compared to quantitative measures of EF) is that those who passed the A-not-B task at 18 months did not demonstrate a higher IJA-ratio at 14 months. It is important to note only a small number of children passed the A-not-B task ($n=13$), likely resulting in insufficient power to detect group differences.

Joint Attention and Overall EF Performance

Although the lack of internal consistency across EF tasks prohibits examining EF performance as a unitary construct in this study, several researchers have demonstrated that coherence between EF measures increases with age (e.g., Carlson et al., 2004; Kochanska, Murray, & Harlan, 2000). Thus, it is possible that during the second year of life a subset of children may demonstrate coherence or consistent EF performance if they

exhibit passing behavior on several EF tasks (i.e., consistently high performance across all tasks). To address this possibility, I examined the number of EF tasks that children passed at 14 and 18 months of age (see Table 1). In order to obtain a measure of pass/fail performance for 18 month olds across all tasks, children who did not pass the training phase of a particular task were considered to fail the task. There did not appear to be any children who demonstrated a consistent passing pattern at 14 months of age, as performance was consistently low and only 1 child passed 3 out of 4 EF tasks. However, by 18 months of age, 23% of the sample passed either 3 or 4 of the 4 EF tasks, and the increase in passing EF performance from 14 to 18 months of age was significant, McNemar $\chi^2(1, n=46) = 6.75, p = .01$.

Next, I conducted a hierarchical linear regression investigating which factors at 14 months predicted the number of EF tasks passed at 18 months (see Table 5). Missing data for this analysis were handled in a listwise deletion fashion, and only children with data for all variables ($n=41$) were included. Effects were tested using the enter method where basic predictors were included in the first two blocks, and joint attention predictors were added in the last block. Significance for variables in earlier blocks was unchanged with the addition of subsequent blocks. In the first block I included basic predictors (i.e., sex and language at 14 months), which revealed that only words understood at 14 months significantly predicted EF at 18 months, $\beta = .37, p = .02$. The next block produced a $\Delta R^2 = .11, p = .03$ and demonstrated that number of EF tasks passed at 14 months significantly predicted the number of EF tasks passed at 18 months (related to longitudinal stability), $\beta = .35, p = .03$. Finally, in the last block all relevant joint

attention measures were entered (IJA-ratio, IJA total, RJA total, IBR total). The only joint attention measure to emerge as a significant predictor of total number of EF tasks passed at 18 months was IJA-ratio, $\beta = .57, p < .001$. The final model was significant, $F(8, 40) = 4.87, p = .001, R^2 = .55$, and demonstrated that IJA-ratio at 14 months explained unique variance in the number of EF tasks passed at 18 months with a significant $\Delta R^2 = .30, p = .002$.

A Kruskal Wallis test was also conducted to determine if IJA-ratio at 14 months differed by the number of EF tasks passed at 18 months. This analysis revealed a group difference, in which IJA-ratio behavior at 14 months differed by the number of tasks passed at 18 months, (see Figure 2). As only 1 child passed 4 tasks, children who passed 3 and 4 tasks ($n=11$) were grouped together to conduct follow up Mann-Whitney U tests. These analyses revealed that children who passed 3 or 4 tasks at 18 months exhibited a significantly higher IJA-ratio at 14 months compared to children who did not pass any tasks, $U(n = 16) = 10.00, p = .05$, and a marginally higher IJA-ratio compared to children who only passed 1 task, $U(n = 21) = 33, p = .10$. Further, children who passed 2 tasks had a significantly higher IJA-ratio compared to children who passed 0 tasks, $U(n = 26) = 25, p = .05$. No other group comparisons were significant. These analyses revealed that children who have a higher tendency to engage in IJA-higher behaviors at 14-months of age eventually exhibit superior EF at 18-months of age (i.e., pass more EF tasks). These analyses also support the hypothesis that early abilities in higher IJA may result in more cohesive EF, as children who demonstrate the most IJA higher behaviors at 14 months are typically passing the majority of EF tasks and demonstrating cohesion at 18 months.

CHAPTER IV

DISCUSSION

This longitudinal study contributes to research on the emergence of basic EF abilities and the relationship between EF and joint attention in the second year of life. Results revealed a unidirectional joint attention → EF relationship, where higher levels of IJA behavior at 14 months (e.g., pointing, showing) were related to better EF at 18 months. Further, children who demonstrated higher IJA behaviors at 14 months exhibited more consistent EF (i.e., passed more EF tasks) at 18 months of age. There was no support for an EF → joint attention relationship, as EF behaviors at 14 months did not predict joint attention at 18 months. EF performance was generally low at 14 months of age and improved across the 4-month time span. In contrast to studies with older children (e.g., Carlson et al., 2004; Hughes & Ensor, 2005, 2007), there was not much evidence for longitudinal stability or the relationship between EF and language. Additionally, there were few relationships between parent report of self-control temperament and children's performance on EF tasks. Further, I found little evidence for internal consistency across EF measures. Children passed more tasks at 18 months of age and a subset of children demonstrated consistency across EF tasks by 18 months, in the sense that they exhibited consistent passing behavior on the majority of EF tasks. These findings suggest that EF during the second year of life shows patterns of development that are distinct from the

later toddler and preschool years, possibly indicative of an emerging common EF ability supported by representational development.

EF Abilities in the Second Year of Life

One goal of the present research was to provide a description of EF abilities in the second year of life (i.e., from 14 to 18 months of age) across multiple EF tasks. The improvement observed across the 4-month span is consistent with previous research (i.e., Diamond et al., 1997; Wiebe et al., 2010). Children also performed poorly at the first time point, which supports Wiebe et al.'s proposal that a common EF ability is initially absent and emerges as children's performance progresses across the second year.

Specifically, Wiebe et al. proposed the emergence of a common EF ability similar to that described by Miyake and Friedman (2012), related to maintaining and using goal-relevant information to guide behavior strategically. The surfacing of a common EF ability during this period seems to fit the general pattern of data in the present study, as performance across EF tasks (i.e., the A-not-B, 3-boxes-task, forbidden toy, and IST) should improve if children are beginning to hold and use goal-relevant information to guide behavior. For example, children who can hold relevant information in mind (e.g., represent the new hiding location in the A-not-B task) or update performance across trials (e.g., track previous search in the 3-boxes task) should demonstrate correct search behavior.

However, it is important to note that this growth was not apparent for performance on the Forbidden Toy task. Although this outcome appears to contradict the proposal that a common EF ability is developing during this period, it is consistent with findings in the EF literature (e.g., Carlson & Meltzoff, 2008; Carlson & Moses, 2001; Hongwanishkul,

Happaney, Lee, & Zelazo, 2005) suggesting that delay tasks (e.g., requiring responses of waiting for gratification) separate from other EF tasks (e.g., conflict tasks requiring a new response that conflicts with a prepotent response, Carlson & Moses, 2001). It is possible that tasks requiring control of affectively driven responses (e.g., waiting for a desirable toy) are more difficult to control via this developing common EF ability, especially within the first few years of life.

The possible emergence of a common EF ability guiding EF performance is also consistent with the results regarding the cohesion of EF abilities during the second year of life. The present study showed a general lack of cohesion in EF abilities at 14 and 18 months of age. These results are consistent with the developmental trend suggesting that internal consistency across EF tasks becomes stronger with age (see Carlson et al., 2004; Hughes & Ensor, 2004, 2007) and may be best explained by a unitary latent factor representing common EF ability in preschool. This early period during the second year of life may mark the surfacing of a common EF ability (i.e., a subset of children beginning to maintain and use task-relevant information to control behavior). This possibility is also reflected by the results demonstrating that more children are able to pass a large majority of EF tasks (i.e., 3 or more EF tasks out of 4) successfully by 18 months of age, possibly because they are using a common EF ability across tasks to guide behavior.

Children's performance on EF tasks during the second year of life also displays other patterns of development that distinguish EF during this period from older toddlers and preschoolers. First, the lack of longitudinal stability in performance across tasks from 14 to 18 months of age contrasts with stable individual differences in composite EF

scores across various time points during the toddler and preschool years (e.g., Carlson et al., 2004; Hughes & Ensor, 2007). In addition, the established relationship between language and EF in toddlers and preschoolers (e.g., Carlson et al., 2004; Carlson & Moses, 2001; Carlson, Davis, & Leach, 2005; Hughes & Ensor, 2007) was not present in the current study (although some parent reports of children's self-control temperaments were correlated with language). Finally, parent reports of children's self-control temperament (i.e., inhibitory control, attention focus, attention shifting, and impulsivity) showed little relation to children's behavioral measures of EF, which contrasts with studies that have shown a relationship between parent reports of self-control and EF tasks in preschoolers (e.g., Carlson et al., 2004; Carlson & Moses, 2001).

There may be several reasons for these different patterns of results. First, Wiebe et al. (2010) also demonstrated a general lack of longitudinal stability in the second year and suggested that frequent assessments may address difficulty in detecting stability during this rapidly developing age range. The second year is generally thought of as a period of remarkable growth in other cognitive abilities such as language and symbol use (e.g., Tomasello, 2003). Results from the present study and Wiebe et al. suggest that EF also demonstrates significant growth within a short period of time during the second year. If this rapid development reflects the emergence of a common EF ability emerging during this period, we should not expect children's behavior at the first time point to be related to behavior at the second time point. For instance, if 14-month old children's behavior is influenced by environmental cues (e.g., seeing the object hidden at B automatically inhibits responding at A; see Jacques & Marcovitch, 2010; Perner et al., 1999) rather than

a common EF ability, then this responding should not necessarily be correlated with more sophisticated EF performance or other cognitive abilities (i.e., language or parent reports of self-control temperament) once a common EF ability emerges.

Although there is no way to be sure whether EF performance on an individual task is driven by a common EF ability or other factors like environmental cues, examining EF across a multitude of tasks may address this issue. The present study revealed a subset of children who performed well on many EF tasks at 18 months, and it is likely that these children relied on an emerging common EF ability (e.g., Miyake & Friedman, 2012; Wiebe et al., 2010), whereas children passing few EF tasks may rely on habit, environmental cues, or other response patterns (e.g., random responding, guessing). Examining EF via a battery of tasks may allow an estimate of common EF separate from specific task demands (see Wiebe et al., 2008, 2011, for an account on how this can be executed using confirmatory factor analysis). Although the lack of cohesion in performance across EF tasks prohibited me from creating a composite EF score, once I examined overall EF performance via the number of EF tasks that children passed there was partial evidence for a cohesive EF in some children, longitudinal stability, and relation to language. Specifically, the number of EF tasks passed at 14 months predicted the number of EF passed at 18 months (longitudinal stability) and word comprehension at 14 months predicted EF at 18 months. This is consistent with studies with older children demonstrating longitudinal stability in EF and a relationship to language when EF is measured across several tasks (e.g., Carlson et al., 2004; Hughes & Ensor, 2007).

There was also evidence for a few significant relationships between parent report measures of self-control temperament and individual EF task performance. Parent reports of attention shifting were negatively related to performance on the forbidden toy and parent reports of attention focus were negatively related to A-not-B performance. Although these findings may initially seem unexpected, they are consistent with current perspectives on the role of attention in cognitive control. Jones, Rothbart, and Posner (2003) suggested that attentional focus and attentional shifting may initially contribute to EF separately, and may even be opposing processes at 36 months of age (e.g., children who can easily focus attention may have difficulty shifting), and these processes become more integrated within an endogenously controlled attention system later in preschool. Thus, 18-month-olds who have difficulty shifting attention in the Forbidden Toy task may succeed by focusing on the less desirable toy to distract themselves. Similarly, a lack of attentional focus on location A may benefit 18-month-olds in the A-not-B task once they have to switch their search behavior to search at the novel location B. Finally, performance on the 3-boxes task was positively related to attentional focus for 18-month-olds, which suggests that children who are better able to focus attention (perhaps related to focused strategic search), performed better on the 3-boxes task. There are two things worth noting when considering this relationship between parent report measures of self-control (specifically related to attention) and EF. First, in the present sample, parent report of attention focus was not negatively related to attention shifting as it was in Jones et al.'s study for 3-year-olds (in fact there was a non-significant trend for the two to be positively related at 18 months). Second, the relationships between attention focus,

shifting, and EF did not emerge until 18-months of age. The fact that attentional focus and shifting were differentially related to different EF tasks supports Jones et al.'s hypothesis, but further research must be conducted to examine the role of attention focus and shifting so early in development.

Another possible contributor to the different pattern of results in the second year could occur at the level of measurement. For example, the task impurity problem (e.g., Miyake et al., 2000; Wiebe et al., 2011) is a common measurement concern that applies to EF data and refers to the issue of obtaining a clear measure of EF when EF tasks involve many other abilities (e.g., language, spatial ability, color knowledge, motor ability). As stated earlier, examining behavioral control across a multitude of EF tasks may address this issue. However, this method typically results in reducing the data across EF tasks to fewer dimensions (Carlson et al., 2004; Carlson & Moses, 2001; Hughes & Ensor, 2005, 2007; Wiebe et al., 2010, 2011). In the present study, performance across EF tasks were not strongly related and could not be reduced down to a unitary EF factor. Thus, the lack of consistency across measures leads to another measurement concern, namely whether EF responses can be validly and reliably assessed in children this young. Unfortunately, multiple trials and repeated testing to examine reliability within a session is often not feasible for very young children because of a variety of reasons (e.g., short attention spans, preference for novelty, difficulty in motivation). It is possible that in the present study, we got different patterns of EF development in the second year because of reliability and validity issues. The fact that results replicated previous findings in the literature (Diamond et al., 1997; Wiebe et al., 2010) may ease these concerns, but it will

be important to extend research examining the psychometric properties of EF measurement in preschool (e.g., Beck, Schaefer, Pang, & Carlson, 2011) to younger populations as more work focuses on the origins of EF. Further, if a common EF ability is emerging during the second year of life, it may be that EF cannot be validly and reliably assessed early in life for some children, as many 1-year-olds may rely on unstable methods for responding to the environment (e.g., orienting to changing environmental factors, random responding), rather than more stable internally mediated strategies across many different contexts (i.e., forming, maintaining, and using task relevant information).

In sum, results from the current study mark EF during the second year of life as a distinct period of EF development, showing different patterns of EF performance relative to older toddlers and preschoolers. The study of early EF generally refers to behavioral control in infants (e.g., Diamond, 2006; Diamond & Doar, 1989; Diamond et al., 1997; Espy et al., 1999; Pelphrey & Reznick, 2002) or the increasingly sophisticated EF of preschoolers (Garon et al., 2008; Jacques & Marcovitch, 2010; Zelazo et al., 1997; Zelazo et al., 2003). These findings contribute knowledge to several existing studies bridging the gap linking the foundational studies of EF in infancy to the more complex EF of preschoolers (e.g., Diamond et al., 1997; Wiebe et al., 2010).

The Relationship between EF and Joint Attention in the Second Year of Life

Examining the relationship between EF and joint attention was a central goal of the present study because higher levels of joint attention (e.g., pointing) were hypothesized to be indicative of an emerging representational ability, critical to EF. Findings provided evidence for a unidirectional relationship, in which joint attention at

14 months predicted later EF at 18 months. More specifically, children who tended to initiate higher levels of joint attention behavior at 14 months (i.e., pointing and showing behaviors) demonstrated better EF at 18 months of age. Further, the tendency to initiate higher levels of joint attention at 14 months significantly predicted and explained a large portion of the variance in the number of EF tasks children would pass at 18 months of age, even after accounting for language and EF performance at 14 months of age. This finding supports reflection-based accounts of EF development (e.g., Marcovitch & Zelazo, 2009; Zelazo, 2004), which suggest that development within the representational system (i.e., children's ability to represent and reflect upon task relevant information) is related to EF. It also aligns with Zelazo's (2004) hypothesis that the first higher LoC emerges at the end of the first year of life when children create labels to reflect upon relevant stimuli to guide behavior. This is likely reflected in children's higher IJA behavior at 14 months, as Zelazo explicitly mentions protodeclarative pointing as one of the first instances that children demonstrate a higher LoC. Specifically, pointing is related to labeling, which links stimuli to semantic memory permitting a higher level of awareness of objects within their current experience, allowing children to respond based on conscious representations of relevant stimuli rather than habitual responses (Marcovitch & Zelazo, 2009).

A representational account of the emergence of EF also aligns nicely with Wiebe et al.'s (2010) assertion that a common EF ability may emerge during the second year of life that is responsible for the steady improvement across EF tasks. Critical developments in representation (e.g., labeling) should correspond to a common EF ability responsible

for maintaining task relevant information to guide behavior (see also Miyake & Friedman, 2012; Wiebe et al., 2011). Indeed, to form, maintain, and use relevant information to guide behavior one must first be able to represent and reflect on relevant stimuli. Therefore, it follows that the first major development within the representational system should predict better EF and the emergence of a more cohesive EF ability. Children who are able to form and reflect on representations in their environment should be able to use this ability to reflect on stimuli within an EF task at a higher level of awareness that can be used to guide behavior across multiple contexts (see also Jacques & Marcovitch, 2010).

These findings also provide some of the first evidence that non-verbal means of representation contribute to cognitive control before the third year of life. This extends work on the established relationship between representation (more specifically language) and EF in preschool (e.g., Jacques & Zelazo, 2005; Kirkham et al., 2003; Lowenstein & Gentner, 2005; Miller & Marcovitch, 2011; Müller et al., 2004; Rattermann & Genter, 1998; Towse et al., 2000) to an even younger age range. Although results from the present study provide correlational and predictive evidence of this early relationship (see also Carlson & Moses, 2001; Hughes, 1998; Hughes & Ensor, 2007), it is a promising first step linking early representation to EF. Higher levels of IJA are connected to language development (Mundy et al., 2007; Mundy & Gomes, 1998), and several theorists proposed that joint attention is an important precursor to language (e.g., Colonnese et al., 2010; Markus et al., 2000; Tomasello & Farrar, 1986; Tomasello et al., 1986; Tomasello & Todd, 1983). In addition, Zelazo (2004) likens the specific instance

of higher IJA (i.e., protodeclarative pointing) to representation (i.e., linguistic labeling). Additional studies encouraging children to use higher levels of IJA (e.g., pointing) within an EF context may further elucidate the relationship between early non-verbal representation and EF.

In addition, these results speak to the significance of the communicative or social context in which representations are generated for young children. For instance, although pointing and gesturing to initiate shared attention was a significant predictor of later EF, child generated pointing and gesturing to request an object (i.e., initiating a behavioral request without the desire to share attention, e.g., Mundy et al., 2003) was not. Further, less active behaviors related to sharing attention (i.e., responding to adults' requests to share attention, e.g., Mundy et al., 2003), also did not predict later EF. Thus, there appears to be something specific about gestures actively generated with the intent to share that may be related to a stronger representational system that can guide behavior. This is related to Vygotsky's (1978) classic work suggesting that representational and symbolic thought emerges within a social context. This is especially important for younger children, who may need to generate language within a social context (i.e., for another person) for it to have meaning (see also Miller & Marcovitch, 2011).

Nonlinguistic representation may operate in a similar manner, where representational meaning of a gesture is dependent on the social context in which it is produced.

Tomasello et al. (2007) drew attention to this in their rich interpretation of pointing, by suggesting that it is important to consider many possible social motivations behind pointing (e.g., informative, expressive, requestive). Further, it has been suggested that

more active joint attention behaviors (e.g., such as pointing to manipulate others' attention) imply sophisticated social representation (Tomasello et al., 2005), related to understanding the roles of all individuals involved in a collaborative engagement.

The last point, that early joint attention may be tied to social representation, addresses a question that has been an important focus of the preschool literature.

Specifically, the EF-joint attention relationship may relate to the established finding that EF in the early preschool years contributes to later ToM (Carlson et al., 2004; Carlson & Moses, 2001; Hughes & Ensor, 2005, 2007). Theoretical accounts (e.g., Camaioni et al., 2004; Tomasello et al., 2005, 2007) and empirical findings (Charman et al., 2000) suggest that early joint attention is related to ToM. However, this relationship has not been extended to children younger than 2 years of age, so it is unclear if this unidirectional EF → ToM relationship holds. Results from the current study suggest that if early joint attention is closely related to ToM ability, not only does the relationship not hold, but it may be altogether reversed. Specifically, early joint attention (linked to early ToM) contributes to the later development of EF but EF does not contribute to joint attention. Although this is inconsistent with the data from the toddler and preschool age range, Miller and Marcovitch (2010) suggested that ToM and EF may be related only to the extent that they rely on the same underlying representational ability. Further, this ToM-EF relationship may change with age, and social understanding may be necessary for developing communicative representations such as language (and indirectly predict EF) in the first few years of life, whereas developing a domain-general EF may be significant to more complex ToM in older toddlers and preschoolers (Carlson et al., 2004;

Carlson & Moses, 2001; Hughes & Ensor, 2005, 2007). Although more work needs to be done examining the joint developmental trajectories of early EF and ToM, these results suggest that a simple unidirectional relationship from infancy to school-age may not be enough to capture the complex relationship between EF, social understanding, and representation.

There are possible objections to studying EF and joint attention as an extension of the EF-ToM relationship. For example, performance on ToM tasks is thought to reflect a domain specific social cognitive ability (e.g., Leslie, 1987, 1994), whereas in the present study joint attention reflects cognitive abilities (e.g., representational abilities, Zelazo, 2004) in addition to social cognition. Thus, one could argue that joint attention does not capture social cognition in the same domain specific manner, making the EF-joint attention relationship incompatible with later EF and ToM. However, research suggests that ToM performance does not reflect a completely modular social cognitive ability, and the EF-ToM relationship need not be conceptualized as a relationship between two completely separate domains. For example, Moses (2001) has proposed that to succeed on ToM tasks one needs to inhibit salient information, such as their own mental states (see also Russell, 1996). Perhaps most important to the present argument, Frye et al. (1995) proposed that ToM performance not only reflects social cognitive abilities, but the ability to represent and reflect on a higher order rule structure within the ToM scenario (similar to joint attention's earlier link to representation). In this sense, the EF-joint attention relationship is easily compared to EF and ToM and provides a means for examining cognitive control, social cognition, and representation in a younger

population. Perhaps the more difficult issue with studying the relationship between joint attention (and even ToM) and EF is isolating the specific elements that are common and contribute to development of the other in this multifaceted relationship. At present, a representational approach appears to explain both the joint attention → EF relationship early in life and the switch to EF → ToM in the toddler years and preschool.

Although results support an account in which early joint attention predicted a more cohesive EF later in the second year, one of the more curious findings of the current study was the lack of concurrent relationships between EF and higher IJA at both 14 or 18 months of age. In fact, lower levels of responding to joint attention (RJA) behaviors were related to 2 EF tasks at both 14 and 18 months. This finding was contrary to my hypothesis that higher IJA behaviors should be related to EF, however this concurrent relationship is reasonable in light of the present results suggesting the emergence of a more cohesive EF during the second year. More specifically, although common EF emerges during this period, a large portion of children have not developed a common EF ability as demonstrated by their inability to guide behavior across multiple contexts during the second year. In the absence of a controlled, internally mediated means of responding to the environment, children may rely on basic selective attention abilities (i.e., related to how children orient to stimuli in the environment, Ruff & Rothbart, 1996). These basic selective attention abilities are likely reflected by RJA, which is the only measure in the joint attention battery that measures the orienting of children's attention to social stimuli (Mundy & Newell, 2006). Therefore, children who demonstrate more instances of RJA may simply perform better in some EF tasks because they are more

attentive and responsive during the testing session. This hypothesis is also consistent with Garon et al.'s (2008) model of EF, suggesting that selective attention guides control of behavior within the first years of life, until more sophisticated abilities in controlled attention, WM, inhibition, and shifting emerge. Finally, it is important to note that RJA does not predict how many EF tasks children pass, suggesting that selective attention only predicts concurrent performance on isolated EF tasks, not cohesive performance across EF tasks.

In sum, the present study extended research on EF, representation, and social understanding in the second year of life. There was support for a unidirectional relationship in which higher IJA behaviors at 14 months predicted a stronger, more cohesive EF at 18 months of age, but little support for an EF → joint attention relationship. These results were interpreted in relation to children's developing representational system; more specifically children who actively generate gestures within a social context (e.g., protodeclarative pointing, showing) are hypothesized to be able to represent stimuli at a higher LoC, which translates to the formation of task relevant representations that can be used to guide behavior in EF (e.g., Zelazo, 2004). Although these results are consistent with reflection based representational frameworks, other representational frameworks are relevant to the EF-joint attention relationship as well. Munakata's (1998) active-latent account suggests that the ability to form more abstract, active representations should also be related to stronger EF. However, the active-latent approach emphasizes graded representations (Munakata, 2001), where generated labels are just one method for forming stronger active representations. Although an active-latent

approach may produce similar predictions compared to reflection based accounts (e.g., pointing within an EF tasks would lead to stronger active representations to guide behavior), the finding that higher IJA predicts a stronger, more cohesive EF (which could be interpreted as the emergence of a common EF ability) appears to be more in line with reflection based accounts that target the formation of this higher LoC as the key transition for representationally driven EF (e.g., Zelazo, 2004).

Another relevant representational theory is Perner and colleagues' (Perner & Lang, 1999; Perner et al., 1999) executive inhibition account. In this theory Perner et al. suggests that to exhibit higher levels of EF behavior children must first understand how mental states guide behavior so they can demonstrate control over their own actions. This is essentially the proposition of a unidirectional relationship in which early ToM predicts later EF, which was somewhat supported in the present study (i.e., IJA→EF). However, the motivation underlying the unidirectional relationship for the executive inhibition account differs compared to reflection based frameworks. Executive inhibition accounts propose a stagnant unidirectional relationship across the preschool years where social understanding is required for EF, which is not well supported in preschool (Carlson et al., 2004; Carlson & Moses, 2001; Hughes & Ensor, 2005, 2007). Reflection accounts suggest a dynamic ToM-EF relationship where these two abilities are related to the extent that social understanding and EF both rely on a common representational ability. This representational ability is socially constructed early in life and social factors come to play less of a role as basic representational abilities become internalized (e.g., inner speech,

Vygotsky, 1934/1986) and more complex (e.g., complex rule structure, Zelazo, 2004) with age.

Conclusions, Limitations, and Future Directions

Although preschool has been marked as a period of tremendous growth in EF abilities, less work has focused on the mechanisms and individual differences that predict the transition from behavioral control in infancy to the more advanced abilities demonstrated by preschoolers. The current study is one of the first to address this question by examining individual differences across a multitude of EF and joint attention tasks in the second year of life. The relationship between early IJA and later EF supports representational models of early EF development (Marcovitch & Zelazo, 2006, 2009; Zelazo, 2004) and the claim that the transition to a more sophisticated and cohesive EF ability (e.g., Miyake & Friedman, 2012; Wiebe et al., 2011) is dependent on the ability to represent, maintain, and reflect on relevant stimuli in the environment. However, the present work also supports the argument that the early representations that guide behavior are socially constructed (e.g., Miller & Marcovitch, 2010, 2011), thus a social-representational approach may be important during this formative period of EF development. With this approach, although the mechanism for the emergence of a common EF (e.g., Miyake & Friedman, 2012; Wiebe et al., 2011) is still representational (e.g., Marcovitch & Zelazo, 2006, 2009; Zelazo, 2004), the driving force behind the emergence of representational ability and EF is social (see also Tomasello, 1999; Vygotsky, 1978). According to this viewpoint, the typical route to higher representation is through the necessity to communicate with another individual (e.g., Tomasello, 2003),

for example pointing to an object for another allows children to communicate and become aware of the object at a higher LoC (Zelazo, 2004). Thus, experience with this type of communication early in life leads to better representational abilities and the transition to internally mediated, representationally-driven behavior from infancy to preschool. A social representational approach does not dramatically modify the overarching representational framework of EF development (see Boseovski & Marcovitch, 2012), rather it identifies a social component to development that may be critical to this specific age range examining the emergence of EF, when representational strategies are not yet fully internalized. Further, it may provide a more complete structure for examining the relationship between EF and social abilities (e.g., ToM, social cognition, peer relationships) and EF in children with Autism (e.g., disruptions in EF could be traced to social-communicative issues which lead to differences in the representational system).

As we move forward in this developing area of research several important questions need to be addressed to understand fully the emergence of this aspect of higher cognition. First, the study of EF in the second year of life suggests that examination across a battery of EF tasks is important, as success across multiple EF tasks may be more likely to suggest performance guided by a common EF ability. However, the construction of an age-appropriate EF battery is difficult for this age range, because there are few developed measures. In the present study, an attempt was made to select tasks that would be appropriate for both 14- and 18-month-olds with a basis in prior research (e.g., Alp, 1994; Diamond et al., 1997; Kochanska et al., 1998; Wiebe et al., 2010) that

stressed multiple components of EF (e.g., WM, inhibition, set-shifting). Yet even the tasks selected were not well-established EF measures because there are few studies in this emerging area of the EF literature. Larger studies including more measures of EF (e.g., Wiebe et al., 2011) and more subjects need to be conducted to address potential issues in infant measures (e.g., floor effects, power) and to corroborate the emergence of a common EF ability suggested by the present results and Wiebe et al. (2010).

Further, it is unclear how the EF tasks selected for 14- and 18-month-olds relate to EF later in life. This study assumes that EF can be assessed in children this young, and that EF performance in the second year of life is related to EF performance later in the toddler years and preschool. Unlike joint attention, which has been studied as a precursor to later ToM and language, the study of EF in the second year of life is largely unexplored. Further, studies examining the psychometric properties (e.g., Beck, Schaefer, Pang, & Carlson, 2011) and longitudinal trajectory of EF from infancy to preschool could help inform at what point we can reliably and validly detect the emergence of a stable common EF ability in young children. Results from the present study suggest that it is not until 18 months that children begin to succeed reliably across multiple EF contexts. In addition, the second year of life has been identified as a period of remarkable growth, and more frequent assessments may help elucidate current issues of longitudinal stability in both EF and joint attention measures (Wiebe et al., 2010).

Finally, experimental manipulations in which children engage in higher IJA within EF tasks may lend even stronger support for representational frameworks of early EF. For instance, representational frameworks would support the hypothesis that

protodeclarative pointing within EF tasks would improve performance in the second year of life. Further, experimental designs can identify which representational frameworks account for growth in EF abilities. Specifically, reflection based theories may propose that child-generated action within a social context provides the earliest instances of representation used to guide behavior (e.g., Zelazo, 2004; Miller & Marcovitch, 2010), whereas a graded representations account (e.g., Munakata, 2001) may suggest that although it is helpful, generation and a supportive social context is not necessary to control early behavior. Addressing these issues can bring us closer to understanding how this complex ability of cognitive control emerges over the first few years of life.

REFERENCES

- Alp, E. (1994). Measuring the size of working memory in very young children: The imitation sorting task. *International Journal of Behavioral Development, 17*, 125-141.
- Adolph, K. E., Joh, A. S., Franchak, J. M., Ishak, S., & Gill, S. V. (2009). Flexibility in the development of action. In J. Bargh, P. Gollwitzer, & E. Morsella (Eds.), *The Psychology of action*, Vol. 2, (pp. 399-426). New York: Oxford University Press.
- Baddeley, A. (1992). Working memory. *Science, 255*, 556-559.
- Bates, E. (1976). *Language and context: The acquisition of pragmatics*. New York: NY: Academic Press.
- Beck, D. M., Schaefer, C., Pang, K., & Carlson, S. M. (2011). Executive function in preschool children: Test-retest reliability. *Journal of Cognition and Development, 12*, 169-193. doi: 10.1080/15248372.2011.563485
- Bibok, M. B., Carpendale, J. I. M., & Müller, U. (2009). Parental scaffolding and the development of executive function. In C. Lewis & J. I. M. Carpendale (Eds.), *Social interaction and the development of executive function. New Directions in Child and Adolescent Development, 123*, 17-34.
- Bono, M. A., & Stifter, C. A. (2003). Maternal attention-directing strategies and infant focused attention during problem solving. *Infancy, 4*, 235-250.

- Boseovski, J. J., & Marcovitch, S. (2012). The hierarchical competing systems model provides a process account of social decision making [Letter to the editor]. *Human Development, 55*, 7-10.
- Butterworth, G., & Morissette, P. (1996). Onset of pointing and the acquisition of language in infancy. *Journal of Reproductive and Infant Psychology, 14*, 219-231.
- Camaioni, L., Perucchini, P., Bellagamba, F., & Colonnese, C. (2004). The role of declarative pointing in developing a theory of mind. *Infancy, 5*, 291-308.
- Carlson, S. M. (2005). Developmentally sensitive measures of executive functioning in preschool children. *Developmental Neuropsychology, 28*, 595-616.
- Carlson, S. M. (2009). Social origins of executive function development. In C. Lewis & J. I. M. Carpendale (Eds.), *Social interaction and the development of executive function. New Directions in Child and Adolescent Development, 123*, 87-97.
- Carlson, S., Mandell, D., & Williams, L. (2004). Executive function and theory of mind: Stability and prediction from ages 2 to 3. *Developmental Psychology, 40*, 1105-1122. doi: 10.1037/0012-1649.40.6.1105
- Carlson, S. M., & Meltzoff, A. N. (2008). Bilingual experience and executive functioning in young children. *Developmental Science, 11*, 282-298. doi: 10.1111/j.1467-7687.2008.00675.x
- Carlson, S., & Moses, L. (2001). Individual differences in inhibitory control and children's theory of mind. *Child Development, 72*, 1032-1053.
- Carlson, S., M., Moses, L. J., & Claxton, L. J. (2004). Individual differences in executive function and theory of mind: An investigation of inhibitory control and planning

ability. *Journal of Experimental Child Psychology*, 87, 299-319. doi:
10.1037/0012-1649.40.6.1105

Carruthers, P. (2009). How we know our own minds: The relationship between mindreading and metacognition, *Behavioral and Brain Sciences*, 32, 121-182. doi: 10.1017/S0140525X09000545

Carpenter, M., Nagell, K., & Tomasello, M. (1998). Social cognition, joint attention, and communicative competence from 9 to 15 months of age. *Monographs of the Society for Research in Child Development*, 63, 1-174.

Charman, T., Baron-Cohen, S., Sweetenham, J., Baird, G., Cox, A., & Drew, A. (2000). Testing joint attention, imitation, and play as infancy precursors to language and theory of mind. *Cognitive Development*, 15, 481-491.

Chen, Z., Sanchez, R. P., & Campbell, T. (1997). From beyond to within their grasp: The rudiments of analogical problem solving in 10- and 13-month-olds. *Developmental Psychology*, 33, 790-801.

Colonesi, C., Stams, G. J. J. M., Koster, I. & Noom, M. (2010). The relation between pointing and language development: A meta-analysis. *Developmental Review*, 30, 352-366. doi: 10.1016/j.dr.2010.10.001

Dawson, G., Munson, J., Estes, A., Osterling, J., McPartland, J., Toth, K., Carver, L., & Abbott, R. (2002). Neurocognitive function and joint attention ability in young children with autism spectrum disorder versus developmental delay. *Child Development*, 73, 345-358.

- Diamond, A. (1985). Development of the ability to use recall to guide action, as indicated by infants' performance on AB. *Child Development, 56*, 868–883.
- Diamond, A. (2002). Normal development of prefrontal cortex from birth to young adulthood: Cognitive functions, anatomy, and biochemistry. In D. Stuss & R. Knight (Eds.), *Principles of frontal lobe function* (pp. 466–503). New York: Oxford University Press.
- Diamond, A. (2006). The early development of executive functions. In E. Bialystock & F. I. M. Craik (Eds.), *Lifespan cognition: Mechanisms of change* (pp. 70–95). New York: Oxford University Press.
- Diamond, A., Cruttenden, L., & Neiderman, D. (1994). AB with multiple wells: Why are multiple wells sometimes easier than two wells? Memory or memory + inhibition? *Developmental Psychology, 30*, 192-205.
- Diamond, A., & Doar, B. (1989). The performance of human infants on a measure of frontal cortex function, the delayed response task. *Developmental Psychobiology, 22*, 271–294.
- Diamond, A. & Goldman-Rakic, P. S. (1989). Comparison of human infants and rhesus monkeys on Piaget's AB task: Evidence for dependence of dorsolateral prefrontal cortex. *Experimental Brain Research, 74*, 24-40.
- Diamond, A., Prevor, M. B., Callender, G., & Druin, D. P. (1997) Prefrontal cortex cognitive deficits in children treated early and continuously for PKU. *Monographs of the Society for Research in Child Development, 62*, 1-206.

- Espy, K. A., Kaufmann, P. M., McDiarmid, M. D., & Gilsky, M. L. (1999). Executive functioning in preschool children: Performance on A-not-B and other delayed response format tasks. *Brain and Cognition, 41*, 178-199.
- Fenson, L., Marchman, V. A., Thal, D. J., Dale, P. S., Bates, E., & Reznick, J. S. (2007). The MacArthur-Bates communicative development inventories: User's guide and technical manual. Baltimore: Paul H. Brookes.
- Frye, D., Zelazo, P. D., & Burack, J. A. (1998). Cognitive complexity and control: I. Theory of mind in typical and atypical development. *Current Directions in Psychological Science, 7*, 116-121.
- Garon, N., Bryson, S. E., & Smith, I. M. (2008). Executive function in preschoolers: A review using an integrative framework. *Psychological Bulletin, 134*, 31-60. doi: 10.1037/0033-2909.134.1.31
- Gopnik, A., & Astington, J. W. (1988). Children's understanding of representational change and its relation to the understanding of false belief and the appearance-reality distinction. *Child Development, 59*, 26-37.
- Gopnik, A., & Meltzoff, A. N. (1997). *Words, thoughts, and theories*. Cambridge, MA: MIT Press.
- Griffith, E. M., Pennington, B. F., Wehner, E. A., & Rogers, S. J. (1999). Executive function in young children with autism. *Child Development, 70*, 817-832.
- Hammond, S. I., Carpendale, J. I. M., Bibok, M. B., Müller, U., & Liebermann-Finestone, D. P. (2012). The effects of parental scaffolding on preschoolers'

executive function. *Developmental Psychology*, 48, 271-281. doi:
10.1037/000025519

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

Hughes, C. (1998). Executive function in preschoolers: Links with theory of mind and verbal ability. *British Journal of Developmental Psychology*, 16, 233-253.

Hughes, C., & Ensor, R. (2005). Executive function and theory of mind in 2 year olds: A family affair? *Developmental Neuropsychology*, 28, 645-668.

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

Hughes, C. H., & Ensor, R. A. (2009). How do families help or hinder the emergence of early executive function? In C. Lewis & J. I. M. Carpendale (Eds.), *Social interaction and the development of executive function. New Directions in Child and Adolescent Development*, 123, 35-50.

Jacques, S., & Zelazo, P. D. (2005). On the possible roots of cognitive flexibility. In B. D. Homer & C. S. Tamis-Lemonda (Eds.), *The development of social understanding and communication* (pp. 53-81). Mahwah, NJ: Erlbaum.

Jacques, S., & Marcovitch, S. (2010). Development of executive function across the lifespan. In W. F. Overton (Ed.), *Cognition, Biology, and Methods across the Lifespan. Volume 1 of the Handbook of Life-span Development* (pp. 431-466), Editor-in-chief: R. M. Lerner. Hoboken, NJ: Wiley.

- Jones, L. B., Rothbart, M. K., & Posner, M. I. (2003). Development of executive attention in preschool children. *Developmental Science, 6*, 498-504.
- Kharitonova, M., Chien, S., Colunga, E., & Munakata, Y. (2009). More than a matter of getting "unstuck": Flexible thinkers use more abstract representations than perseverators. *Developmental Science, 12*, 662-669. doi: 10.1111/j.1467-7687.2008.00799.x
- Kirkham, N. Z., Cruess, L., & Diamond, A. (2003). Helping children apply their knowledge to their behavior on a dimension-switching task. *Developmental Science, 6*, 449-476.
- Kochanska, G., Murray, K. T., & Harlan, E. T. (2000). Effortful control in early childhood: Continuity and change, antecedents, and implications for social development. *Developmental Psychology, 36*, 220-232. doi: KM037//0012-1649.36.2.220
- Kochanska, G., Tjebkes, T., & Forman, D. (1998). Children's emerging regulation of conduct: Restraint compliance, and internalization from infancy to the second year. *Child Development, 69*, 1378-1389.
- Lehto, J., Juujarvi, P., Kooistra, L., & Pukkinen, L. (2003). Dimensions of executive functioning: Evidence from children. *British Journal of Developmental Psychology, 21*, 59-80.
- Leslie, A. M. (1987). Pretence and representation: The origins of "theory of mind". *Psychological Review, 94*, 412-426.

- Leslie, A. M. (1994). Pretending and believing: Issues in the theory of ToMM. *Cognition*, 50, 211-238.
- Lewis, C., & Carpendale, J. I. M. (2009). Introduction: Links between social interaction and executive function. In C. Lewis & J. I. M. Carpendale (Eds.), *Social interaction and the development of executive function. New Directions in Child and Adolescent Development*, 123, 1-15.
- Lowenstein, J. & Gentner, D. (2005). Relational language and the development of relational mapping. *Cognitive Psychology*, 50, 315-353. doi: :10.1016/j.cogpsych.2004.09.004
- Luria, A. R. (1979). *The making of mind: A personal account of Soviet psychology*. Cambridge, MA: Harvard University Press.
- Mangelsdorf, S. C., Shapiro, J. R., & Marzolf, D. (1995). Developmental and temperamental differences in emotion regulation in infancy. *Developmental Psychology*, 66, 1817-1828.
- Marcovitch, S., & Zelazo, P. D. (1999). The A-not-B error: Results from a logistic meta-analysis. *Child Development*, 70, 1297-1313.
- Marcovitch, S., & Zelazo, P. D. (2006). The influence of number of A trials on 2-year-olds' behavior in two A-not-B-type search tasks: A test of the hierarchical competing systems model. *Journal of Cognition and Development*, 7, 477-501.
- Marcovitch, S., & Zelazo, P. D. (2009). A hierarchical competing systems model of the emergence and early development of executive function. *Developmental Science*, 12, 1-25. doi: 10.1111/j.1467-7687.2008.00754.x

- Markus, J., Mundy, P., Morales, M., Delgado, C. E. F., & Yale, M. (2000). Individual differences in infant skills as predictors of child-caregiver joint attention and language. *Social Development, 9*, 302-315.
- Meltzoff, A. N., Gopnik, A., & Repacholi, B. (1999). Toddlers' understanding of intentions, desires, and emotions: Explorations of the dark ages. In P. Zelazo, J. Astington, & D. Olson (Eds.) *Developing theories of intention: Social understanding and self-control* (pp. 17-41). Mahwah, NJ: Erlbaum.
- Miller, S. E., & Marcovitch, S. (2010). *The role of representation and reflection in the relationship between theory of mind and executive function*. Manuscript submitted for publication.
- Miller, S. E., & Marcovitch, S. (2011). Toddlers benefit from labeling on an executive function search task. *Journal of Experimental Child Psychology, 108*, 580-592. doi:10.1016/j.jecp.2010.10.008
- Miyake, A., & Friedman, N. P. (2012). The nature and organization of individual differences in executive functions: Four general conclusions. *Current directions in psychological science, 21*, 8-14. doi: 10.1177/0963721411429458
- Miyake, A., Friedman, N., Emerson, M., Witzki, A., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology, 41*, 49–100. doi: 10.1006 / cogp.1999.0734
- Moses, L. J. (2001). Executive accounts of theory-of-mind development. *Child Development, 72*, 688-690.

- Müller, U., Zelazo, P. D., Hood, S., Leone, T., & Rohrer, L. (2004). Interference control in a new rule use task: Age related changes, labeling, and attention. *Child Development, 75*, 1594-1609.
- Müller, U., Zelazo, P. D., Lurye, L. E., & Liebermann, D. P. (2008). The effect of labeling on preschool children's performance on the Dimensional Change Card Sort Task. *Cognitive Development, 23*, 395-408. doi: 10.1016/j.cogdev.2008.06.001
- Munakata, Y. (1998). Infant perseveration and implications for object permanence theories: A PDP model of the AB task. *Developmental Science, 1*, 161-211.
- Munakata, Y. (2001). Graded representations in behavioral dissociations. *Trends in cognitive sciences, 5*, 309-315.
- Mundy, P., Block, J., Delgado, C., Pomarez, Y., Van Hecke, A. V., & Parlade, M. V. (2007). Individual differences and the development of joint attention in infancy. *Child Development, 78*, 938-954.
- Mundy, P., Delgado, C., Block, J., Venezia, M., Hogan, A., & Seibert, J. (2003). A manual for the Abridged Early Social Communicative Scales (ESCS). Available through the University of California-Davis Psychology Department, Sacramento, California. Retrieved 2009, from: http://www.ucdmc.ucdavis.edu/mindinstitute/ourteam/faculty_staff/mundy.html
- Mundy, P., & Gnomes, A. (1998). Individual differences in joint attention skill development in the second year. *Infant Behavior and Development, 21*, 469-482.

- Mundy, P., & Newell, L. (2007). Attention, joint attention, and social cognition. *Current Directions in Psychological Science*, 5, 269-274.
- Nelson, K. E. (1996). *Language in cognitive development: Emergence of the mediated mind*. New York: Cambridge University Press.
- Nichols, K. E., Fox, N., & Mundy, P. (2005). Joint attention, self-regulation, and neurocognitive functions in toddlers. *Infancy*, 7, 35-51.
- Norman, D., & Shallice, T. (1986). Attention to action: Willed and automatic control of behaviour. In R. Davidson, G. Schwartz, & D. Shapiro (Eds.), *Consciousness and self-regulation* (Vol. 4, pp. 1-18). New York, NY: Plenum Press.
- Ozonoff, S. & McEvoy, R. E. (1994). A longitudinal study of executive function and theory of mind development in autism. *Development and Psychopathology*, 6, 415-431.
- Pelphrey, K., & Reznick, J. (2002). Working memory in infancy. *Advances in Child Development and Behavior*, 31, 173-227.
- Pelphrey, K. A., Reznick, S., Goldman, B. D., Sasson, N., Morrow, J., Donahoe, A., & Hodgson, K. (2004). Development of visuospatial short-term memory in the second half of the 1st year. *Developmental Psychology*, 2004, 836-851. doi: 10.1037/0012-1649.40.5.836
- Perner, J., & Lang, B., (1999). Development of theory of mind and executive control. *Trends in Cognitive Sciences*, 3, 337-344.
- Perner, J., & Lang, B. (2000). Theory of mind and executive function: Is there a developmental relationship? In S. Baron-Cohen, H. Tager-Flusberg, & D. Cohen

- (Eds.), *Understanding other minds: Perspectives from autism and developmental cognitive neuroscience* (pp. 150-181). Oxford, England: Oxford University Press.
- Perner, J., Strummer, S., & Lang, B. (1999). Executive functions and theory of mind: Cognitive complexity or functional dependence? In P. D. Zelazo, J. W. Astington, D. R. Olson (Eds.), *Developing theories of intention: Social understanding and self control*, (pp. 133 – 153). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.
- Piaget, J. (1954). *The construction of reality in the child*. New York: Humanities Press.
- Putnam, S. P., Rothbart, M. K., & Gartstein, M. A. (2008). Homotypic and heterotypic continuity of fine-grained temperament during infancy, toddlerhood, and early childhood. *Infant and Child Development*, *17*, 387-405. doi: 10.1002/ICD.582
- Rattermann, M. J., & Gentner, D. (1998). The effect of language on similarity: The use of relational labels improves young children's performance in a mapping task. In K. Holyoak, D. Gentner, & B. Kokinov (Eds.), *Advances in analogy research: Integration of theory and data from the cognitive, computational, and neural sciences* (pp. 274-282). Sophia: New Bulgarian University.
- Repacholi, B. M., & Gopnik, A. (1997). Early reasoning about desires: Evidence from 14- and 18-month-olds. *Developmental Psychology*, *33*, 12-21.
- Rothbart, M., & Posner, M. (2001). Mechanisms and variation in the development of attentional networks. In C. Nelson & M. Luciana (Eds.), *Handbook of developmental cognitive neuroscience* (pp. 353-363). Cambridge, MA: MIT Press.

- Ruff, H. A., & Rothbart, M. K. (1996). *Attention in early development: Themes and variations*. New York, NY: Oxford University Press.
- Russell, J. (1996). *Agency: Its role in mental development*. Hove, England: Erlbaum.
- Rumsey, J. M., & Hamburger, S. D. (1990). Neuropsychological divergence of high-level autism and severe dyslexia. *Journal of Autism and Developmental Disorders*, 20, 155-168.
- Schutte, A. R., & Spencer, J. P. (2002). Generalizing the dynamic field theory of the A-not-B error beyond infancy: Three-year-olds' delay-and experience-dependent location memory biases. *Child Development*, 73, 377-404.
- Spencer, J. P., Smith, L. B., & Thelen, E. (2001). Tests of a dynamic systems account of the A-not-B error: The influence of prior experience on the spatial memory abilities of two-year-olds. *Child Development*, 72, 1327-1346.
- Tomasello, M. (1999). *The cultural origins of human cognition*. Cambridge, MA: Harvard University Press.
- Tomasello, M. (2003). *Constructing a language: A usage-based theory of language acquisition*. Cambridge, MA: Harvard University Press.
- Tomasello, M., & Camaioni, L. (1997). A comparison of the gestural communication of apes and human infants. *Human Development*, 40, 7-24.
- Tomasello, M., Carpenter, M., Call, J., Behne, T., & Moll, H. (2005). Understanding and sharing intentions: The origins of cultural cognition. *Behavioral and Brain Sciences*, 28, 675-735.

- Tomasello, M., Carpenter, M., & Liszkowski, U. (2007). A new look at infant pointing. *Child Development, 78*, 705-722.
- Tomasello, M., & Farrar, M. J. (1996). Joint attention and early language. *Child Development, 57*, 1454-1463.
- Tomasello, M., & Herrmann, W. (2010). Ape and human cognition: What's the difference? *Current Directions of Psychological Science, 19*, 3-8. doi: 10.1177/0963721409359300
- Tomasello, M., Mannle, S., & Kruger, A. C. (1986). Linguistic environments of 1- to 2-year-old twins. *Developmental Psychology, 22*, 169-176.
- Tomasello, M., & Todd, J. (1983). Joint attention and lexical acquisition style. *First Language, 4*, 197-211.
- Towse, J. N., Redbond, J., Houston-Price, C. M. T., & Cook, S. (2000). Understanding the dimensional change card sort: Perspectives from task success and failure. *Cognitive Development, 15*, 347-365.
- Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological process* (M. Cole, V. John-Steiner, S. Scribner, & E. Souberman, trans). Cambridge, MA: MIT Press (Original work published 1930-1935).
- Vygotsky, L.S. (1986). *Thought and language* (A. Kozulin, Trans.). Cambridge, MA: MIT Press. (Original work published 1934).
- Wiebe, S. A., & Bauer, P. J. (2005). Interference from additional props in an elicited imitation task: When in sight, firmly in mind. *Journal of Cognition and Development, 6*, 325-363.

- Wiebe, S. A., Espy, K. A., & Charak, D. (2008). Using confirmatory factor analysis to understand executive control in preschool children: I. latent structure, *Developmental psychology, 44*, 575-587. doi: 10.1037/0012-1649.44.2.575
- Wiebe, S. A., Lukowski, A. F., & Bauer, P. J. (2010). Sequence imitation and reaching measures of executive control: A longitudinal examination in the second year of life. *Developmental Neuropsychology, 35*, 522-538. doi: 10.1037/0012-1649.44.2.575
- Wiebe, S. A., Sheffield, T., Nelson, J. M., Clark, C. A. C., Chevalier, N. & Espy, K. A. (2011). The structure of executive function in 3-year-olds. *Journal of Experimental Psychology, 108*, 436-452. doi: 10.1016/j.jecp.2010.08.008
- Wellman, H. M. (1990). *The child's theory of mind*. Cambridge: MIT Press, A Bradford Book.
- Wellman, H. M., Cross, D., & Watson, J. (2001). Meta-analysis of theory-of-mind development: The truth about false belief. *Child Development, 72*, 655-684.
- Wellman, H. M., & Liu, D. (2004). Scaling of theory-of-mind tasks. *Child Development, 75*, 523-541.
- Willatts, P. (1999). Development of means-end behavior in young infants: Pulling a support to retrieve a distant object. *Developmental Psychology, 35*, 651-667.
- Wimmer, H., & Perner, J. (1983). Beliefs about beliefs: Representation and constraining function of wrong beliefs in young children's understanding of deception, *Cognition, 13*, 103-128.

- Wood, D., Bruner, J. S., & Ross, G. (1976). The role of tutoring in problem solving. *Journal of Child Psychology and Psychiatry, 17*, 89-100.
- Zelazo, P. D. (2004). The development of conscious control in childhood. *Trends in Cognitive Science, 8*, 12-17. doi:10.1016/j.tics.2003.11.001
- Zelazo, P. D., Carter, A., Reznick, J.S., & Frye, D. (1997). Early development of executive function: A problem-solving framework. *Review of General Psychology, 1*, 198-226.
- Zelazo, P. D., & Müller, U. (2002). Executive function in typical and atypical development. In U. Goswami (Ed.), *Handbook of childhood cognitive development* (pp. 445-469). Oxford, England: Blackwell Publishers.
- Zelazo, P., Müller, U., Frye, D., & Marcovitch, S. (2003). The development of executive function in early childhood. *Monographs of the Society for Research in Child Development, 68*, 1-137.
- Zelazo, P. D., Reznick, J. S., & Spinazzola, J. (1998). Representational flexibility and response control in a multistep multilocation search task. *Developmental Psychology, 34*, 203-214.
- Zelazo, P. R., & Zelazo, P. D. (1998). The emergence of consciousness. In H. H. Jasper, L. Descarries, V. F. Castellucci, & S. Rossignol (Eds.), *Consciousness: At the frontiers of neuroscience: Advances in Neurology*, Vol. 77 (pp. 149-165). New York, NY: Lippincott-Raven Press.

FOOTNOTES

¹ During the experiment, reaches were scored based on where experimenters perceived children to break the seal first. However, upon review of the video, five 14-month-olds and two 18-month-olds broke the seal at two locations simultaneously on at least one search trial. In these instances, the first location that children gazed to, touched, and approached with their dominant hand was scored in the video. The location that received the majority of these three behaviors was counted as children's response. This scoring did not conflict with experimenter scoring during the experimental session.

² Children who withdrew from the tasks committed an average of 5.19 errors at 14 months and 4.83 errors at 18 months before withdrawing.

³ Although all quantitative variables were not normally distributed, transformations had little effect on significantly correcting normality or the Pearson's r statistic. Non-parametric Spearman rank correlations and Phi coefficients were also conducted, but yielded similar results. Thus, because Pearson's r is robust against violations of normality and nonparametric analyses yielded similar findings, Pearson's r correlations are reported.

APPENDIX A

TABLES

Table 1
Descriptive Statistics of All Measures at 14 and 18 Months

Measure	Age							
	14 Months				18 Months			
	M	(SD)	Range	N	M	(SD)	Range	N
Executive Function Measures								
A-not-B								
Pass/Fail A trials	.72	(.45)	0-1	47	.96	(.20)	0-1	47
A-trial errors	1.97	(2.70)	0-12	34	.98	(1.55)	0-7	45
Pass/Fail 1 st B trial	.09	(.29)	0-1	34	.29	(.46)	0-1	45
Error run	3.53	(2.39)	0-6	34	2.02	(2.05)	0-6	45
Forbidden toy task								
Pass/Fail	.26	(.44)	0-1	46	.28	(.45)	0-1	47
Time to touch	52.02	(47.97)	1-120	46	60.36	(47.38)	0-120	47
3-boxes pass								
Pass/Fail	.22	(.42)	0-1	45	.66	(.48)	0-1	47
Total toys retrieved	1.96	(.67)	1-3	45	2.55	(.69)	1-3	47
Error run	6.07	(3.03)	0-10	45	3.09	(3.15)	0-10	47
Imitation sorting task								
Pass/Fail	.22	(.42)	0-1	45	.62	(.49)	0-1	47
Highest level	1.11	(.57)	0-2	45	1.68	(.78)	0-3	47
Total correct sorts	1.28	(1.31)	0-4	40	2.95	(1.96)	0-7	44
# EF Tasks Passed	.73	(.85)	0-3	44	1.83	(.96)	0-4	47
Joint Attention Measures								
IJA Measures								
IJA total	9.45	(5.53)	1-25	47	8.15	(3.71)	0-18	47
IJA higher	1.02	(1.53)	0-7	47	1.09	(1.35)	0-6	47
IJA ratio	.13	(.21)	0-1	47	.15	(.18)	0-.67	47
RJA Total	2.47	(1.12)	0-4	47	3.47	(.91)	0-4	47
IBR Total	9.09	(3.24)	1-19	47	8.45	(3.08)	3-14	47
Parent Report Measures								
Language								
Receptive	125.49	(73.46)	15-304	43	245.09	(89.21)	45-390	44
Production	18.28	(14.94)	0-67	43	91.52	(78.38)	48-390	44
ECBQ Parent Reports								
Attn Shifting	4.41	(.51)	3.33-5.60	43	4.57	(.67)	2.25-6.08	43
Attn Focus	4.02	(.84)	2.33-6.17	43	4.18	(.85)	2.58-5.75	43
Inhibition	3.40	(.95)	1.45-5.25	43	3.83	(1.02)	1.33-5.67	43
Impulsivity	4.79	(.81)	3.38-6.50	43	4.98	(.61)	3.44-6.20	43

Note. Pass/fail on EF measures is reported as proportion passing. IST = imitation sorting task, IJA = initiating joint attention, RJA = responding to joint attention, IBR = initiating behavioral response, CDI= MacArthur Bates Communicative Development Inventory, ECBQ = Early Childhood Behavior Questionnaire.

Table 2

Correlations Among All Measures at 14 Months

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
1. Sex	1.00	-.10	-.14	.14	.06	.13	.20	-.12	-.16	-.04	.13	.21	-.03	-.12	-.32*	.09
2. CDI Comprehension		1.00	.24	-.07	.22	.25	-.01	-.13	.01	.07	.12	.11	.39**	-.15	.40**	-.07
3. CDI Production			1.00	.06	-.07	-.10	-.02	.10	.03	.15	-.09	.39*	.05	-.16	.23	-.02
4. A-not-B Error Run				1.00	.00	-.16	-.03	.01	.17	.17	.33+	-.10	-.10	-.02	-.26	.25
5. Forbidden Toy Latency					1.00	.14	.19	-.27+	-.16	.03	.09	.22	-.08	.24	.14	-.06
6. 3-boxes Error Run						1.00	-.01	-.25+	-.09	.17	.00	.31*	-.03	.25	-.09	.14
7. IST Number Correct Trials							1.00	-.03	-.08	-.10	.32*	-.02	-.15	-.26	-.16	-.04
8. IJA Total								1.00	.23	-.16	.21	-.23	-.11	-.21	.09	-.08
9. IJA Higher									1.00	.72**	-.10	-.37**	-.01	.21	.04	-.12
10. IJA Ratio										1.00	-.20	-.04	-.01	.26+	-.03	-.05
11. RJA Total											1.00	-.03	-.14	-.15	-.15	.11
12. IBR Total												1.00	-.13	-.02	.11	.09
13. ECBQ Attention Focus													1.00	.25	.27+	-.17
14. ECBQ Attention Shifting														1.00	-.04	.01
15. ECBQ Inhibitory Control															1.00	-.19
16. ECBQ Impulsivity																1.00

Note. + $p \leq .10$, * $p \leq .05$, ** $p \leq .01$, CDI= MacArthur Bates communicative developmental inventory, IST = imitation sorting task, IJA = initiating joint attention, RJA = responding to joint attention, IBR = initiating behavioral response, ECBQ = Early Childhood Behavior Questionnaire

Table 3
Correlations Among All Measures at 18 Months

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
1. Sex	1.00	-.07	.06	.08	.10	.03	-.26+	.08	-.29*	-.19	.06	-.21	.01	-.19	-.10	.14
2. CDI Comprehension		1.00	.49**	.03	.05	.14	.02	-.19	.32*	.32*	.13	-.24	.19	.19	.51**	.06
3. CDI Production			1.00	.12	.05	.02	-.18	-.02	.23	.15	.27+	-0.2	.07	.02	.27+	-.07
4. A-not-B Error Run				1.00	.09	.20	-.02	.11	-.15	-.12	.34*	-.11	-.28+	-.15	-.17	.05
5. Forbidden Toy Latency					1.00	-.01	.04	.19	-.09	-.20	-.02	-.22	-.01	-.41**	-.03	.21
6. 3-boxes Error Run						1.00	.07	-.26+	-.11	.01	.36*	.02	.26+	-.05	.13	-.04
7. IST Number Correct Trials							1.00	-.21	-.02	.13	.09	-.10	.21	.01	.02	.08
8. IJA Total								1.00	.15	-.22	-.02	-.18	-.14	-.02	-.33*	.22
9. IJA Higher									1.00	.82**	.07	-.25+	-.11	.14	-.02	-.16
10. IJA Ratio										1.00	.12	-.17	-.10	.24	.11	-.19
11. RJA Total											1.00	-.17	-.10	-.07	.07	.09
12. IBR Total												1.00	-.10	.17	.06	-.01
13. ECBQ Attention Focus													1.00	.27+	.44**	-.33+
14. ECBQ Attention Shifting														1.00	.18	-.05
15. ECBQ Inhibitory Control															1.00	-.18
16. ECBQ Impulsivity																1.00

Note. + $p \leq .10$, * $p \leq .05$, ** $p \leq .01$, CDI = MacArthur Bates communicative developmental inventory, IST = imitation sorting task, IJA = initiating joint attention, RJA = responding to joint attention, IBR = initiating behavioral response, ECBQ = Early Childhood Behavior Questionnaire

Table 4
 Longitudinal Correlations from 14 to 18 Months of Age

14 Months of Age	18 Months of Age														
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
1. CDI Comprehension	.73**	.10	.19	.06	.23	.07	-.19	.15	.21	.16	-.19	.23	.30+	.34*	.05
2. CDI Production	.37*	.73**	.06	-.01	.06	-.25	-.01	.25	.16	.17	-.05	.01	.21	.05	.03
3. A-not-B Error Run	.00	.09	.12	-.12	.08	.18	.26	.02	-.19	.04	-.08	-.15	-.25	-.16	.27
4. Forbidden Toy Latency	.27+	-.04	.02	.24	.27+	.13	.02	.05	-.08	.21	-.08	.14	.12	.10	-.10
5. 3-Boxes Error Run	.10	-.08	.13	.19	.02	.19	-.01	-.19	-.07	-.10	.14	.16	.12	.05	-.01
6. IST Number Correct Trials	.19	.21	.02	.30+	-.01	.25	.17	.20	.17	.23	-.34*	.01	-.25	.22	.03
7. IJA Total	-.11	.07	-.22	.01	-.18	-.17	.46**	.09	-.12	-.04	-.10	-.09	-.14	-.07	.22
8. IJA Higher	.00	.09	.07	.02	.25+	.31*	.10	-.02	.06	.13	.01	.14	-.21	.02	.12
9. IJA Ratio	-.01	.04	.25+	.13	.25+	.39**	-.12	-.10	.03	.07	.11	.12	-.21	.01	.06
10. RJA Total	.23	.15	.16	.00	.07	.19	.06	-.03	-.07	.29*	-.21	-.03	-.17	.08	.29+
11. IBR Total	.20	.27+	.18	.18	.22	-.28+	-.21	-.07	-.06	.02	.12	.01	-.04	.08	-.25
12. ECBQ Attention Focus	.24	-.08	-.07	-.19	.07	-.11	-.07	.08	.14	-.34*	-.19	.57**	.45**	.26+	-.20
13. ECBQ Attention Shifting	-.09	-.09	.12	.14	.11	.11	.16	-.10	-.11	-.19	-.05	.22	.21	-.18	-.18
14. ECBQ Inhibitory Control	.49**	.24	-.18	.04	.14	-.11	-.18	.06	-.06	.00	.06	.46**	.21	.64**	-.29+
15. ECBQ Impulsivity	.01	.02	.11	.05	-.08	-.21	.21	-.08	-.22	.09	.27+	-.10	-.06	-.05	.55**

Note. + $p \leq .10$, * $p \leq .05$, ** $p \leq .01$, CDI = MacArthur Bates communicative developmental inventory, IST = imitation sorting task, IJA = initiating joint attention, RJA = responding to joint attention, IBR = initiating behavioral response, ECBQ = Early Childhood Behavior Questionnaire.

Table 5
 Summary of Hierarchical Regression Analysis for Variables (14 months) Predicting Number of EF Tasks Passed (18 months)

Variable	<i>B</i>	<i>SE B</i>	β	R^2 Change
Block 1				.13
Sex	.10	.31	.05	
Words Understood	.01	.002	.37*	
Words Produced	-.01	.01	-.13	
Block 2				.11*
# EF Tasks Passed	.40	.17	.35*	
Block 3				.30**
IJA-Ratio	2.55	.56	.57**	
IJA Total	.03	.02	.15	
RJA Total	.01	.07	.01	
IBR Total	.01	.05	.03	

Note. * $p < .05$, ** $p < .01$, IJA = initiation of joint attention, RJA = responding to joint attention, IBR = initiation behavioral response.

APPENDIX B

FIGURES

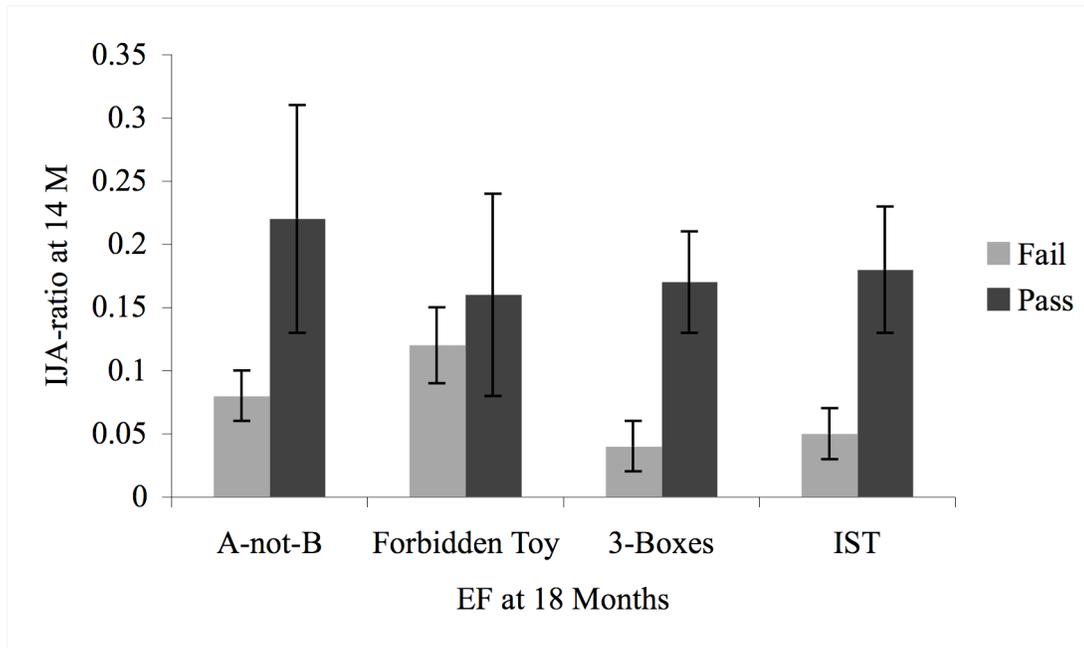


Figure 1. IJA-ratio (i.e., percentage of IJA behaviors that are higher level behaviors) at 14 months by EF pass/fail behavior at 18 months. IJA= initiation of joint attention, IST= imitation sorting task. Children who passed the 3 boxes task and IST at 18 months demonstrated a significantly higher IJA ratio at 14 months. Standard errors are represented in the figure bar by error bars attached to each column.

Note. + $p \leq .10$, * $p < .05$

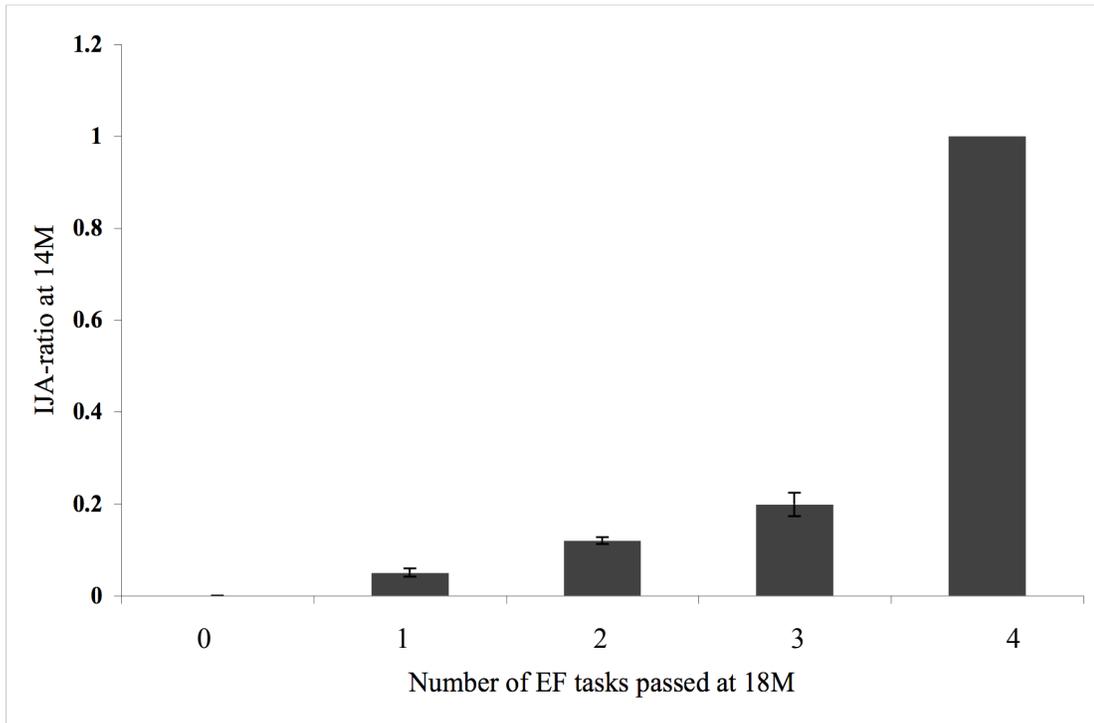


Figure 2. IJA-ratio (i.e., percentage of IJA behaviors that are higher level behaviors) at 14 months by number of EF tasks passed at 18 months. IJA=initiation of joint attention. Children who passed the 3 or 4 tasks at 18 months had a significantly higher IJA-ratio at 14 months compared to children that passed 0 or 1 EF tasks. Further, children who passed 2 tasks had a significantly higher IJA-ratio compared to children who passed 0 tasks. Standard errors are represented in the figure bar by error bars attached to each column.