

# Examining Executive Function in the Second Year of Life: Coherence, Stability, and Relations to Joint Attention and Language

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Several theories of executive function (EF) propose that EF development corresponds to children's ability to form representations 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, shared joint attention) occur within the 1st years of life. In the present study, 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 suggest that the 2nd year of life is a distinct period of EF development in which children exhibit very little coherence or stability across a battery of EF tasks. However, by 18 months, a subset of child participants consistently passed the majority of EF tasks, and superior EF performance was predicted by 14-month representational abilities (i.e., language comprehension and some episodes of initiating joint attention). This research suggests that the transition from foundational behavioral control in infancy to the more complex EF observed in preschool is supported by representational abilities in the 2nd year of life.

*Keywords:* executive function, joint attention, longitudinal, toddlers, representation

Despite the wealth of information regarding behavioral and cognitive control in preschool and childhood (for reviews, see Carlson, 2005; Garon, Bryson, & Smith, 2008; Jacques & Marcovitch, 2010), research examining the development of *executive function* (EF; i.e., conscious control over thought and behavior directed toward a goal) rarely extends to children younger than 3 years of age. Certainly, there are indications that infants and toddlers begin to demonstrate controlled, goal-directed behavior through developments in problem solving (e.g., Chen, Sanchez, & Campbell, 1997; Diamond, 2006), delaying gratification (e.g., Kochanska, Tjebkes, & Forman, 1998), and imitation (e.g., Alp, 1994; Wiebe & Bauer, 2005). However, it is difficult to discern whether these isolated instances of infants' behavioral control are related to later EF, in which preschoolers evidence complex cognitive control across multiple EF tasks. Further, most empirical studies of early behavioral control study children within the 1st year of life (e.g., Chen et al., 1997; Diamond, 1985), despite the fact that various frameworks propose that important developments in EF occur during the 2nd year (e.g., Diamond, 2006; Garon et al.,

2008; Marcovitch & Zelazo, 2006, 2009; Zelazo, 2004). The goal of the current research was to conduct a systematic study of EF during the 2nd year of life through the administration of multiple EF tasks in conjunction with the examination of early communicative abilities thought to underlie the ability to control behavior. The study of EF in this age range has the potential to extend developmental frameworks to focus on the emergence of EF and link studies of behavioral control in infancy to EF work in preschool.

Few researchers have examined EF in the 2nd year of life using a battery of EF tasks. Diamond, Prevor, Callender, and Druin (1997) collected data on 15-, 18-, and 21-month-olds' EF as part of a longitudinal study on the cognitive functioning of children treated for phenylketonuria in early childhood. Through their examination of matched controls, Diamond and colleagues found some evidence for growth in EF abilities within this age range. For instance, in the three-boxes task, children were encouraged to retrieve three identical toys hidden in three different-colored boxes. Search required increasing levels of cognitive and behavioral control, because after children searched at one location, the toy was removed and they had to monitor and inhibit search to the previously correct location to find the new toy. Children's performance in both versions (i.e., boxes scrambled and unscrambled before search) improved, as evidenced by the fact that they required fewer searches to find all toys across the 2nd year. However, improvement was not demonstrated across the entire battery of EF tasks administered. In the A-not-B task with invisible displacement, after repeatedly searching for a hidden object and building a habit toward one hiding location, location A, children were encouraged to switch search to a new location, location B (see Marcovitch & Zelazo, 2009). However, the addition of invisible displacement to the traditional A-not-B task (i.e., the toy was moved to the A or B location out of the direct sight of the child)

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resulted in poor performance during the 2nd year, which did not begin to improve until after 21 months. In another study examining early EF across a battery of tasks, Wiebe, Lukowski, and Bauer (2010) actually uncovered growth in the A-not-B task with invisible displacement in addition to the three-boxes task scrambled and an imitation task in which children had to remember a sequence of actions to achieve a goal (related to holding information in mind). In this EF battery, Wiebe and colleague's participants demonstrated initially poor performance at 15 months, and performance on all tasks improved by 20 months of age.

Although children improved across a number of EF tasks during this transitional period, closer examination of the cohesion and stability across EF tasks reveals critical differences compared with later preschool performance. Diamond et al. (1997) did not find any interrelations between EF tasks. Wiebe et al. (2010) also demonstrated that performance across different EF tasks was generally not correlated concurrently at 15 or 20 months of age, although there were a few exceptions. Further, individual differences in task performance were not stable (i.e., performance at 15 months was not well correlated with performance at 20 months). This conflicts with perspectives suggesting that performance across EF tasks should show some degree of overlap in childhood and into adulthood (e.g., Lehto, Juuaärvi, Kooistra, & Pulkkinen, 2003; Miyake & Friedman, 2012; Miyake et al., 2000; Wiebe, Espy, & Charak, 2008; Wiebe et al., 2011) and is generally stable across time (Carlson, Mandell, & Williams, 2004; Hughes & Ensor, 2005, 2007).

Understanding exactly what this lack of cohesion and lack of stability mean in the 2nd year warrants a review of their importance in later EF. Currently, there is some debate as to whether these relations point to a unitary account of EF in which a single control mechanism is responsible for cognitive control (e.g., Baddeley, 1992; Norman & Shallice, 1986) or the diversity in EF should be acknowledged (e.g., Carlson & Moses, 2001; Diamond, 2002; Lehto et al., 2003; Miyake et al., 2000) by noting the separate subprocesses that likely contribute to EF (e.g., *working memory* [WM], the ability to hold and manipulate increasing amounts of task-relevant information in mind over delays; *inhibition*, the suppression of prepotent or affectively driven behaviors; *shifting*, flexible switching of responses and attention between task-relevant information). Further complicating this debate, relations between EF tasks seem to change with age, as confirmatory factor analysis work suggests that performance on EF tasks in preschool is best explained by a unitary EF factor (Wiebe et al., 2011), whereas componential or differentiated models are better supported in later childhood and adulthood (Lehto et al., 2003; Miyake et al., 2000). Miyake and Friedman's (2012) unity/diversity framework may reconcile these theoretical and structural EF differences by proposing the existence of a common EF (i.e., maintenance of task-relevant information that guides lower level processes toward execution of a goal) that is shared across all component processes. Thus, although Miyake and Friedman maintain that the ability to control thought and behavior can still be separated into several underlying EF component abilities, all of these component abilities draw on common EF in addition to component-specific abilities (i.e., WM and shifting-specific abilities), and individual differences in the inhibition component can be entirely explained by common EF. Applied to developmental data, a unitary EF factor in preschool may reflect common EF that

guides behavior across all tasks, because shifting- and WM-specific abilities may have not yet emerged (Garon et al., 2008; Wiebe et al., 2011). The initial poor performance and lack of cohesion in the 2nd year of life could reflect the initial absence and gradual emergence of a unitary EF in this transitional period of EF development.

One way to provide additional support for the existence and emergence of a common EF ability in children is to examine factors hypothesized to underlie common EF. Specifically, representational ability (i.e., the ability to form, maintain, and reflect on mental information) has been linked repeatedly with EF. For instance, Munakata's (1998) active-latent model suggests that active memory traces processed in the prefrontal cortex (e.g., maintenance of relevant representations) can aid in the control of behavior, whereas latent memory traces processed in the more posterior regions of the brain (e.g., habitual or prepotent forces on behavior) can often result in incorrect automatic responses. Zelazo and colleagues' (Jacques & Marcovitch, 2010; Marcovitch & Zelazo, 2006; Zelazo, 2004) reflection-based accounts suggest that reflection on or processing of task-relevant information at a higher level (also within the prefrontal cortex) is a crucial representational ability necessary in the control of behavior. Most important, Miyake and Friedman's (2012) definition of common EF implicates representation in the maintenance of task-relevant information used to influence lower level processes. Specifically, they link maintenance of task-relevant information to representational strength and have suggested, through neural network modeling work, that one of the parameters linked to individual differences in common EF is related to the strength of representations maintained in the prefrontal cortex. Although Miyake and Friedman's rationale does not focus on development, it is strikingly similar to developmental theories of EF development (Jacques & Marcovitch, 2010; Marcovitch & Zelazo, 2006; Munakata, 1998; Zelazo, 2004) suggesting that the strength of underlying representations influences EF. However, because children's ability to form and use representations is developing, the development of EF should be associated with the development of representation.

In preschoolers, demonstrations of the link between EF and representation come from numerous studies correlating EF with language ability (e.g., Carlson & Moses, 2001; Hughes, 1998; Hughes & Ensor, 2007) and experimental work demonstrating that language and symbolic manipulations typically improve EF in preschoolers (for a review, see Jacques & Zelazo, 2005). However, no studies have examined the link between representation and EF before the age of 3, despite the fact that several representational models propose that important developments in representation and EF occur before that age. For instance, the reflection-based levels of consciousness (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. At the lowest level of consciousness (minimal consciousness), infants' awareness is automatic and unreflective (e.g., they may respond automatically to a rattle by sucking on it). At the end of the 1st year, recursive consciousness emerges, and children become less reflexive and can reflect on objects in consciousness through labeling (e.g., putting the label *rattle* on the object links the current experience to a semantic memory, such as that it makes noise). Development of this higher level of consciousness results in more controlled behavior, or better EF, because it allows infants to

override habitual responses (Marcovitch & Zelazo, 2009). For example, labeling and reflecting on the rattle may lead children to control behavior and shake, rather than suck on, the rattle.

Studies have not yet extended this representational framework to early EF development, likely because of the difficulties of examining representational abilities in children this young. Although measures of early receptive and productive vocabulary exist, the representations of language novices are not analogous to older children's representations. For instance, it has been proposed that young children must first generate linguistic or symbolic information in a social context for it to have meaning (e.g., Vygotsky, 1934/1986). Second, measures of representation in older children (typically vocabulary and language) may not be the best measures of younger children's representational competence. One ability that emerges within the first 2 years of life and has strong ties to later language, representation, and nonlinguistic communication is *joint attention* (e.g., Colonesi, Stams, Koster, & Noom, 2010; Tomasello & Farrar, 1986). 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, Butterworth, & Moore, 1998). However, attention can be shared in a variety of ways, and Mundy and colleagues (Mundy et al., 2007; Mundy & Gomes, 1998; Mundy & Newell, 2007) have distinguished between two different types of joint attention: *responding to joint attention* (RJA; i.e., following others' attention) and *initiating joint attention* (IJA; i.e., directing attention). RJA emerges first and is guided by a more primitive attention system (i.e., the orienting attention system), which is based on attention to novelty, whereas IJA is supported by a later developing executive attention system responsible for higher levels of internal control of attention. These attention systems have also been tied to the emergence of executive control, with Posner, Rothbart, Sheese, and Voelker (2012) suggesting that the orienting attention network initially controls behavior in infancy and transitions to the executive attention network by 3–4 years of age. Thus, the emergence of a common EF guided by representational ability (e.g., IJA within the executive attention system) may also be in line with Posner and colleagues' proposed transition of regulation shifting to the executive attention system in the toddler and preschool years.

More directly related to representational theories of EF development, IJA behaviors have been identified as some of the first instances of higher representation in the 1st years of life. For example, Zelazo (2004) suggested that one of the first instances of labeling may actually be declarative pointing (i.e., pointing to direct and share attention with another). Because this type of pointing is meant to direct or share attention, children must have some reason to direct attention, and this declarative interest in the object essentially results in labeling—linking the object in the current environment to some idea, experience, or concept to share. Within the pointing literature, many theorists have also considered declarative pointing more complex (relative to imperative pointing to control another's behavior, such as requesting an object), 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 Colonesi et al. (2010) provided support for a robust relationship between all forms of pointing and lan-

guage when examined concurrently in a meta-analysis, declarative pointing was more predictive of later language than was imperative pointing. Further, age moderated this relationship and suggested that the longitudinal relationship between earlier pointing and later language became stronger when declarative pointing was measured later in life (i.e., 15–20 months of age) compared with earlier assessments. Colonesi et al. suggested that these results provide support for the idea that pointing is the first instance of referential and intentional communication that contributes to language.

## Present Study

In this study, we examined the emergence of EF and its relation to representational abilities (i.e., joint attention and language) concurrently and longitudinally from 14 to 18 months of age. Four measures of EF were administered. A more difficult version of Piaget's (1954) A-not-B task (i.e., five hiding locations and a 10-s delay) was included because it requires multiple EF abilities, such as holding the hiding location in mind, inhibiting the prepotent response to search at location A, and shifting to a new response set (Marcovitch & Zelazo, 2009). The forbidden toy task, based on Kochanska et al.'s (1998) work prohibiting infants from playing with an attractive toy, was included as an age-appropriate delay-of-gratification task (see Carlson, 2005; Garon et al., 2008). The three-boxes task (Diamond et al., 1997) was included because it requires children to hold object locations in mind and update this information throughout the task. Finally, the imitation sorting task (Alp, 1994), requiring children to imitate an experimenter sorting an increasing number of objects into two buckets, was administered because it has been used to assess children's ability to hold information in mind over a delay. It is important to note that performance on all of these tasks would benefit from common EF (Miyake & Friedman, 2012) and the ability to form and reflect on relevant representations to guide behavior (Jacques & Marcovitch, 2010; Marcovitch & Zelazo, 2009; Zelazo, 2004).

Language comprehension and production were measured via the parent-report MacArthur-Bates Communicative Development Inventories (CDI; Fenson et al., 2007). Joint attention measures were adapted from the Early Social Communication Scale (ESCS; Mundy et al., 2003), constructed to measure early social understanding of children from 8 months to 30 months of age. Because active sharing joint attention behaviors were hypothesized to be most strongly related to EF (e.g., Zelazo, 2004), we included the object spectacle task and the book presentation task, designed to elicit IJA behaviors (e.g., pointing, shared gazing) by presenting children with interesting and novel toys. Further, because self-initiated gesture was hypothesized to encourage stronger representations used to guide EF (e.g., Zelazo, 2004), IJA-higher behaviors (i.e., declarative pointing and showing gesturing toward adults) were examined. In addition, we measured RJA behaviors (i.e., behaviors related to *sharing* attention in response to an adult) with a gaze-following task in which an adult pointed to an interesting object. We also measured initiating behavioral request behaviors (IBR; i.e., behaviors related to requesting an object *initiated* by the child) in the object spectacle task. Although we hypothesized that RJA and IBRs would not relate to EF, these measures were included to determine whether any sharing or child-initiated behavior was related to EF or there was something particular to child-initiated sharing behaviors critical to the development of representation and EF.



We had two major goals in this study. First, we sought to describe EF abilities during the 2nd year of life by observing EF task performance across our four EF tasks, coherence between EF measures concurrently, and longitudinal stability from 14 to 18 months of age. Second, we aimed to investigate the relationship between developing representation and EF through examination of children's joint attention and parent-report measures of receptive and productive vocabulary. On the basis of representational theories of EF development, we hypothesized that abilities linked to children's representational abilities (i.e., language and higher levels of IJA) would be related to the emergence of early EF during this period.

## Method

### Participants

Participants from a midsized southeastern U.S. city were recruited from a database of parents expressing interest in participating in child development research. The final sample consisted of 47 children (25 boys, 22 girls) who participated in the longitudinal study at 14 and 18 months of age. Five children were excluded from the final sample because they failed to return for the second visit ( $n = 4$ ) or because task performance was influenced by parental involvement ( $n = 1$ ). Parents received a \$5 gift card for each visit, and children received a snack and a toy for participation. The mean age at Time 1 was 14.38 months ( $SD = 0.34$  months, range = 13.77–15.10 months), and the mean age at Time 2 was 18.48 months ( $SD = 0.35$  months, range = 17.84–19.25 months). The average length of time between the first and second visit was 4.12 months ( $SD = 0.28$  months, range = 3.57–4.79 months). Of the final sample, approximately 38% self-reported as Caucasian, 7% as African American, 4% as Asian, 19% as multiracial, and 32% did not respond. Thirty-two percent reported annual household earnings above \$60,000, 34% reported annual household earnings below \$60,000, and 34% did not respond. Of the 72% of parents who reported on the languages spoken in the home, 97% listed English as the primary language, and 3% listed English as the secondary language.

### Procedure

The same female experimenter presented tasks to children in a fixed order at 14 and 18 months to equate order and experimenter effects: (a) object spectacle task, (b) A-not-B task, (c) gaze-following task, (d) book presentation task, (e) forbidden toy task, (f) object spectacle task, (g) three-boxes task, (h) object spectacle task, and (i) imitation sorting task. 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. Joint attention tasks were also administered flexibly (e.g., presented later if a child did not initially attend to the experimenter), because the experimenter must be responsive to children's communicative bids for the items presented (see Mundy et al., 2003). Parents typically held or sat behind children during testing. Parents were informed that interactions of interest would occur between the experimenter and children, and if children attempted interaction with them, they should respond in a natural manner and redirect attention to the experimenter.

### Executive Function Measures

**A-not-B task with multiple hiding locations.** The hiding apparatus consisted of five shallow wells (9.5 cm in diameter, 7 cm in depth) used as hiding locations embedded within a wooden box (43 cm length  $\times$  56 cm width  $\times$  7 cm height). Hiding locations were arranged in a semicircle 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, a 56-cm  $\times$  43-cm white poster board was placed on the top of the apparatus to occlude all but the center well. Children chose one toy from a set of three to be hidden. Once children demonstrated that they could retrieve a conspicuously hidden toy placed inside the center well, the experimenter placed the toy inside the center well and sealed the Velcro cover. The experimenter then covered the hiding apparatus with a 76-cm  $\times$  50-cm foam poster board and counted aloud to 10. Children passed training once they broke the Velcro seal at the center hiding location. For all trials, children were rewarded for correct search with praise and play time with the toy.

In the testing phase, A and B trials were similar to training trials, except all five hiding locations were visible. Children had to retrieve the toy at location A correctly three times before they saw the object hidden at a new location (location B). Hiding locations were counterbalanced, with the stipulations that the center well was never used as a hiding location and location B was located on the opposite side of the midline from location A (see Marcovitch & Zelazo, 2006). At the beginning of each test trial, the experimenter brought children's attention to the center by tapping the toy at the midpoint of the testing apparatus. The experimenter then hid the toy in one of the hiding locations as children watched. Next, the experimenter sealed the Velcro and covered all five hiding locations simultaneously (see Diamond, Cruttenden, & Neiderman, 1994) with the white poster board and counted to 10. The hiding apparatus was then presented to 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.<sup>1</sup> If children refused to search, the trial was considered incorrect. Children who searched incorrectly were shown the correct location of the object but were not rewarded with praise or permitted to play with the toy. B trials were repeated until children retrieved the object correctly at location B twice or refused to continue to search. In line with previous work, children were considered to pass the task if they searched correctly on the first B trial of the A-not-B task (e.g., Marcovitch & Zelazo, 1999).

**Forbidden toy task.** First, children shared 3 min of free play with the experimenter, during which they 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 (a Fisher-Price GeoTrax train) that was out of close reach. The train was activated (i.e., drove around a circular train track) for

<sup>1</sup> On review of the videos, five 14-month-olds and two 18-month-olds broke the seal at two locations simultaneously on at least one trial. When eye gaze, touch, and dominant hand approach were scored from the video, the location that received the majority of these three behaviors was consistent with the experimenter's scoring during the experimental session.

15 s at the 45-, 105-, and 165-s marks during free play. To ensure that children understood the prohibition, each time they touched or attempted to reach for the toy, the experimenter prohibited them 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. At the end of supervised free play, the experimenter repeated the prohibition and suggested that children continue to play with the available toy while she left the room for 2 min. The parent typically 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 s at the 0- and 60-s marks during unsupervised play. Children passed the task if they waited the entirety of the trial to interact with the forbidden object (e.g., Carlson, 2005).

**Three-boxes task.** Three distinct boxes were used as hiding locations (a blue box with a star handle, a yellow box with a circle handle, and a red box with a square handle; all handles were approximately 6 cm × 6 cm). Each box (12 cm length × 11 cm width × 3.5 cm height) was affixed to a foam base (47 cm length × 16.5 cm width × 4.5 cm height) that presented boxes 7.5 cm apart at a slight downward angle toward children. The location of the boxes was counterbalanced across children. Children watched as the experimenter lifted the lids of all three boxes and placed three attractive toys inside them (i.e., three pink plastic rattles that made noise), one in each box. The experimenter then simultaneously replaced the lids and occluded the hiding apparatus with the white foam poster board for 5 s. After the delay, the experimenter presented children with the search display and encouraged them to search.<sup>2</sup> For correct searches, children were praised and briefly allowed to play with the toy while the boxes remained out of reach, with the chosen box open. For incorrect searches, children were not rewarded and were shown that the toy was not in the chosen box. After each search trial, the lid was replaced, and the apparatus was occluded for 5 s. Next, the hiding apparatus was again presented to children for search. Searching continued until children retrieved all three objects or until they failed to find a toy for four consecutive trials. Children were considered to pass the task if they found the toy in all three hiding locations on the three-boxes task (Diamond et al., 1997).

**Imitation sorting task.** In this abbreviated version of the imitation sorting task (based on Alp, 1994), the experimenter sorted objects into two clear plastic containers (8 cm in height, 10.5 cm in diameter) mounted on a 47-cm × 14-cm foam base 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 × 6 cm to 5 cm × 5 cm were used for sorting. Children were presented with increasingly difficult levels (i.e., more objects to sort) as the task progressed. At level 1 (training), the sorting bucket (color counterbalanced) was always placed to children's right, and children watched as the experimenter sorted one toy into the right bucket and uttered, "The frog goes in this bucket. Hop, hop, hop." The toy was removed from the bucket and placed in the center of the foam base, and the experimenter encouraged children to imitate by moving the apparatus toward them and saying, "Now, you try." Children were rewarded with praise and passed level 1 if they correctly imitated the experimenter by placing the frog in the bucket three times.

Imitation sorting began in level 2 with the introduction of a second sorting bucket to the children's left. The experimenter sorted a set of two new toys, the first in the container on the children's left and the second in the container to their right. The experimenter then removed the toys, placed them on the center of the foam base, and encouraged the children to sort. Children's sorting was scored once all toys were placed in a container and was considered correct if they put each toy in a separate bucket. If children sorted incorrectly or refused to sort, the experimenter showed them the sorting process again with the same set. If children failed the sort the second time, the experimenter selected a new set of two toys and repeated the process. Children were given a maximum of five sets of toys and were designated as passing and moved on to the next level as soon as they sorted three sets correctly. Each level followed the same procedure, except the number of toys increased (e.g., level 3 involved sorting three toys into two buckets). Children who were unable to sort three sets correctly did not pass the level and did not participate in the task further. Children were considered to pass the imitation sorting task if they completed level 2 (i.e., the first level at which they needed to hold information in mind to sort correctly).

**EF reliability.** A primary coder scored performance on each EF task from video. A second coder scored 10 randomly selected videos for 14- and 18-month visits. Interrater reliability for categorical ( $\kappa$ ) and continuous (intraclass correlation) variables were greater than .92, except for behavior on the forbidden toy task at 18 months ( $\kappa = .73$ ), which reflected disagreement on one out of the 10 cases. In instances of disagreement, the primary coder's data were considered. At 14 months, there were missing data for the forbidden toy task ( $n = 1$ ), the three-boxes task ( $n = 2$ ), and the imitation sorting task ( $n = 2$ ), which were handled in a pairwise deletion fashion in which all available information was used for each case.

## Joint Attention Measures

**Gaze-following task.** This was the measure of RJA used to evaluate children's ability to respond to or follow the experimenter's request to share attention. In this task, four posters were located to the left, right, behind left, and behind right of children. The experimenter called a child's name and touched her own nose to direct the child's attention to her. The experimenter began with the poster on the child's right, turned her entire torso, visually oriented to the poster, pointed, and said the child's name three times with increasing force before returning her gaze to the child. The experimenter repeated this for all posters, and at the end of each trial commented on the target to acknowledge or encourage action in the child (e.g., "Did you see the dog?"). Children received credit for responding to joint attention if they turned their eyes or head to indicate that 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 she showed them the posters.

<sup>2</sup> In the few instances in which children lifted two lids simultaneously, their responses were determined on the basis of eye gaze or the location they continued to open.

**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 presented children with an active toy (i.e., a wind-up seal that spun a ball, a puppet that the experimenter popped up out of a cone, or a wind-up caterpillar that crawled) on the table just out of reach and let it remain active for at least 6 s 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., reach for the toy). If children attempted to initiate joint attention with the experimenter, the experimenter provided them 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. 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. It was considered IJA behavior when children alternated looking between an active toy and the experimenter’s eyes or if they looked to the experimenter while they were playing with an inactive toy. In addition, IJA-higher behaviors (a subscale of total IJA) were coded when children pointed to an active toy or held the toy to show the experimenter. IBR behaviors were scored when children requested the toy or action from the experimenter (e.g., reaching/pointing to obtain the toy, giving the toy to the experimenter so she 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 s, during 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 s, 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 s of the task.

**Joint attention reliability.** First, the primary coder rated joint attention on 10 tapes provided with the ESCS manual. Intraclass correlations were calculated between the primary coder’s behavioral ratings and the manual’s established coding. All correlations for IJA, IJA-higher behavior, 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 study for each time point, and the secondary coder’s ratings were compared with 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 behavior, .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 behavior, .80 for RJA, and .92 for IBR. There were no missing data for joint attention measures at either time point.

**MacArthur-Bates CDI.** Parents also completed the “Words and Gestures” MacArthur-Bates CDIs parent report (Fenson et al., 2007). 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.

## Results

### EF Abilities in the 2nd Year of Life

Descriptive statistics for EF performance at 14 and 18 months of age are displayed in Table 1. The dichotomous measure of passing performance is depicted as the main measure of EF performance for ease of comparison (see Carlson, 2005)<sup>3</sup>. Nonparametric statistics appropriate for dichotomous data were applied when examining growth from 14 to 18 months (i.e., McNemar chi-squares) or examining associations (i.e., phi coefficients) for EF data. Children who did not pass the training phase of a particular task were considered to have failed the task. 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 ( $r_{\Phi}s < .19$ ,  $ps > .20$ ); therefore, sex was not further considered as a variable in EF analyses.

**EF task performance and growth.** On the A-not-B task, the majority of children passed the A trial phase (i.e., completed three A trials successfully), and this significantly increased from 14 to 18 months of age, McNemar  $\chi^2(1, n = 47) = 6.67, p = .01, p_1 - p_2 = .23$ , 95% confidence interval (CI) [.07, .40]. Children who did not pass the A trial phase were not considered in the measures of B-trial performance because they did not receive a reversal trial (see Diamond et al., 1994). The percentage of children who searched correctly on the first B trial was low at both 14 months and 18 months of age. Although performance improved across this age range, the increase was marginal, McNemar  $\chi^2(1, n = 32) = 2.50, p = .11, p_1 - p_2 = .19$ , 95% CI [-0.03, .40]. On the forbidden toy task, the percentage of children who refrained from play was low and did not significantly change from 14 to 18 months of age, McNemar  $\chi^2(1, n = 46) = 0.00, p = 1.0, p_1 - p_2 = .02$ , 95% CI [-0.16, .21]. On the three-boxes task, the majority of children were able to pass the task by 18 months, a percentage that significantly increased from 14 to 18 months of age, McNemar  $\chi^2(1, n = 45) = 13.89, p < .001, p_1 - p_2 = .44$ , 95% CI [.24, .65]. Finally, in the imitation sorting task, the percentage of children who passed significantly increased from 14 to 18 months of age, McNemar  $\chi^2(1, n = 45) = 16.06, p < .001, p_1 - p_2 = .40$ , 95% CI [.23, .57].

**Cohesion in EF measures and longitudinal stability.** There did not appear to be much cohesion between EF tasks at 14 or 18 months of age, as the majority of associations between EF performance were not significant at either age ( $r_{\Phi}s < .17, ps > .26$ ). Only performance on the imitation sorting task was related to performance on the forbidden toy task at 14 months ( $r_{\Phi} = .32, p = .03$ ; see Tables 2 and 3). The only task that demonstrated longitudinal stability from 14 to 18 months of age was the imitation sorting task ( $r_{\Phi} = .42, p = .01$ ). Performance was not related from 14 to 18 months for the A-not-B task ( $r_{\Phi} = .04, p = .83$ ), the forbidden toy task ( $r_{\Phi} = .18, p = .23$ ), or the three-boxes task ( $r_{\Phi} = .04, p = .80$ ).

<sup>3</sup> Continuous measures of performance on EF tasks were also measured and analyzed and yielded similar results.



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

Measure	14 months				18 months			
	<i>M</i> ( <i>SE</i> )	95% CI	Range	<i>n</i>	<i>M</i> ( <i>SE</i> )	95% CI	Range	<i>n</i>
Executive function measures (proportion passing task)								
A-not-B								
A trials	.72 (.07)	[.58, .86]	0–1	47	.96 (.03)	[.89, 1.03]	0–1	47
First B trial	.09 (.05)	[–.02, .20]	0–1	34	.29 (.07)	[.15, .43]	0–1	45
Forbidden toy	.26 (.06)	[.12, .40]	0–1	46	.28 (.07)	[.14, .42]	0–1	47
Three-boxes	.22 (.06)	[.09, .35]	0–1	45	.66 (.07)	[.51, .81]	0–1	47
Imitation sorting	.22 (.06)	[.09, .35]	0–1	45	.62 (.07)	[.47, .77]	0–1	47
Total EF tasks passed	.73 (.13)	[.47, .98]	0–3	44	1.83 (.14)	[1.55, 2.11]	0–4	47
Joint attention and language measures								
IJA								
IJA total	9.45 (.80)	[7.82, 11.07]	1–25	47	8.15 (.54)	[7.06, 9.24]	0–18	47
IJA-higher/lower ratio	.13 (.03)	[.07, .19]	0–1	47	.15 (.03)	[.10, .20]	0–.67	47
RJA total	2.47 (.16)	[2.14, 2.80]	0–4	47	3.47 (.13)	[3.20, 3.73]	0–4	47
IBR total	9.09 (.47)	[8.13, 10.04]	1–19	47	8.45 (.45)	[7.54, 9.35]	3–14	47
Language Measures								
CDI comprehension	125.49 (11.20)	[102.88, 148.10]	15–304	43	245.09 (13.45)	[217.97, 272.21]	45–390	44
CDI production	18.28 (2.28)	[13.68, 22.88]	0–67	43	91.52 (11.82)	[67.69, 115.35]	48–390	44

Note. *N* = 47. CI = confidence interval; EF = executive function; IJA = initiating joint attention; RJA = responding to joint attention; IBR = initiating behavioral requests; CDI = MacArthur-Bates Communicative Development Inventories (Fenson et al., 2007).

### Joint Attention and Language Abilities in the 2nd Year of Life

Descriptive statistics for performance on joint attention and language measures at 14 and 18 months are displayed in Table 1. Measures of joint attention performance and language were continuous, as specified by the ESCS (Mundy et al., 2003) and CDI (Fenson et al., 2007), and parametric statistics were used to examine growth from 14 to 18 months (i.e., paired *t* tests) and associations (i.e., simple bivariate correlations) between joint attention and language measures. Children were only included in longitudinal analyses if they had data at both time points. Joint attention abilities and language were not significantly related to sex at either age (*r*s < .22, *p*s > .15); therefore, sex was not further considered as a variable in joint attention and language analyses.

**Joint attention and language performance and growth.** 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, Cohen's *d* = .26. We also examined the IJA-higher ratio (IJA-higher behaviors/total number of IJA behaviors), because it was recommended by Mundy and Gomes (1998) to measure children's tendency to use higher level IJA behaviors (e.g., protodeclarative pointing). The IJA ratio did not change from 14 to 18 months, *t*(46) = .58, *p* = .57, Cohen's *d* = .08. RJA behaviors (i.e., behaviors related to sharing attention initiated by an adult, such as following an adult's gaze) significantly increased from 14 to 18 months of age, *t*(46) = 5.64, *p* < .001, Cohen's *d* = .82, whereas total measures of IBR (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, Cohen's *d* = .15. Finally, there was significant growth in parent report of both language comprehension, *t*(40) = 12.71, *p* < .001, Cohen's *d* = 1.98, and language

Table 2  
Correlations Among Measures at 14 Months

Measure	1	2	3	4	5	6	7	8	9	10	11
1. Sex	—	.09	–.05	.18	.05	–.12	–.04	.13	.21	–.10	–.14
2. A-not-B		—	.03	–.19	.04	–.04	–.07	.12	–.15	–.30 <sup>†</sup>	–.03
3. Forbidden toy			—	.16	.32*	–.17	.05	.16	.12	.13	–.07
4. Three-boxes				—	–.12	–.34*	.11	–.04	.30*	.20	.02
5. Imitation sorting					—	–.03	–.08	.34*	.11	.01	.01
6. IJA total						—	–.16	.21	–.23	–.13	.10
7. IJA ratio							—	–.20	–.04	.07	.15
8. RJA total								—	–.03	.12	–.09
9. IBR total									—	.11	.39*
10. CDI comprehension										—	.24
11. CDI production											—

Note. Phi coefficients are reported for correlations between dichotomous data; otherwise, Pearson correlations are reported. IJA = initiating joint attention; RJA = responding to joint attention; IBR = initiating behavioral requests; CDI = MacArthur-Bates Communicative Development Inventories (Fenson et al., 2007).  
<sup>†</sup> *p* ≤ .10. \* *p* ≤ .05.

Table 3  
Correlations Among Measures at 18 Months

Measure	1	2	3	4	5	6	7	8	9	10	11
1. Sex	—	-.19	.10	.14	-.04	.08	-.20	.06	-.21	-.07	.06
2. A-not-B		—	-.08	.06	-.01	-.08	-.08	.15	.13	.02	-.05
3. Forbidden toy			—	.04	.00	.29*	-.14	-.01	-.33*	.08	-.11
4. Three-boxes				—	.08	-.25 <sup>†</sup>	-.03	.28 <sup>†</sup>	-.03	.11	.03
5. Imitation sorting					—	-.09	.10	.12	-.14	.12	-.10
6. IJA total						—	-.22	-.02	-.18	-.20	-.02
7. IJA ratio							—	.12	-.17	.32*	.15
8. RJA total								—	-.17	.13	.27 <sup>†</sup>
9. IBR total									—	-.24	-.20
10. CDI comprehension										—	.49**
11. CDI production											—

Note. Phi coefficients are reported for correlations between dichotomous data; otherwise, Pearson correlations are reported. IJA = initiating joint attention; RJA = responding to joint attention; IBR = initiating behavioral requests; CDI = MacArthur-Bates Communicative Development Inventories (Fenson et al., 2007).

<sup>†</sup>  $p \leq .10$ . \*  $p \leq .05$ . \*\*  $p \leq .01$ .

production,  $t(40) = 6.80, p < .001$ , Cohen's  $d = 1.06$ , from 14 to 18 months of age.

**Correlations between joint attention and language measures.** Relationships between joint attention measures demonstrated that dimensions of joint attention were distinct and unrelated, similar to the findings of previous studies of joint attention using the ESCS (e.g., Mundy et al., 2007). At both 14 months (see Table 2) and 18 months (see Table 3), none of the distinct joint attention measures were related to each other,  $r(45) < .22, ps > .11$ . Regarding language measures, only IBR total and CDI production were significantly related at 14 months,  $r(41) = .39, p = .01$ . At 18 months, CDI comprehension was related to IJA ratio,  $r(42) = .32, p = .04$ , whereas CDI production was marginally related to RJA total,  $r(42) = .27, p = .08$ .

**Longitudinal stability.** There was modest stability in joint attention measures from 14 to 18 months, which is also consistent with the findings of previous studies (e.g., Mundy et al., 2007). IJA-total scores at 14 months were significantly correlated with IJA-total scores at 18 months,  $r(45) = .46, p = .001$ . However, IJA ratio did not demonstrate stability across the 4-month period,  $r(45) = .03, p = .84$ . 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,  $r(45) = .12, p = .41$ . Both language comprehension and production showed strong longitudinal stability,  $r(41) = .73, ps < .001$ .

### Correlations Among EF, Joint Attention, and Language

We conducted simple bivariate correlations appropriate for examining associations between two continuous variables (i.e., Pearson's  $rs$ ) and a dichotomous and continuous variable (i.e., point biserial correlations, a special case of Pearson's  $rs$ ) to examine the relationships among EF, joint attention, and language (see Tables 2 and 3). Contrary to our hypothesis, the results did not reveal a relationship between IJA ratio and better EF at either 14 months or 18 months ( $rs < .12, ps > .36$ ), and IJA total was only positively related to one EF task at 18 months, the forbidden toy task,  $r(45) = .29, p = .05$ , and was significantly or marginally negatively related

to the three-boxes task at 14 months,  $r(43) = -.34, p = .02$ , and 18 months,  $r(45) = -.25, p = .09$ .

Although we hypothesized that it was unlikely that non-IJA behaviors would be related to EF (see, e.g., Nichols, Fox, & Mundy, 2005), this was not entirely supported. RJA was positively related to performance on the imitation sorting task at 14 months,  $r(43) = .34, p = .02$ , and marginally related to performance on the three-boxes task at 18 months,  $r(45) = .28, p = .06$ . IBR was positively related to performance on the three-boxes task at 14 months,  $r(43) = .30, p = .05$ , and negatively related to performance on the forbidden toy task at 18 months,  $r(45) = -.33, p = .03$ . Finally, language seemed to show little relation to EF, with the exception of language comprehension, which was marginally negatively related to 14-month-olds' performance on the A-not-B task,  $r(30) = -.30, p = .10$ .

### Prediction of EF and Joint Attention Abilities

It is not entirely surprising that our hypothesis that IJA ratio would relate to better EF was not supported in light of examination of performance across individual EF tasks. Most studies examining EF separate specific task demands by extracting an estimate of common EF from a battery of EF tasks (see Wiebe et al., 2008, 2011). However, the lack of stability and cohesion across EF tasks prohibited this approach with the current data. Although the data suggest that the majority of children do not exhibit cohesive EF abilities in the 2nd year of life, it is possible that examining passing behavior across several EF tasks could reveal a subset of children who demonstrated superior EF abilities across multiple EF tasks. To address this possibility, we totaled the number of EF tasks that children passed at 14 and 18 months of age (see Table 1), which resulted in a relatively normal distribution at 14 months (skewness = .81,  $SE = .36$ ; kurtosis =  $-.40, SE = .70$ ) and 18 months (skewness =  $-.25, SE = .35$ ; kurtosis =  $-.27, SE = .68$ ). At 14 months, there did not appear to be any children who consistently passed EF tasks, as performance was consistently low, with only one child passing three out of four EF tasks. The only significant concurrent correlation at 14 months was between RJA and total number of EF tasks passed,  $r(42) = .36, p = .02$ . IJA total, IJA



ratio, IBR, language comprehension, and language production were not significantly related to total number of EF tasks passed at 14 months ( $r_s < .24$ ,  $p_s > .10$ ). However, by 18 months of age, 23% of the sample passed either three or four of the four EF tasks, and this increase was significant, McNemar  $\chi^2(1, n = 46) = 6.75$ ,  $p = .01$ ,  $p_1 - p_2 = .22$ , 95% CI [.06, .37]. RJA was marginally related to total number of EF tasks passed at 18 months,  $r(45) = .24$ ,  $p = .10$ , and there were no significant concurrent correlations at 18 months between total number of EF tasks passed and IJA total, IJA ratio, IBR total, language comprehension, and language production ( $r_s < .17$ ,  $p_s > .24$ ).

We next conducted a hierarchical linear regression to investigate what factors at 14 months predicted number of EF tasks passed at 18 months (see Table 4). Only children with data for all variables ( $n = 41$ ) were included in this analysis. 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, we included sex, which was not significant ( $\beta = .03$ ,  $p = .85$ ). The next block produced a change in  $R^2$  of .25 ( $p = .02$ ) and demonstrated that number of EF tasks passed at 18 months was predicted by CDI comprehension at 14 months ( $\beta = .30$ ,  $p = .05$ ), indicating that early language was a significant predictor of EF once performance across all tasks was considered. Further, the number of EF tasks passed at 18 months was predicted by the number of EF tasks passed at 14 months ( $\beta = .35$ ,  $p = .03$ ), and the number of EF tasks passed at 14 months was correlated with number of EF tasks passed at 18 months,  $r(42) = .37$ ,  $p = .03$ , demonstrating longitudinal stability and consistency in EF when measured across tasks. Finally, in the last block, all relevant joint attention measures were entered. The only joint attention measure to emerge as a significant predictor of total number of EF tasks passed at 18 months was IJA ratio at 14 months ( $\beta = .57$ ,  $p < .001$ ). 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 change in  $R^2 = .30$  ( $p = .002$ ). Figure 1 shows this relationship between mean IJA ratio at 14 months and later EF at 18 months. As only one child passed four tasks at 18 months, children who passed three and four tasks ( $n = 11$ ) were grouped together to conduct pairwise Mann–Whitney  $U$  tests, justified by the nonnormal distribution of the IJA ratio, (skewness = 2.30,  $SE = 0.35$ ; kurtosis = 5.96,  $SE = 0.68$ ). These analyses revealed that children who passed three or four tasks at 18 months exhibited a significantly higher IJA ratio at 14 months ( $Mdn = .08$ ) than did children who did not pass any tasks ( $Mdn = 0$ ),  $U(n = 16) = 10.00$ ,  $z = 2.19$ ,  $p = .05$ ,  $r = .55$ . Further, children who passed two tasks had a marginally significant higher IJA ratio ( $Mdn = .06$ ) than did children who passed no tasks ( $Mdn = 0$ ),  $U(n = 26) = 25$ ,  $z = 1.99$ ,  $p = .08$ ,  $r = .39$ . No other group comparisons were significant.

Similarly, number of EF tasks passed at 14 months did not emerge as a significant predictor in three similar hierarchical linear regressions predicting IJA ratio, RJA total, and IBR total at 18 months ( $\beta_s = .09$ ,  $.10$ , and  $-.08$ , respectively,  $p_s > .56$ ). However, the number of EF tasks passed at 14 months did predict IJA-total behavior ( $\beta = .31$ ,  $p = .04$ ) once sex, 14-month IJA total, and CDI language measures were accounted for. The final model was significant,  $F(5, 40) = 3.7$ ,  $p = .01$ ,  $R^2 = .35$ .

## Discussion

The findings from the current longitudinal study on early emerging EF abilities suggest that EF during the 2nd year of life shows patterns of development that are distinct from those of the later toddler and preschool years. We found little evidence for internal consistency across EF measures. Although performance was initially poor, children passed more tasks at 18 months of age, and a subset of 18-month-olds demonstrated consistent passing behavior on the majority of EF tasks. Superior EF performance at 18 months was predicted by 14-month EF performance, language comprehension, and higher IJA abilities (e.g., pointing, showing). Taken together, results are indicative of an emerging EF ability supported by representational development.

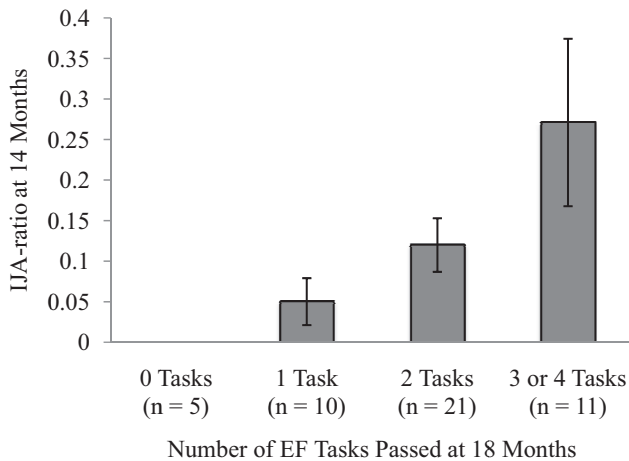
## EF Abilities in the 2nd Year of Life

One goal of the present research was to provide a description of early EF abilities across multiple EF tasks. The lack of internal consistency paired with dramatic growth is consistent with the findings of previous research (i.e., Diamond et al., 1997; Wiebe et al., 2010). This pattern of results extends the finding that there is little internal consistency across EF tasks early in life, as cohesion may only become stronger with age (see Carlson et al., 2004; Hughes & Ensor, 2005, 2007). In the present study, 18-month-olds' improved EF performance and the fact that a subset of 18-month-olds shows consistent passing performance across a majority of EF tasks may be indicative of an emerging common EF (i.e., the ability to hold and use goal-relevant information to guide performance across multiple EF tasks). These data may also speak to the developing structure of EF and suggest that the ability to consciously control behavior across multiple situations is initially absent and emerges across the 2nd year (see Wiebe et al., 2010).

Table 4  
Summary of Regression Analyses for Variables at 14 Months  
Predicting Number of EF Tasks Passed at 18 Months  
(Coefficients Listed by Step)

Variable	<i>B</i>	<i>SE B</i>	$\beta$	$\Delta R^2$
Block 1				.00
Sex	0.06	0.32	.03	
Block 2				.25*
Sex	-0.02	0.30	-.01	
No. of EF tasks passed	0.40	0.17	.35*	
CDI comprehension	0.004	0.002	.30*	
CDI production	-0.01	0.01	-.13	
Block 4				.30**
Sex	-0.02	0.25	-.01	
No. of EF tasks passed	0.41	0.16	.35*	
CDI comprehension	0.004	0.002	.33*	
CDI production	-0.02	0.01	-.24	
IJA total	0.03	0.02	.15	
IJA ratio	2.55	0.56	.57**	
RJA total	0.01	0.07	.01	
IBRs total	0.01	0.05	.03	

Note. EF = executive function; CDI = MacArthur-Bates Communicative Development Inventories (Fenson et al., 2007); IJA = initiating joint attention; RJA = responding to joint attention; IBR = initiating behavioral requests.  
\*  $p < .05$ . \*\*  $p < .01$ .



*Figure 1.* Number of executive function (EF) tasks passed at 18 months by initiating joint attention (IJA)-ratio at 14 months. Children who passed 3 or 4 EF tasks at 18 months had significantly higher IJA-ratios at 14 months compared to children who passed 0 tasks. Further, children who passed 2 tasks at 18 months had marginally higher IJA-ratios at 14 months compared with children who passed 0 tasks. Mean IJA ratio is presented with standard error bars on each column.

This provides a starting point for existing frameworks suggesting that performance is best explained by an initially absent but emerging EF in the 2nd year, a common EF factor in preschool (i.e., the ability to maintain task-relevant information, Wiebe et al., 2008), and is expanded on with the addition of component-specific abilities in shifting and WM into later childhood and adulthood (e.g., Miyake & Friedman, 2012).

Another possible contributor to the different pattern of results in the 2nd year of life could occur at the level of measurement. For example, the fact that the various EF tasks were not strongly related could lead one to question whether EF responses can be validly and reliably assessed in children this young. It is possible that, in the present study, we found different patterns of EF development in the 2nd year (compared with preschool EF development) because of the difficulty of measuring EF in children this young. The fact that our results replicated previous findings in the literature (Diamond et al., 1997; Wiebe et al., 2010) suggests that this pattern of results is typical for this age, 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 2nd 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).

The emergence of a common EF ability can explain other patterns of development distinct to the 2nd year. For instance, the lack of longitudinal stability on individual EF tasks from 14 to 18 months of age also contrasts with stable individual differences in EF across various time points during the toddler and preschool

years (e.g., Carlson et al., 2004; Hughes & Ensor, 2007). Wiebe et al. (2010) also demonstrated a lack of stability in the 2nd year and suggested that frequent assessments may address difficulty in detecting stability within this rapidly developing age range. However, if this rapid development reflects the emergence of a common EF ability emerging during this period, we would not expect children's behavior at the first time point to be related to behavior at the second time point. For instance, if a 14-month-old's behavior is influenced by environmental cues (e.g., in the A-not-B task, seeing the object hidden at B automatically inhibits responding at A; see Jacques & Marcovitch, 2010; Perner, Strummer, & Lang, 1999) rather than a common EF ability, then this responding would not necessarily be correlated with more sophisticated EF performance or other cognitive abilities (i.e., language and joint attention).

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, examination of EF across a multitude of tasks may address this issue. The present study revealed a subgroup 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, whereas children passing few EF tasks may have relied 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). Although the lack of cohesion in performance across EF tasks prohibited us from creating a composite EF score, once we examined overall EF performance via the number of EF tasks passed, there was partial evidence for longitudinal stability (i.e., the number of EF tasks passed at 14 months predicted the number of EF tasks passed at 18 months) and relation to language (i.e., word comprehension at 14 months predicted EF at 18 months). This aligns with studies of 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).

### Relationship Between EF and Representational Abilities in the 2nd Year of Life

Our examination of children's representational ability also speaks to the emergence of a common EF during this early period of development. The fact that word comprehension and higher IJA behaviors (i.e., pointing and showing) predicted the number of EF tasks passed at 18 months aligns nicely with Wiebe et al.'s (2010) assertion that maintaining goal-relevant information may underlie steady improvement across EF tasks in the 2nd year of life. Critical developments in representation (e.g., labeling) should correspond to a common EF ability responsible for maintaining task-relevant information to guide behavior across EF tasks. However, this representation-EF relationship does more than provide construct validity for our examination of a common EF, it speaks to the mechanisms underlying EF development and supports models (Marcovitch & Zelazo, 2006, 2009; Zelazo, 2004) claiming that the transition to a more sophisticated EF ability is dependent on the representational abilities of the child. Indeed, to maintain and use relevant information to guide behavior, one must first be able to represent and reflect on that information. In the first years of life, the aspect of representation that held the most predictive power for

EF was IJA, as the tendency to initiate higher levels of joint attention at 14 months explained a large portion of the variance in the number of EF tasks children passed at 18 months of age, even after accounting for language and EF performance at 14 months of age. According to Zelazo's (2004) LoC model, these higher IJA behaviors represent the first higher level of consciousness emerging at the end of the 1st year of life, when children create labels to reflect on relevant stimuli to guide behavior. Specifically, pointing is related to labels linking stimuli to semantic memory, permitting a higher level of awareness of objects within their current experience. This allows children to respond on the basis of conscious representations of relevant stimuli rather than habitually (Marcovitch & Zelazo, 2009).

One of the more curious findings of the present study was the lack of concurrent relationships between EF and higher IJA at both 14 and 18 months of age. In fact, lower levels of RJA behaviors were related to EF tasks at both 14 and 18 months. Further, RJA was significantly related to the total number of EF tasks passed at 14 months and marginally related to the number of EF tasks passed at 18 months. This is in line with Posner et al.'s (2012) proposal that the orienting attention system is initially important to regulation of behavior before children transition to control mediated by the executive attention system. More specifically, although common EF may begin to emerge during this period, a large number of children may not have developed a common EF ability or transitioned to regulation guided by the executive attention system, as demonstrated by their inability to guide behavior across multiple contexts during the 2nd year. In the absence of a controlled, internally mediated means of responding to the environment, children may rely on basic selective-attention abilities within the orienting attention system (Posner et al., 2012; Ruff & Rothbart, 1996). These basic selective-attention abilities are likely reflected by RJA, which is the only measure in the joint attention battery related to the orienting of children's attention to social stimuli (Mundy & Newell, 2007). 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. Cuevas and Bell (2014) have also shown that orienting abilities at 5 months of age related to EF measured later at 24, 36, and 48 months, and they have proposed that this may reflect the increasing synchrony between the two attention systems. Specifically, any early connectivity of the orienting attention system to the prefrontal cortex would be particularly significant, as the prefrontal cortex has been shown to play a significant role in later EF. Finally, it is important to note that RJA seems to become less important to EF with age, which is perhaps indicative of the transition of regulation guided by the orienting system to control via the executive attention system.

However, the contribution of executive attention to EF cannot be easily addressed in the current data. Mundy and Newell's (2007) proposal that IJA is linked to the development of the executive attention system (i.e., the system some hypothesize to underlie self-regulation or executive attention; Posner & Rothbart, 2007) makes it difficult to discern whether the EF-IJA relationship we found is attributable to developments in representation, the executive attention system, or some combination of the two. Although IJA likely draws on the developing executive attention system, and the EF-IJA relationship may be suggestive of the transition to behavior controlled by the executive attention system

(Posner et al., 2012), for several reasons we do not believe that the EF-IJA relationship only reflects improvements in the executive attention system. First, if IJA was just a proxy for measuring the executive attention system, we might expect to see concurrent EF-IJA relationships. Second, Mundy and Newell suggested that total IJA (i.e., all child-initiated sharing attention behaviors, including alternating gaze) is linked to the executive attention system. In contrast, our results suggest that there is something specific about the tendency to use higher IJA (i.e., only behaviors like declarative pointing and showing) that longitudinally predicts later control of behavior. We propose that higher IJA at 14 months more accurately reflects specific developments in representation (e.g., Zelazo, 2004), because these declarative behaviors are most strongly related to language (Colonnesi et al., 2010). A representational interpretation of our data is also supported by the fact that 14-month-old language comprehension also predicted EF at 18 months.

The fact that EF performance at 18 months was related to 14-month-olds' language comprehension also extends the established relationship between linguistic representation and EF in preschool (e.g., Jacques & Zelazo, 2005; Kirkham, Cruess, & Diamond, 2003; Miller & Marcovitch, 2011; Towse, Redbond, Houston-Price, & Cook, 2000) to an even younger age. However, perhaps a more interesting finding is that nonverbal means of representation seemed to account for variance in later EF, even after language at 14 months was accounted for. This finding contributes to an emerging body of work that has uncovered a link between nonverbal representation (i.e., gesturing) and EF in preschoolers (e.g., O'Neill & Miller, 2013) and adults (Beilock & Goldin-Meadow, 2010). It also extends the adult finding that gesture independently contributes to EF performance (Beilock & Goldin-Meadow, 2010) to younger ages. Related to this last point, examining nonverbal means of representation may be especially important with young children, because they are in the beginning stages of language. Further work examining the specific contributions of verbal and nonverbal representation across different periods of development and experimental work encouraging children to use higher levels of IJA (e.g., pointing) within an EF context may further elucidate the relationship between early nonverbal representation and EF.

In addition, the EF-IJA relationship speaks 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., IBR behaviors; 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 (1930–1935/1978) classic work suggesting that representational and symbolic thought emerge 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, with representational meaning of a gesture being 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, requesting). Further, it has been suggested that more active joint attention behaviors (e.g., pointing to manipulate others' attention) imply sophisticated social representation (Tomasello, Carpenter, Call, Behne, & Moll, 2005) related to understanding the roles of all individuals involved in a collaborative engagement.

The present work also adds a social component to representational models, suggesting that the early representations that guide behavior are socially constructed (e.g., Miller & Marcovitch, 2011, 2012). A social representational approach to EF may be particularly important to 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, 1930–1935/1978). 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 level of consciousness (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 the emergence of EF for this specific age range, within which 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., theory of mind, social cognition, peer relationships) and EF in children with autism (e.g., one hypothesis is that disruptions in EF could be traced to social–communicative issues that lead to differences in the representational system).

### Limitations, Conclusions, and Future Directions

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 2nd 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, construction of an appropriate EF battery is a challenge for this age range, because there are few developed measures. In the present study, we attempted 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.

Further, limitations in statistical power in the present study must be acknowledged. We suggested a possible trajectory, in which EF

is initially absent and emerges in the 2nd year, is best explained by a unitary factor in preschool, and becomes differentiated into adulthood. However, the lack of EF unity and diversity (Miyake et al., 2000) in the present study was a result of a very small sample size and a model that did not employ latent variable models, which limited ability to detect these relationships. Studies including more measures of EF (e.g., Wiebe et al., 2011) and larger sample sizes are needed to corroborate the emergence of a common EF ability suggested by the present results and Wiebe et al. (2010).

Furthermore, it is unclear how the EF tasks selected for 14- and 18-month-olds relate to EF later in life. Additional studies examining the psychometric properties (e.g., Beck et al., 2011) and longitudinal trajectory of EF from infancy to preschool could help to identify 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 of age that children begin to succeed reliably across multiple EF contexts. In addition, the 2nd 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 2nd year of life. Addressing these issues can bring us closer to understanding how this complex ability of cognitive control emerges over the first few years of life.

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