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RESEARCH ARTICLE

Emerging coherence and relations to communication among executive function tasks in toddlers: Evidence from a Latin American sample

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Abstract

Recent work within early executive function (EF) seems to suggest that toddlers show distinct patterns of development, involving poorly correlated performance across EF tasks and significant improvements over relatively short periods of time. The present study sought to extend these findings by investigating evidence for these patterns in toddlers and the existence of more traditional patterns of EF (e.g., correlations between tasks, links to language) when using the same tasks in a novel Latin American sample. Eighty toddlers (18–24 months) and sixty young preschoolers (30–36) months completed a battery of EF tasks, early social communication, and receptive and expressive language measures. Results indicated that toddlers showed similar distinct patterns of development (i.e., few relations between tasks and links to responding to joint attention), but by early preschool a more cohesive EF and links to language were present. Further, work demonstrated significant age (older children outperformed younger children), gender (girls outperformed boys), and socioeconomic differences (satisfied basic needs outperformed unsatisfied basic needs, but only on the snack delay). This work provides evidence for patterns of emerging EF development within this novel cultural sample (and evidence for group differences) that may be supported by communicative and representational development.

1 | INTRODUCTION

Although work demonstrates goal-directed behavior in the first years of life, until recently, the early study of controlled behavior generally shied away from studying these behaviors as executive function (i.e., EF or conscious control of behavior). This could be for several reasons. For one, the study of EF originated in the adult neuropsychological literature, when researchers equated lapses in EF with consistently observed failures in active control across novel problem-solving tasks in patients with frontal lobe damage (e.g., Norman & Shallice, 1986). Thus, it may not have seemed appropriate to study EF during infancy and toddlerhood—a period of relative immaturity in the prefrontal cortex (e.g., Diamond, 2006). Second, EF work marked the preschool years as a period developmental significance (Zelazo et al., 2003), perhaps initially indicating preschool as a period of emergence for EF. Finally, the mechanics of studying controlled cognition in infants tend to look quite different from the study of EF with older samples. Although there is a plethora of work indicating infants and toddlers exhibit controlled goal-directed behavior, these are usually studied as individual instances within specific literature (e.g., working memory, problem-solving, temperament, means-end behavior, motor control, see Adolph et al., 2009; Alp, 1994; Chen et al., 1997; Diamond & Doar, 1989; Kochanska et al., 1998; Pelphrey & Reznick, 2002; Willatts, 1999) rather than the broader EF literature. This is not to say that no studies within the first 2 years refer to EF. Indeed, the A-not-B task (i.e., tasks that involve searching for an object at a new location B after repeatedly finding it at another location A) has been proposed as an early measure of EF (e.g., Diamond, 2006; Diamond et al., 1997; Garon et al., 2008; Marcovitch & Zelazo, 2009; Wiebe et al., 2010) because it involves holding the new search location in mind, inhibiting search to the old location, and flexibly switching to the new location (see also Wiebe & Bauer, 2005 for other early EF tasks). This approach of examining performance within individual tasks has been informative to understanding age-related shifts in EF and related abilities in infants and toddlers (e.g., Garon et al., 2008), although it is likely that this approach does not tell the whole story of early EF development.

One difference in infant and toddler EF work is the reliance on singular tasks to understand EF-related abilities. Notably, the study of EF suffers from the task impurity problem (Miyake et al., 2000; Wiebe et al., 2011), which refers to the issue of obtaining a clear measure of EF when tasks involve many other abilities (e.g., communication/language, spatial ability). Although this is likely not a problem within these individual literatures (e.g., understanding age-related abilities in controlling motor behavior, Adolph et al., 2009), using singular tasks or integrating evidence across multiple domains to inform the study of EF as a domain-general higher-order cognitive skill has limitations. EF work in older samples has partially relied on the study of behavioral and cognitive control across a multitude of tasks to address these issues. This approach originated with the dissociable or componential approach focused on understanding the structure of EF (e.g., Miyake et al., 2000), which initially proposed that examining performance across multiple tasks requiring behavioral and cognitive control revealed a 3-factor structure where EF performance could be separated into distinct components: (a) cognitive flexibility or to the ability to change and flexibly switch focus and responses to adapt to changes in the environment, (b) working memory (WM) related to the ability to hold and manipulate increasing amounts of task-relevant information in mind over delays, and (c) inhibitory control referring to the capacity to resist or suppress prepotent effects or behaviors to reach a goal (Miyake & Friedman, 2012; Miyake et al., 2000). This approach contrasted with the initial unitary accounts, suggesting a single control mechanism (usually related to attention) responsible for cognitive control across a variety of EF tasks (e.g., Baddeley, 1992; Norman & Shallice, 1986) and also in low-SES samples (Willoughby et al., 2010). However, recent works have seemingly reconciled these two perspectives, with Miyake and Friedman (2012) updating their framework—now termed the unity/diversity framework—to shift focus to examining common EF (i.e., related to the ability to maintain task-relevant information which guides lower-level processes toward executing a goal). This common EF is thought to be required across all EF tasks with the potential for component-specific abilities (i.e., WM, inhibitory control, and flexibility-specific abilities) also required for the conscious control of behavior.

Developmentally, examining a potentially changing structure of EF by examining performance across multiple tasks is intriguing. Although there is evidence for independent contributions of component-specific abilities in older school-age children (e.g., Lehto et al., 2003), researcher questioned whether component-specific abilities in WM, inhibitory control, and flexibility were fully developed in preschool and suggested EF may be best explained by a unitary EF factor (e.g., Wiebe et al., 2011)—perhaps similar to Miyake and Friedman's (2012) common EF. Work with children from 2 to 4 years of age shows that EF at 2 years of age do show correlations between tasks (e.g., Bernier et al., 2011; Carlson et al., 2004; Hughes & Ensor, 2007) and internal consistency of an EF index is initially modest for younger 2- and 3-year-olds, and good by age 4 (Hughes & Ensor, 2007). With regard to EF development in infants and toddlers younger than 24 months of age, the little work that exists examining performance across multiple tasks during this period suggests another developmental pattern—namely, EF tasks involving conscious control that should correlate given task demands often do not (Devine et al., 2019; Diamond et al., 1997; Miller & Marcovitch, 2015; Wiebe et al., 2010, see also work by Bernier et al. (2011) for work showing initially unrelated EF performance before 24 months with increasing correlations early in the third year). Researchers have suggested this indicates an initially absent but emerging EF ability linked to Miyake and Friedman's conceptualization of common EF (e.g., Devine et al., 2019; Miller & Marcovitch, 2015). However, more work is needed to understand the structure and individual differences seen in EF performance across the first years of life and potential parallels to later EF work.

In the present study, we examine EF across multiple tasks in both toddlers (i.e., 18–24 months) and young preschoolers (i.e., 30–36 months) to contribute to existing data suggesting an initially amorphous but emerging EF structure in the less-studied toddler years (Devine et al., 2019; Diamond et al., 1997; Miller & Marcovitch, 2015; Wiebe et al., 2010). We extend the existing literature in several ways. First, we examine performance across multiple EF tasks in a less-studied toddler sample in addition to the more typically studied preschool years. To date, one of the criticisms of an initially absent but emerging EF is that the EF tasks administered to younger samples lack continuity with EF assessments in older samples and may not be valid and reliable assessments of EF (e.g., Devine et al., 2019). Given that multiple studies have now replicated a lack of relations between multiple EF tasks in the toddler years and that these assessments do not suffer from restrictions in performance variability (e.g., Devine et al., 2019; Johansson et al., 2016; Miller & Marcovitch, 2015), this has alleviated the latter concern. However, there is still the issue that EF assessments at this young age typically look much different than the assessments in later preschool and beyond, questioning whether the tasks themselves assess EF in a similar manner to measures later in life. To address this concern, in the present study we examine not only performance across a battery of EF tasks in toddlers, but also performance in a young preschool sample as well to determine whether the EF patterns typically seen in older samples (e.g., correlations among measures, links with language) are replicated when using tasks appropriate for younger samples.

Second, we examined links to communication and language as another way to address the validity of EF tasks at this young age and link to theoretical models of emerging EF. One of the most studied complementary abilities to developing EF has been strong links to communication and language (e.g., Cragg & Nation, 2010; Jacques & Zelazo, 2005; Winsler et al., 2009), which has been discussed as one of the main instruments of cognitive regulation since Vygotsky's proposal regarding the utility of internal speech (Vygotsky, 1986). In young preschoolers and toddlers, these communications skills are often developing so relations to language and communication more broadly defined (e.g., joint or shared attention, gesture) have been examined. For example, within the second year a number of studies have linked EF-related abilities to non-verbal communication related to gestures, with authors suggesting: (a) private gestures have the function of directing infants' behavior (Basilio & Rodríguez, 2017; Kuvalja et al., 2013), (b) cognitive abilities common to EF link to gestures and language (Kuhn et al., 2014, 2016), and (c) during joint attention episodes parents scaffold basic components of cognitive control (Brandes-Aitken et al., 2020). In addition, studies have found EF links to initiating joint attention (i.e., IJA, internally motivated sharing of interest and experiences with adults), with authors suggesting infants must represent and reflect on the representation to guide sharing behavior (Miller & Marcovitch, 2015). Receptive and expressive language also show links to EF-related abilities in the second and into the third year (e.g., Carlson et al., 2004; Miller & Marcovitch, 2015; Vallotton & Ayoub, 2011; Vaughn et al., 1984). The extension of this early communication–EF link to younger samples not only replicates patterns found in older samples, but also aligns with representational accounts of EF (Marcovitch & Zelazo, 2009; Miller & Marcovitch, 2015; Zelazo, 2004, 2015) arguing that the developing ability to form and reflect on task-relevant representations during an EF task may drive the emergence of consciously controlled behavior and the ability to follow more complex rules (Zelazo, 2004, see also Kuhn et al., 2016; Kuhn et al., 2014).

Third, one particular challenge of the infant and toddler EF work is that research has consistently demonstrated null relations between EF tasks (Devine et al., 2019; Diamond et al., 1997; Miller & Marcovitch, 2015; Wiebe et al., 2010). Given potential publication bias toward publishing significant over nonsignificant findings (e.g., Ferguson & Heene, 2012), it is encouraging that papers have documented null findings that contradict the positive relations among tasks typically seen in older samples. However, null findings elicit additional challenges, such that null hypothesis significance testing does not lend itself to necessarily accepting the null hypothesis (i.e., a lack of relations among EF task). Thus, one important consideration to research in early EF is replication. This study not only aimed to replicate these null relations among EF tasks, but attempted to do so in a novel cultural sample.

Specifically, in the present study, we examine a novel Latin American sample. The majority of early EF work is conducted with samples from westernized often mid- to high-SES samples from North America and Europe. In contrast, Latin America is a region typically considered a collectivist culture, albeit likely showing cohesion in a different manner as compared to more typically studied Asian cultures (e.g., involving extended family and peers, multiple Latin ethnicities, Hofstede, 1989; Mesurado et al., 2016; Triandis, 2001). Further, according to the most recent reports (CEPAL, 2020), poverty in Latin America affect a large portion of the population (37.3% and 230.9 million people), with extreme poverty affecting 15.5% of the total population. Studies have shown that vulnerable contexts in Latin America are related to low educational level (incomplete secondary school), reduced maternal and paternal sensitivity, informal jobs, and overcrowding and precarious housing (CEPAL, 2020; Clerici et al., 2020), which has been linked to lower scores in cognitive tasks (Hermida et al., 2019; Lipina et al., 2004). Although this study does not utilize cross-cultural comparisons, it is informative to determine whether hypothesized universals (e.g., initially amorphous but emerging EF) do indeed exist across multiple cultures. Examination of a Latin American sample will provide a novel cultural sample compared to what is typically studied and may help us understand possible points for differentiation in early EF, as studies with older children have shown EF advantages in collectivists compared to more individualistic cultures (e.g., Hong Kong vs. the United Kingdom, Wang et al., 2016).

Finally, hypothesized universals do not negate the possibility of differences in the developmental timetable. We examined two group differences in the present study—social vulnerability/socio-economic status (SES) and gender. Work has already demonstrated EF limitations in samples with lower SES in older samples (Arán-Filippetti, 2013; Brandes-Aitken et al., 2020; Hermida et al., 2019; Hughes & Ensor, 2007; Willoughby et al., 2010), with few studies replicating these differences in samples under 24 months, likely due to the fact that there is less research and fewer assessments designed for toddlers relative to older samples (e.g., Gago Galvagno et al., 2019; Hughes & Ensor, 2007; Veer et al., 2017). In addition, work showing gender differences in EF are equivocal, with girls tending to perform better on different EF and communication measures in the first 3 years (e.g., Espy et al., 1999; Lipina et al., 2004; Silva et al., 2017; Weinberg et al., 1999, but see Lind et al., 2017; Lindsey et al., 2010).

2 | METHOD

2.1 | Participants

Caregiver–infant dyads (n = 150, 96% mothers) were recruited from daycare centers (n = 105) and homes in the Autonomous City and Province of Buenos Aires. Ten infants were excluded because of identified symptoms of hearing loss and autism spectrum disorder (n = 2), refusal to participate (n = 4), Spanish was not the first language (n = 1), and premature birth (n = 3). The final sample consisted of eighty 18- to 24-month-olds (M_{age} = 21.33, SD = 2.70, female = 42) and sixty 30- to 36-month-olds (M_{age} = 33.28, SD = 3.02, female = 31). Infants were primarily Argentine (n = 137), typically developing, with Spanish as the primary language.

2.2 | Procedure

Sessions (approximately 40 min) were videotaped with children seated in their caregiver's lap with a table between the child the experimenter. The present study was conducted according to guidelines laid down in the Declaration of Helsinki, with written informed consent obtained from all guardians for each child before any assessment or data collection. All procedures involving human subjects in this study were approved by the Comité de Conductas Responsables of the Universidad de Buenos Aires.

Caregivers were instructed not to give any help or cues, respond in a natural way, and to direct attention to the experimenter if children tried to engage them. The same male evaluator presented the tasks on a table in the same order: (a) object spectacle, (b) book presentation, (c) gaze tracking, (d) A-not-B, (e) spatial reversal, (f) snack delay, (g) PLS-5 (30–36 months only), and (h) sociodemographic questionnaire. Table 1 describes all of the tasks administered and the behaviors coded from each task (i.e., both continuous and dichotomous measures) in the order that they were presented.

2.3 | EF assessment

For reliability, the primary coder scored EF performance for each task via video recording. A second coder scored 35 randomly selected videos (approximately 25% for each age-group). Inter-rater

TABLE 1 Summary of communication and executive function tasks administered

Task	Brief description of task	Measured behavior from the task
Early social communication tasks		
Object spectacle task	One of the four toys (i.e., toy car, balloon, a rubber toy that whistled, and a rope toy) was presented in front but out of direct reach of children on three occasions for approximately 6 s each presentation. If children attempted IJA 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	**IJA:** child points to an object to share attention to the object with another **IBR:** child extends their arm as an attempt to obtain the toy **Vocalizations:** words said within the task
Book presentation task	Children were presented with the book ¡A comer! of the tin cat® edition Guadal for 20 s that contained images of different foods and objects. The experimenter pointed for 6 s on each page of the book and asked, "What do you see here?”	**IJA:** child points to a picture in the book to share attention before the tester has pointed **RJA:** child turns head/eyes to look where the experimenter points **IBR:** child extends their arm to obtain the book out of reach **Vocalizations:** words said within the task
Gaze-following task	Four colorful posters were placed to the left, back left, back right, and right of the infant. There were four trials in which the experimenter called children by name, turned their torso, and pointed to the poster by slightly raising their elbow and looking at the poster and commenting (e.g., “Did you see the doll?”)	**IJA:** child points to the poster to share attention before the experimenter pointed **RJA:** child turns head/eyes to look where the experimenter points **IBR:** child extends their arm to obtain the poster out of reach **Vocalizations:** words said within the task

(Continues)

TABLE 1 (Continued)

Task	Brief description of task	Measured behavior from the task
Executive function tasks		
A-not-B (Miller & Marcovitch, 2015)	The *hiding apparatus* consisted of 5 sealed wells covered by blue felt embedded in a semicircle configuration in a wooden box During *training* children chose one of three dolls to be placed in the central well (other wells covered) to familiarize children with task goals (i.e., searching for the doll) In the *A-trial phase*, all 5 hiding locations were visible and the toy was hidden in location A in view of the child. Next, the experimenter covered the hiding locations, counted to 10, and presented the apparatus for children to search. They were rewarded with play if correct and shown the location if incorrect. A-trials were repeated until children found the object three times at location A. In the *B-trial phase*, the object was moved to a new location, location B in view of the child (counterbalanced, on the opposite side of the midline). Search was terminated after 10 B trials	**Error run:** number of incorrect searches **Passing behavior:** whether children successfully completed the task (i.e., search correctly twice in B)
Spatial reversal task (Espy et al., 1999)	Two plastic containers were placed on blue fabric and a toy was hidden in one container (container A) out of children's sight behind a cardboard screen. The screen was removed, and children were encouraged to search for the toy. They were rewarded with play if correct and shown the location if incorrect. This was repeated until children found the object four times at container A. Next, the experimenter moved the toy to a new position, container B, out of children's sight and they were again encouraged to search for the toy. This procedure was repeated until children found the object at location B twice. Search at location B was terminated after 10 B trials	**Perseveration:** searches back to container A once the object was moved to container B **Passing behavior:** whether children successfully completed the task (i.e., searched correctly twice in container B)
Snack delay (Kochanska et al., 1998)	A Mini Oreo® cookie was placed on a dish and a transparent plastic container was placed on top. The experimenter told children "you can eat the cookie when the bell rings, you have to wait" and imposed a delay (3 trials: 10-, 20-, and 30-s delay) while holding a neutral face. The experimenter then rang the bell and encouraged children to eat if they had not yet eaten the cookie	**Latency:** The amount of time it took the infant to touch the container once presented added across 3 trials **Passing behavior:** whether children successfully completed the task (i.e., waited all 3 trials)

Note: For A-not-B error run, although the majority (75%) of responses were perseverative (i.e., exactly to location A), we considered all inaccurate responding in error run.

Abbreviations: IBR, initiating behavioral responses; IJA, initiating joint attention; RJA, responding to joint attention.

reliability for continuous variables (intraclass correlation) was >.92 for both age-groups ($p < .05$). Reliability for all categorical measures (Kappa) was >.96. for all age-groups ($p < .05$).

2.4 | Early social communication scales, ESCS

Table 1 describes the tasks administered from the ESCS and the behaviors coded (i.e., responding to joint attention (RJA), initiating joint attention (IJA), initiating behavioral requests (IBR), and vocalizations) (Mundy et al., 2003). For reliability, a primary coder coded IJA, RJA, IBR instances, and vocalizations for all videos. A second coder recorded instances of these behaviors in 20 randomly selected videos at 2 years, and 15 videos at 3 years (25% of the total). Inter-rater reliability for continuous variables (intraclass correlation) was >.89 ($p < .05$), and for categorical variables (kappa), reliability was >.96 ($p < .05$).

2.5 | Preschool language scale (Fourth Edition, PLS-5

This measure was only administered for the older sample (i.e., 30–36 months) (Zimmerman et al., 2011). To test receptive communication, children were asked to point to the object that corresponded to word stated by the experimenter. Number of correct identifications out of ten trials that increased in difficulty (i.e., more distracting stimuli and more challenging vocabulary) was assessed. Expressive communication was measured by asking children to respond verbally to an image presented by the experimenter (e.g., asking “What is it?"). The number of correct identifications out of 9 trials was assessed. A primary coder measured receptive and expressive behaviors for all videos. A second coder recorded instances of these behaviors in 15 randomly selected videos (25% of the older total). Inter-rater reliability (intraclass correlation) was >.98 for both measures of communication ($p < .05$).

2.6 | Ad-hoc sociodemographic questionnaire

Mothers answered questions regarding the infants' medical records, overcrowding and housing type, and educational level of both parents. From this measure (97% completion), dyads were classified as low SES or unsatisfied basic needs (UBN, $n = 86$, 61%) if they met one of the following: lived in precarious settlement (e.g., shantytown), house had no bathroom or access to drinking water, overcrowding (i.e., more than 3 people per room), elementary school-aged children were not attending school, and parents did not have secondary school education. Fifty-one dyads (36%) who did not meet one of these criteria were considered satisfied basic needs (SBN).

3 | RESULTS

3.1 | Analysis plan

Data were analyzed using SPSS statistical software for Windows (version 25). Based on data screening indicating acceptable sample size, skewness, and kurtosis (and no outliers), we conducted parametric analyses (Kwak & Kim, 2017; West et al., 1995). To examine task performance by age and gender, we conducted MANOVAs. SES differences were examined with Mann–Whitney U tests due to unequal samples. To analyze EF relations between tasks and measures of communication, we examined Pearson's *r* partial correlations for each age-group, controlling for parent education and gender. We also applied exploratory Bayesian Pearson's correlational analyses (i.e., Uniform prior $c = 0$) to supplement frequentist analysis and examine evidence for the null, given repeated null relations between EF tasks in younger samples in the literature. Finally, a hierarchical regression model was used to analyze the relative relation between Verbal and Non-verbal Communication to EF tasks passed (see Miller & Marcovitch, 2015), controlling for gender and age-group.

3.2 | Descriptive statistics, gender, age, and SES differences

Descriptive statistics and group differences are depicted in Table 2, generally showing that older children and girls performed the best on EF tasks (although there was no age difference in the snack delay) and children with SBN waited longer on the snack delay. MANOVAs with age and gender conducted on EF and Early communication (parent education as a control) did not reveal significant interactions.

3.3 | Relations between EF tasks

Given the hypothesized and demonstrated age difference in EF, we examined correlations at each age with Pearson's *r* partial correlation, controlling for gender and parent education. For 18- to 24-month-olds, only 1 of 3 possible correlations between EF task performance was significant (i.e., more errors on the A-not-B related to more perseveration on the Spatial Reversal, see Table 3). For 30- to 36-month-olds, performance on all 3 EF tasks correlated, suggesting that better performance on one task related to better performance on another, see Table 4.

For 18- to 24-month-olds group, Bayesian Pearson's correlations between A-not-B and spatial reversal performance suggested data were extremely more probable under the alternative hypothesis, $BF_{01} = .0000056$, 95% CI: (.370, .701), and relations between snack delay to the A-not-B and spatial reversal were moderately more probably under the null hypothesis, $BF_{01} = .9.92$, 95% CI: (−.266, .204) and $BF_{01} = 6.75$, 95% CI: (−.340, .121), respectively. For 30- to 36-month-olds, relations between A-not-B and spatial reversal performance suggested data were extremely more probable under the alternative hypothesis, $BF_{01} = .000011$, 95% CI: (.480, .800) and relations between snack delay to the A-not-B and spatial reversal provided anecdotal evidence for the alternative hypothesis, $BF_{01} = .39$, 95% CI: (−.437, .092) and $BF_{01} = .41$, 95% CI: (−.588, −.090), respectively.

3.4 | Relations between EF and early communication

We examined relations between individual measures of EF and communication at each age, given the difference in communication tasks, using partial Pearson's *r* correlation to control parent education and child gender. For 18- to 24-month-olds, only RJA was related to all measures of EF performance, as more instances of RJA related to fewer errors on A-not-B and spatial reversal and longer latencies on the snack delay when controlling for parental education and child gender, see Table 3. For 30- to 36-month-olds, no elements of joint attention were related to EF performance; however, elements of language were related to EF, see Table 4. Namely, more vocalizations were related to fewer

TABLE 2 EF and early communication by age, gender, and SES

		Age					Gender					SES				
		18–24 months		30–36 months			F		M			UBN		SBN		
	Range	*M*(SD)	95% CI	*M*(SD)	95% CI	η^2	*M*(SD)	95% CI	*M*(SD)	95% CI	η^2	MR	SR	MR	SR	Rosenthal r
EF tasks																
A-not-B	0–10	3.7(4.0)	[2.7–4.7]	1.3(2.7)	[0.5–2.1]	.146**	2.2(3.4)	[1.3–3.1]	3.3(3.9)	[2.3–4.4]	.046*	58.1	5050.5	59.8	1735.5	.024
Spatial reversal	0–10	4.3(3.4)	[3.5–5.1]	1.0(1.7)	[0.5–1.5]	.278**	2.1(2.5)	[1.5–2.8]	3.9(37)	[2.9–4.9]	.096**	63.5	1904	56.1	4766	.100
Snack delay	0.3–60	20.1(20.5)	[15–25.1]	28.2(23.7)	[21.3–35.1]	.019	27.8(22.4)	[21.9–33.6]	19.0(21.2)	[13.3–24.7]	.052*	46.3	1388	62.1	5282	.214*
# EF passed	0–3	1.9(1.0)	[1.6–2.6]	2.2(0.6)	[2.1–2.5]	.070**	2.2(0.7)	[2.1–2.5]	1.8(1.0)	[1.6, 2.1]	.059*	57.4	4994.5	63.6	1908.5	.086
Communication																
RJA	0–9	7.0(2.6)	[6.4–7.7]	8.4(1.1)	[8.0–8.7]	.086**	7.9(1.7)	[7.5–8.4]	7.2(2.6)	[6.6, 8.0]	.025	60.7	5341	53.9	1562	.098
IJA	0–31	11.6(6.9)	[9.9–13.4]	12.4(6.0)	[10.7–14.1]	.011	12.7(5.9)	[11.3–14.3]	11.0(8.0)	[9.2, 13.0]	.011	58.8	5229	61.8	1792	.038
IBR	0–22	7.2(4.6)	[6.1–8.1]	6.3(4.5)	[5.0–7.6]	.001	6.0(4.4)	[4.9–7.1]	7.8(4.6)	[6.62, 9.13]	.055*	51.9	4617	82.9	2404	.397**
Vocalizations	0–30	4.1(6.2)	[2.6–5.6]	5.8(6.2)	[4.1–7.6]	.054*	5.1(5.9)	[3.6–6.6]	4.6(6.6)	[2.8, 6.4]	.001	59.6	5302	59.2	1718.5	.090
Receptive	0–10			6.2(3.2)	[5.1–7.3]		6.7(5.9)	[5.4–8.1]	5.5(4.1)	[3.7, 7.4]	.029					
Expressive	0–9			5.8(3.1)	[4.9–6.8]		6.5(2.8)	[5.3–7.7]	5.0(3.2)	[3.5, 6.5]	.062					

Abbreviations: A-not-B, error run; EF, executive functions; IBR, initiation of behavior request; IJA, initiating of joint attention; RJA, responding to joint attention; snack delay, latency to touch container; spatial reversal, number of perseverations.

perseverations on the spatial reversal, while better receptive communication was related to fewer errors on the A-not-B and spatial reversal and longer waiting latencies on the snack delay.

3.5 | Contribution of verbal and non-verbal communication to EF tasks passed

Finally, we considered relative verbal (vocalizations only) and non-verbal communication contributions to EF performance across the whole sample. Table 5 presents the results of the hierarchical regression. In the first block, sex differences (i.e., girls outperforming boys) and age differences (i.e., 30- to 36-month-olds outperforming 18- to 24-month-olds, entered categorically) were significant. Also, the second block adding non-verbal (i.e., RJA, IJA, IBR) and verbal (i.e., vocalizations) was significant. Only better RJA performance was significantly related to an increase in number of EF tasks passed. Interactions considered in further blocks between communication and sex and communication and age were not significant ($ps > .05$) and thus were not included in final models.

4 | DISCUSSION

The present work is informative to the recent refocus on emerging behavioral and cognitive control within an EF framework during the first years of life. Current findings corroborate the recent body of work suggesting performance across tasks designed to assess EF are not well correlated during the second year of life, but the strength of these relations improves into the third year. The present work further extends this finding to a novel Latin American sample of low to mid-SES demonstrating significant age, sex, and SES differences in EF performance. Finally, findings also suggest that communication plays a role in emerging EF, with differential communication contributions at each age. Non-verbal communication in RJA was related to EF in the second year, while verbal communication in vocalizations and receptive communication was related to EF in the third year. For the complete sample, only RJA positively predicted number of EF passed. Taken together, this work provides evidence of and justification for examining this unique developmental period of EF in the early years of life.

TABLE 3 Partial correlations between EF and early communication during second year controlling for gender and parent education

Variables	1.	2.	3.	4.	5.	6.	7.
1. A-not-B	—	.52**	−.01	−.28*	.02	−.06	.15
2. Spatial Reversal		—	−.06	−.27*	−.10	−.11	−.11
3. Snack Delay			—	.25*	.12	−.12	.22
4. RJA				—	.33**	.07	.28*
5. IJA					—	.04	.21
6. IBR						—	.29*
7. Vocalizations							—

Note: Pearson correlations were reported for all measures. *$p < .05$. **$p < .01$.

Abbreviations: A-not-B, error run; EF, executive functions; IBR, initiation of behavior request; IJA, initiating of joint attention; RJA, responding to joint attention; snack delay, latency to touch container; spatial reversal, number of perseverations.

TABLE 4 Partial correlations between EF and early communication during third year controlling for gender and parent education

Variables	1	2	3	4	5	6	7	8	9
1. A-not-B	—	.71**	−.39*	−.19	.14	.05	−.21	−.37*	−.21
2. Spatial reversal		—	−.33*	−.24	.01	−.07	−.32*	−.31*	−.21
3. Snack delay			—	−.13	−.10	−.27	.17	.40*	.26
4. RJA				—	.14	.11	.12	.19	.11
5. IJA					—	.14	−.18	−.20	−.32*
6. IBR						—	.12	−.02	.06
7. Vocalizations							—	.51**	.60**
8. Receptive communication								—	.81**
9. Expressive communication									—

Abbreviations: A-not-B, error run; EF, executive functions; IBR, initiation of behavior request; IJA, initiating of joint attention; RJA, responding to joint attention; snack delay, latency to touch container; spatial reversal, number of perseverations.

TABLE 5 Summary of regression analysis of EF tasks passed at 18 months (coefficients listed by step)

Variable	*B*	*SE B*	*β*	R^2 change
Block 1				
Sex	−.433	.165	−.241**	.101**
Age	.409	.167	.220*	
Block 2				
Sex	−.335	.171	−.182	.151**
Age	.256	.176	.138	
RJA	.085	.042	.205*	
IJA	−.001	.013	−.005	
IBR	−.021	.019	−.107	
Vocalizations	.008	.014	.056	

Note: Abbreviations: IBR, initiating behavioral response; IJA, initiating joint attention; RJA, responding to joint attention; SES, socioeconomic status.

$p < .10$, $*p < .05$, $**p < .01$.

Perhaps one of the most striking findings suggesting the first 3 years as a potentially important period of EF transition is that multiple studies now demonstrate a unique transition from toddler to preschooler with weak but emerging links between performance across multiple EF tasks from the second to third year (e.g., Devine et al., 2019; Diamond et al., 1997; Gago Galvagno et al., 2019; Miller & Marcovitch, 2015; Wiebe et al., 2010). The reasons for these developmental patterns are still under investigation, but representational accounts (e.g., Miller & Marcovitch, 2015) have suggested results are indicative of an emerging cohesive EF ability likely consistent with Miyake and Friedman's (2012) proposal of a common EF (i.e., related to the ability to represent and use task-relevant information and more complex rules to guide lower-level behavior common across all EF tasks, Zelazo, 2004). Although this adult-focused model proposes common EF contributes to task performance in addition to set-shifting or WM where relevant, developmental approaches have suggested EF may emerge first as a unitary factor for children with the gradual emergence of component-specific abilities in WM and set-shifting (Miller & Marcovitch, 2015; see also Lehto et al., 2003; Wiebe et al., 2010; Wiebe et al., 2011).

Several findings from the current study are consistent with a representational account. For one, there were strong age differences in EF performance in 2 of our 3 EF tasks, indicating significant improvement—to be expected if a unitary EF ability was emerging. Failure to see age differences in the snack delay could be due to the fact that this task also included elements of hot EF (i.e., affect-related decision making, Zelazo & Carlson, 2012 see also Watts et al., 2018) and is consistent with other examinations of age-related differences in the toddler (Miller & Marcovitch, 2015) and preschool years (Carlson et al., 2005; Prencipe & Zelazo, 2005). However, methodologically, it is also possible that these results could be due to fatigue effects, given the delay of gratification occurred later in the standardized order of assessment. Perhaps most important to representational accounts is the link to verbal and non-verbal communication thought to link to the way children represent their environment (e.g., Jacques & Zelazo, 2005; Vygotsky, 1986; Zelazo, 2004). For 18- to 24-month-olds, RJA was most strongly related to EF performance (see also Gago Galvagno et al., 2019; Miller & Marcovitch, 2015). Although IJA has been linked to representational abilities, these have usually centered around more active higher levels of IJA that involve pointing or showing for another person (e.g., IJA pointing essentially involves representing or labeling an object in the environment to share, Zelazo, 2004). The fact that levels of RJA were most strongly related at age two and predict number of EF task passed at first 3 years of life aligns with the suggestion that EF is not yet well developed but emerging in toddlers (e.g., as evidenced by the lack of cohesion and dramatic EF improvements). From a representational standpoint, children control behavior in the second year, but this ability may not be consistent because it is more externally/environmentally driven as RJA-EF links reflect children's reliance on more primitive orienting attention systems (e.g., RJA reflects children's more passive ability to orient to novelty in following another's attention, e.g., Mundy & Newell, 2007; Posner & Rothbart, 2000). By 30–36 months, children exhibit patterns of cohesion between EF tasks expected of preschoolers, and RJA links are less important as children begin to transition to more internally driven control guided by representational ability as reflected in EF links to vocalizations and receptive communication (i.e., those better at vocalizing and understanding language should be better able to create and reflect on task-relevant representations, rather than relying on orienting to novelty in situations requiring control, Zelazo, 2004). Although representational accounts are not the only frameworks advocating for the importance of language in EF (see Cragg & Nation, 2010), representational accounts may be unique in their examination of developing EF links to communication (and non-verbal joint attention links in particular) as children transition from the orienting to executive attention system driven by developments in their verbal and non-verbal methods for representation (Zelazo, 2004).

Finally, although this study has replicated and provided additional support for an emerging EF ability supported by representational ability in the second and third years, it is important to note that this study was novel for several reasons. First, our results extended to underrepresented countries of Latin American with a sample of low to mid-SES. This is the first study in Latin America that used behavioral tasks with toddlers and young preschoolers, and not the typical indirect parent reports or paper and pencil methods with preschool children, which are not easily scalable (Obradović & Willoughby, 2019). Although not a cross-cultural comparison, it is important to determine whether findings in basic research extend beyond the WEIRD (i.e., Western, Educated, Industrialized, Rich, and Democratic, Henrich et al., 2010) samples typically studied in psychology. Second, at a cultural level, the fact that the emergence of EF (i.e., related to *individual* cognitive and behavioral control) seems to show similar patterns of development in this more collectivist culture (i.e., that places less of an emphasis on individual agency) is informative, as it may speak to universalities in development, with the acknowledgment that other factors (e.g., bilingualism) may be important to understanding cross-cultural differences.

Third, this study examined SES differences that included measurement beyond educational level and income. Although we did not see differences between individuals with UBN and SBN in the A-not-B and Spatial Reversal task, our sample overall identified as low to mid-SES and it is possible, we could see more differentiation with more variability in SES. Also, the lack of differences could be due to the task impurity problem in this age range and lack of measures of parenting abilities, caregivers–infant interactions, and informal activities (e.g., playing ball games, clapping, and drawing) in the different SES groups, which could serve as a protective factor of poverty (Bernier et al., 2011; Brandes-Aitken et al., 2020). Having said that, we did see that child with UBN showed shorter latencies on the snack delay compared to children with SBN. Similar results have been found in preschool and school-aged children with some suggesting these findings develop from failed coping within an overwhelming environment (e.g., Evans & English, 2002; Raver et al., 2011; Sturge-Apple et al., 2016). Our results are some of the first to show these SES differences in delaying gratification before the age of 3 (Gago Galvagno et al., 2020).

In sum, although further work is needed (with a longitudinal approach and probabilistic sampling) the examination of the development of EF within the first years of life seems to be converging on evidence for emerging EF from the second to third year of life. There is potential for representational frameworks suggesting EF emergence may be linked to the shift from more passive orienting to internally mediated control in problem-solving with the emergence of representational abilities—particularly language.

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