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Neuropsychological assessment of Chilean children with a history of extreme prematurity: An exploratory study

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ABSTRACT
This study was conducted to explore the neuropsychological abilities of premature Chilean children. Two groups (Premature and Control, 10 children each, age ranging from 5 to 7.11) were established based on weeks of gestation and/or weight at birth. Relevant variables such as age, gender, schooling, and socioeconomic level were matched considering Chile's particular demographic context. Children were assessed by means of the Evaluación Neuropsicológica Infantil (ENI-2) battery, measuring nine cognitive domains encompassing 23 subscales. In turn, subscales are grouped in two scales: Cognitive Functions and Executive Functions. Since the ENI-2 battery provides norms for Spanish-speaking children, obtained data were inspected both for possible between-group differences and either adjustment or deviance from average range. Results show that premature children perform within typical ranges in all subscales except for Visual attention and Graphic fluency. When comparing both groups, some differences emerged. These differences are most prominent in subscales related to visuoperceptual skills. Interestingly, between-group linguistic performance is very similar. The point is made that early linguistic interventions conducted on premature children seem to positively impact on oral language expression and comprehension. On the contrary, early interventions focused on visuospatial abilities did not seem to attain the same impact. This may be a consequence of visual-information processing problems derived from cortical dorsal stream's vulnerability, which literature correlates with prematurity.

KEYWORDS
Cognitive functions; executive functions; neuropsychological assessment; premature; visuospatial abilities

Introduction

The World Health Organization defines preterm as babies born before 37 weeks of pregnancy (Organización Mundial de la Salud, 1992). In Chile, "extreme prematures are infants born before 32 weeks of gestation and/or weighting below 1500 g at birth," as stated by the Chilean Ministry of Health (Ministerio de Salud de Chile, 2010, p. 8). Children with a history of prematurity or very low birthweight are considered to be a vulnerable population. They are prone to suffer from neurological and sensory disorders that may produce long-lasting sequelae (Adams-Chapman, 2009; Crunelle, Le Normand, & Delfosse, 2003; Lundequist, Böhm, & Smedler, 2013; Mangal, 2016; Pérez-López & Brito De La Nuez, 2004; Salt & Redshaw, 2006; Sastre-Riba, 2009).

In a study conducted with Chilean children weighing below 1,000 g at birth, it was reported that 20% of participants had moderate-to-severe motor impairment and 6% had moderate-to-severe sensorineural bilateral hearing loss (Salas, Sanhueza, & Maggi, 2006). Elevated rates of other early-life disorders, including cortical blindness, deafness, and cerebral palsy, have also been reported in literature (Crunelle et al., 2003; Mangal, 2016; Wood, Marlow, Costeloe, Gibson, & Wilkinson, 2000). Several studies have found long-term sequelae among preschoolers and schoolers with a history of prematurity, although some of these children do not notably deviate from typical neurological and cognitive functioning (Adams-Chapman, 2009; Deforge et al., 2006; Mangal, 2016; Pascal et al., 2018; Salt & Redshaw, 2006). Literature suggests that some impairments, such as deficits related with high-level cognitive functions, tend to become apparent after 6 years of age, which makes them difficult to diagnose among infants or

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preschoolers (Casasbuenas, 2005; Espy et al., 2002). Such high-level cognitive deficits include learning and language disorders, attention deficit syndrome (with or without hyperactivity), diminished memory capacity and slower processing capabilities, executive-functions related deficits, low IQ, low performance on visuospatial skills, and some other behavioral dysfunctions (Brydges et al., 2018; Brumbaugh et al., 2016; Maggiolo, Varela, Arancibia, & Ruiz, 2014; Narberhaus, Segarra, Pueyo, Botet, & Junqué, 2008; Padilla Gomes, Botet Mussons, Soria-Pastor, Gratacós Solsona, & Figueras Aloy, 2014). Throughout recent decades, because of an increase in preterm children's survival rate, long-term cognitive sequelae have been studied in depth (Brydges et al., 2018). It has become clear that when children enter the school system and face steeper academic requirements, previously undetected difficulties arise (Anderson & Doyle, 2008; Casasbuenas, 2005; Marlow, 2006; Peña, Pittaluga, & Farkas, 2010). Moreover, some of these difficulties have been reported to extend throughout the latter years of elementary school and even into adolescence. These difficulties include general cognitive dysfunctions as well as deficits related with executive functions, verbal memory, spatial memory, verbal and nonverbal learning, time discrimination, and attention. These impairments often lead to academic problems (Anderson & Doyle, 2004; Baron et al., 2012; Hack, 2009; Hack et al., 2002; Ishii, Shizue, Isotani, & Perissinoto, 2006; Narberhaus & Segarra, 2004; Tinelli et al., 2015).

Despite the growing body of literature and the increasing number of studies, there is one possible shortcoming detectable in literature, namely the fact that research on premature children has usually focused on isolated cognitive functions rather than on comprehensive cognitive assessments. Lundequist et al. (2013) are among the few researchers who conducted a study of children with a history of prematurity using a comprehensive neuropsychological battery. They reported that premature children scored, overall, lower than control children on neuropsychological measures. To date, no similar data are available in Chile.

This study was thus conceived to neuropsychologically describe Chilean children aged 5 years to 7 years and 11 months with a history of extreme prematurity (less than 32 weeks of gestation and/or birthweight below 1,500 g). Crucially, preterm children in this study were patients followed for prematurity at an urban polyclinic center who fully adhered to a long-term treatment. Participants' neuropsychological abilities were assessed using a standardized, validated battery to determine whether performance was within or below average range. The performance of the premature children was also compared with a control group's performance.

Table 1. Descriptives for premature and control children.

	Premature				Control			
	n	Mean age	*SD*	Range	*n*	Mean age	*SD*	Range
Male	7	6.43	0.90	5.25–7.58	6	6.40	0.95	5.08–7.58
Female	3	6.17	0.74	5.58–7.00	4	6.26	0.82	5.58–7.41

Table 2. Descriptives for population and sample of premature children.

			Weeks		Weight	
	Gender	*n*	Mean	*SD*	Mean	*SD*
Population	Female	25	27.68	7.11	1131.00	473.30
	Male	33	26.45	6.1	1172.48	309.50
Sample	F	3	28.67	3.21	1193.33	410.04
	M	7	28.71	1.7	1041.43	303.83

Methods

Participants

The sample consisted of 20 monolingual, Spanish-speaking Chilean children. Ten children had a history of extreme prematurity (less than 32 weeks of gestation and/or birth weight below 1,500 g; Ministerio de Salud de Chile, 2010), and 10 were typical children with no history of prematurity. Tables 1 and 2 provide relevant descriptives for the sample, the population, and the control group.

Children with a history of prematurity were patients followed for prematurity at the Health Reference Center polyclinic (CRS, Cordillera Oriente). This is one of the few state-run hospitals in Chile where these children are treated and followed over time. It is also arguably the only state-run health-care center adequately equipped to provide quality treatment to these children. The premature children observed in this study received treatment by physiotherapists, occupational therapists, speech therapists, psychologists, neonatologists, and neurologists. The intervention program in this health-care center starts immediately after hospital discharge and continues until children are seven years of age. The 10 children included in this study were the only ones, from an initial larger sample, that both completed all assessment sessions and fully adhered to the intervention program devised for them. Also, some other children were invited but could not be assessed because of lack of consent by their parents/caregivers. It is worth mentioning that even if the sample observed in this study is very small, it still represents 17.24% of all children aged 5–7 who sought intervention at and are being followed by the Health Reference Center polyclinic. Thus, these children may very well be considered an adequate sample as they capture the effects of the conducted cognitive intervention and the general therapy. It is very important to mention that the children treated and followed in this health-care center did not suffer from any major neurological and/or cognitive disorders or conditions. This is because a diagnosis of severe neurological/cognitive impairments in a child requires a referral to different institution. Therefore, the observed sample is free from conditions such as cerebral palsy, severe bilateral hypoacusis, and metabolic disorders. Sensory problems, whether auditory or visual, were also absent from the sample.

Inclusion criteria for children in the premature group were: (a) to be monolingual and Spanish-speaking; and (b) to have been born in Chile to Chilean parents. All of the children attended either public or state-subsidized private elementary schools in Santiago, Metropolitan Region, Chile. Relevant medical histories were obtained from clinic files at the health center.

As for children in control group, they were recruited from schools located in the same district in which premature children's schools were located. Inclusion criteria for these children were: (a) absence of a history of prematurity; (b) absence of early-life hospitalization; and (c) absence of cognitive disorders, given the fact that preterm children in this study had no severe cognitive impairments. Inclusion criteria were established to recruit typical children, which was complemented with information from academic records. Relevant information was obtained from school medical and academic files. All of the children in the control group also attended either public or state-subsidized private elementary schools in Santiago. Given Chile's specific schooling and educational context, pairing types of schools allowed controlling for socioeconomic variables. Different types of schools highly correlate with demographic factors such as parents' income level and sociocultural background, since Chilean schooling system is highly segregated (Ramírez & Rosas, 2007; Valenzuela, Bellei, & De los Ríos, 2014). Children in the control group were matched for age, gender, and schooling grade with children in the premature group.

This research was reviewed and approved by the ethics committee of the University of Chile School of Medicine. Following standard guidelines, the parent or guardian of every participant signed an informed consent form before their child was evaluated for the study.

Procedures

Evaluators underwent 4 months of training to administer the selected instrument (see below), following standardized methods. They were 10 third- and fourth-year students from the University of Chile's Department of Speech Therapy and 3 licensed Speech Pathologists, all participating voluntarily. Since ENI-2 protocols were not blindly administered or rated (evaluators knew which group each child belonged to), an independent examiner was asked to inspect all rated protocols once assessment was completed. This blind inspection was performed by a professional with neuropsychological background and an extensive experience administering and rating psychological and neuropsychological tests. The rater concluded that the differences found were minor and driven by mathematical errors which did not affect the quality of the data. The errors were restricted to the Cognitive flexibility category.

Materials

The Neuropsychological Assessment of Children (acronym ENI-2, standing for Spanish "Evaluación Neuropsicológica Infantil"; Matute, Rosselli, Ardila, & Ostrosky, 2013) was chosen for this study, this instrument having been designed for and validated on Spanish-Speaking Latin American children (Ardila, Rosselli, Matute, & Inozemtseva, 2011; Matute et al., 2008; Rosselli, Ardila, Matute, & Inozemtseva, 2009; Velez-van-Meerbeke et al., 2013). Unlike other instruments, ENI-2 provides a fine-grained look at cognitive functions, which allows for a detailed inspection of potential deficits. The battery covers 12 neurocognitive domains, and the results can be used to outline: (a) Basic Cognitive Functions (includes 8 cognitive domains), (b) Executive Functions (includes 1 cognitive domain), and (c) Academic Skills (includes 3 cognitive domains) (Rosselli et al., 2004). Academic Skills were not considered in this study as most participants had not yet learned to read or write fluently because of their age and grade-level at school.

The following domains of the ENI-2 test battery were included in the present analysis. A detailed description of the complete battery can be found in Rosselli et al. (2010) and Ardila et al. (2011).

1. **Constructional abilities**. This domain belongs to the basic cognitive functions scale and assesses

visuospatial and visuomotor processing. It includes two subscales. The first one is *Stick Construction* and the task consists of children copying designs (one at a time), using toothpicks. The second subscale, *Drawing skills*, consists of three tasks: *Copying Simple Figures* (children copy figures presented separately), *Drawing a Human Figure* (children are asked to draw a human figure), and *Copying a Complex Figure* (children are asked to copy a complex figure presented on a card.

2. **Memory encoding**. This domain belongs to the basic cognitive functions scale and includes two subscales (with verbal and nonverbal tasks). (a) *Auditory Verbal Memory: Word Learning.* A list of words is presented for four consecutive trials. This list of words is used again 30 minutes later in a delayed-recall auditory memory task. *Story retelling:* children are told a story. 30 minutes later, they are asked to retell the previously heard story. (b) *Visual Memory: Visual Learning.* A list of geometric figures presented one at a time on cards is presented for four consecutive trials. After finishing the presentation of each trial, the children reproduce the figures on a blank paper. The child is asked to recall the figures 30 minutes later in a delayed recall visual memory task.
3. **Memory recall**. This domain belongs to the basic cognitive functions scale and includes two subscales: (a) auditory stimuli recall and (b) visual stimuli recall. It was administered 30 minutes after memory encoding and consists of four tasks: word learning, story retelling, visual learning and complex-figure recall.
4. **Perceptual skills**. This domain belongs to the basic cognitive functions scale and includes three subscales: visual, auditory and tactile. *Visual Perception:* This test assesses the ability to identify visual stimuli. It involves recognizing superimposed figures, recognizing blurry images of objects, identifying incomplete drawings (visual closure), integrating the parts that make up objects (e.g., identifying a table by looking at its parts), and recognizing facial emotional expressions. *Tactile Perception:* This test evaluates the ability to identify objects by touching them with the right or the left hand. *Auditory Perception*: this test assesses how musical notes, phonemes and environment sounds are recognized. Children were presented recorded pairs of musical notes and asked to determine whether notes were similar or different. Children also had to recognize real-life sounds such as a car-engine running or a baby crying. Phonemes were assessed by presenting children word-pairs differing in distinctive features and asking them to ascertain whether they were similar or different.
5. **Language**. This domain belongs to the basic cognitive functions scale and evaluates the ability to produce spontaneous speech, name common objects, repeat verbal information, and understand commands. It includes three subscales: *Repetition*, in which children had to repeat orally presented syllables, words, nonwords, and sentences; *Language Expression*, which consisted of two tasks: (a) image-naming; and (b) story retelling; *Language Comprehension*, which consisted of three tasks: (a) image pointing, with children signaling cards following word-cues uttered by the evaluator; (b) oral commands, with children being asked to follow oral instructions provided by evaluators; and (c) discourse comprehension, with evaluators reading a text and subsequently asking questions.
6. **Metalinguistic skills**. This domain belongs to the basic cognitive functions scale and assesses the ability to process the units of language by counting or blending phonemes in words, spelling words, and counting the number of words in sentences. This domain includes the following tasks: *Phonemic Counting* (assessing children's ability to isolate and count words' sounds), *Phoneme Blending Within a Word* (assessing children's ability to build words from words' sounds), *Spelling* (assessing children's ability to name the letters of words), and *Word Counting Within a Sentence*.
7. **Spatial skills**. This domain belongs to the basic cognitive functions scale and includes verbal and non-verbal skills. *Verbal.* This test includes tasks that assess the ability to express and comprehend verbal spatial terms, such as *right* and *left*. Children are required to perform right–left orientation commands with a map and to express right–left orientation commands to move a little doll across the same map. A task involving pictures at different angles is also included (expressing the orientation of a drawing of an object). *Nonverbal.* This task assesses visuospatial processing. It includes line orientation (the selection from an array of lines that correspond to a target) and coordinates location (i.e., drawing a

Table 3. Wilcoxon test results for subscales from the Basic Cognitive Functions scale and the Executive functions scale.

Subscale	Control	Premature	*W*	*P*	*r*	CI (95%)	
Cognitive functions							
Stick construction	59.40 (36.65)	58.60 (36.5)	51.50	1.00	0.02	−3.99996	4.00000
Drawing skills	35.75 (36.5)	30.21 (27.21)	48.50	1.00	0.02	−9.99994	9.99996
Auditory verbal memory	39.51 (35.91)	34 (26.54)	51.00	1.00	0.02	−6.00007	5.99998
Visual memory	38.20 (27.54)	37.20 (23.12)	47.00	1.00	0.05	−2.00001	3.00002
Auditory stimuli recall	32.40 (28.7)	34.54 (20.56)	47.50	1.00	0.04	−9.00002	8.00001
Visual stimuli recall	37 (30.91)	33.8 (34.83)	58.00	1.00	0.13	−7.99999	13.99993
Tactile perception	56.40 (12.47)	47.34 (24.04)	59.50	1.00	0.16	−1.99992	3.99993
Visual perception	69.50 (23.06)	39.34 (28.61)	85.00	0.003	0.59	1.99996	16.00000
Auditory perception	76.40 (21.96)	56.70 (28.56)	69.50	1.00	0.33	−0.99993	7.99994
Repetition	60.40 (26.01)	34.60 (25.7)	76.50	0.68	0.44	0.00002	13.00000
Language expression	39.34 (25.23)	36.30 (25.08)	48.50	1.00	0.02	−5.99994	5.99999
Language comprehension	54 (20.71)	55.10 (20.63)	52.50	1.00	0.04	−3.99995	3.00001
Visual attention	31.50 (21.09)	14.60 (16.85)	74.00	1.00	0.40	−0.99997	10.00006
Auditory attention	61.60 (32.11)	46.51 (36.54)	62.50	1.00	0.21	−3.00000	9.99999
Metalinguistic skills	53.21 (31.2)	29.95 (26.69)	70.50	1.00	0.34	−1.00006	17.99999
Conceptual skills	56.10 (30.24)	44.20 (38.22)	60.00	1.00	0.16	−8.99996	10.00004
Spatial skills	43.70 (19.25)	26.14 (27.99)	72.00	1.00	0.37	−1.99995	18.99998
Executive functions							
Verbal fluency	26.90 (24.41)	26.70 (21.94)	52.50	0.87	0.04	−5.99998	5.00003
Graphic fluency	33.80 (26.83)	16.70 (14.19)	72.50	0.09	0.38	−0.99995	5.99996
Perseveration	70.22 (26.91)	55.50 (31.39)	59.50	0.24	0.26	−1.00002	3.99993
Number of categories	73.90 (28.65)	48.10 (34.73)	72.00	0.09	0.37	−0.00005	6.00000
Total of errors	62.30 (31.94)	38.40 (34.48)	70.00	0.13	0.34	−1.99996	6.00005
Planning	68.22 (18.91)	60.52 (34.44)	43.50	0.93	0.02	−1.00005	3.99998

Notes. All tests are two-tailed. r measure provided for effect size (.1 small, .3 medium, .5 large). Presented *p*-values were adjusted following Bonferroni pairwise correction. Confidence intervals reveal significant differences when intervals do not include zero.

route in the coordinates based on visual directions).

8. **Attention**. This domain belongs to the basic cognitive functions scale and includes *auditory and visual subscales. The auditory attention* subscales are Digits Forward and Digits Backward. *The Visual attention* subscales include two cancelation tasks. In one—Drawing Cancellation—children are asked to cross out the largest rabbits in an array of rabbits of two different sizes. The second is a Letter Cancellation task that requires the child to cross out the letter *X* only if it is preceded by an *A* in an array of six different letters.
9. **Conceptual skills**. This domain belongs to the basic cognitive functions scale. Includes three tasks: *Similarities*, (children were requested to find commonalities between pairs of words). *Matrices* (children were presented a figure missing one element and asked to complete it. They were given many options per figure.), and *Arithmetical problems* (children had to solve orally presented arithmetical problems by means of a verbal answer).
10. **Executive functions**: This domain included the assessment of verbal and graphic fluency, cognitive flexibility and planning abilities (Pyramid of Mexico). *Verbal fluency*: includes semantic fluency (children had to name as many fruits and animals as they could recall within a time limit) and phonemic fluency (children had to name as many words starting with phoneme/m/as they could recall within a time limit). *Nonverbal fluency:* includes *semantic fluency* (children had to draw as many real recognizable objects as possible within a time limit) and *nonsemantic* fluency (children had to draw as many linear drawings within a time limit). *Cognitive flexibility:* children were given three cards and asked to use them to subsequently classify 54 cards. These cards provide an underlying classification principle based on color, shape or number. Children are expected to determine the underlying classification principle as they perform the task. This test provides a measure for *number of perseverations* (children are not able to switch categories once established in spite of conflicting evidence), *number of categories* (number of categories in which children are able to correctly include 10 stimuli in a row), and *total number of errors* (number of incorrect classifications). *Planning abilities* (Pyramid of Mexico): Children had to build designs, sequentially presented, using blocks and with the least possible amount of movements.

Each child was assessed during four 1-hour sessions following the standardized instructions provided by the battery manual.

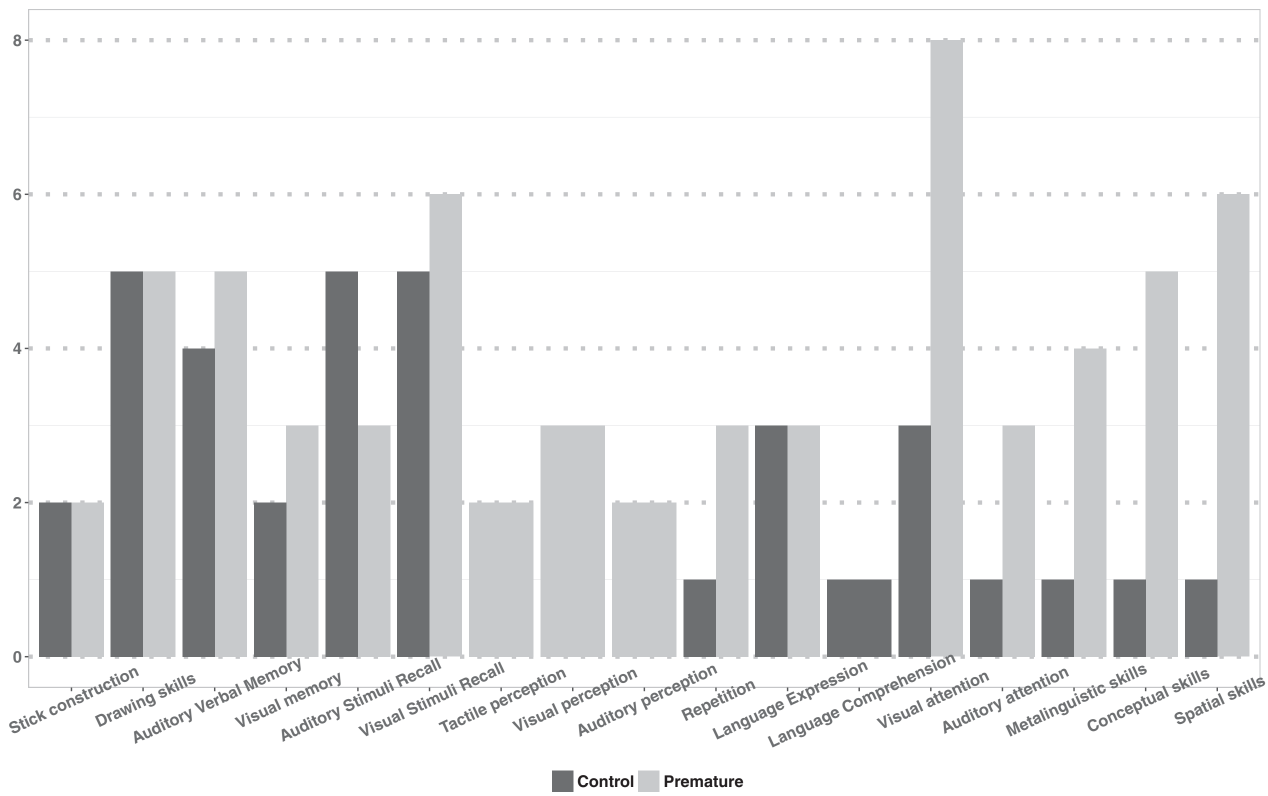

Figure 1. Frequency distribution of children performing below typical range, according to ENI-2 norms, on all Cognitive Functions subscales.

Results

Data were analyzed and plotted with R (R Core Team, 2015; Wickham, 2009). The ENI-2 manual provides age-based norms for the domains, subscales, and tasks. Consequently, the first step of data analysis was to convert the raw scores for each item to age-based percentile scores. Next, the 23 subscales were then grouped in two scales, Basic Cognitive Functions (17) and Executive Functions (6), and analyzed separately. All data were inspected for normality. As might be expected given sample size, some of the scores did not show a normal distribution, either for one or both groups. Non-parametric Wilcoxon tests were thus implemented to analyze data and to conduct between-group comparisons. Non parametric r (rank correlation) is reported as effect size measure. Given the amount of contrasts, *p*-values were adjusted following Bonferroni correction to control for familywise type I error. A more robust measure of differences was obtained by calculating 95% confidence intervals for each contrast, based on the median of the differences between the two samples. Confidence intervals reveal significant between-group differences whenever they do not include zero.

Results for subscales from the Basic Cognitive Functions scale and the Executive functions scale are presented in Table 3. Figures plotting groups' means and typical/atypical group performance are provided in the Appendix section. To better grasp possible differences, two plots were constructed to visualize how many children in each group scored below typical limit (percentile 25th or lower). Figures 1 and 2 present this frequency per subscale.

Results show that premature children only perform below typical range on Visual Attention and Graphic Fluency. However, groups' means were not found to be statistically different based on bootstrapped CIs. Preterm children's mean scores for remaining subscales are within typical range. Statistically significant between-group differences were only found for Visual Perception and Repetition, with control group outperforming premature group. This significance is based on non-zero confidence intervals for the median of the differences between both samples. Inspection of frequency distribution of underperformers showed that even if group means for Spatial Skills, Metalinguistic Skills, Conceptual Skills, and Total of Errors are within average range, roughly half the premature children performed below typical range on these subscales. This pattern is very different from control group's pattern and may reflect possible

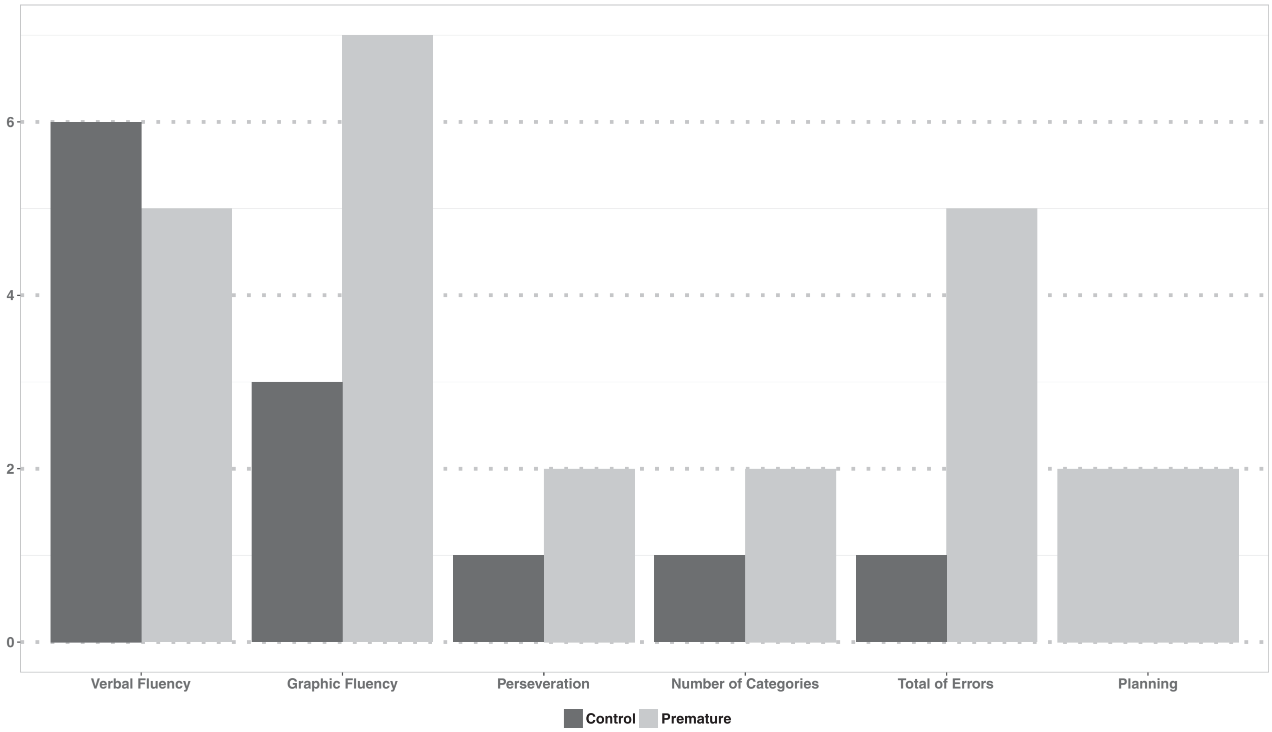

Figure 2. Frequency distribution of children performing below typical range, according to ENI-2 norms, on all Executive Functions subscales.

population differences not captured because of sample size. Confidence intervals for these subscales, even if including zero, are qualitatively different from other subscale intervals. However, no conclusive claims can be made on these variables. A closer look at these subscales reveals that preterm children's performance is particularly diminished on Metalinguistic Skills and Spatial skills (albeit typical).

Discussion

Overall, premature children performed within typical range on most of 23 subscales, consistently scoring above 25th percentile. When comparing premature children against control group, robust statistical differences were observed on only two subscales. However, descriptive inspection of underperformers per group revealed potential between-group differences on some other subscales, which might have not been captured because of sample size. These results are consistent with literature. A meta-analysis by Pascal et al. (2018) reported that when comparing preterm children against typical children, mild cognitive impairments are more frequent than moderate/severe impairments.

Results are mostly related with two cognitive domains: visuospatial abilities and language. Regarding visuospatial abilities, premature children scored below the average range on Visual Attention (basic cognitive functions) and Graphic Fluency (executive functions). They also scored particularly low (in terms of number of underperformers) on Spatial Skills. All of these skills require planning, organizing, and, generally speaking, manipulating visuospatial information. These findings are consistent with several studies reporting that children with a history of prematurity are more likely to experience deficits in visuospatial abilities (Caravale, Tozzi, Albino, & Vicari, 2005; Vicari et al., 2004), as well as to suffer from problems related with executive functions, such as organization skills (Brydges et al., 2018; Taylor & Clark, 2016). These deficits may be associated with abnormalities in the dorsal cortical stream and its connections with parietal, frontal, and hippocampal areas (Atkinson & Braddick, 2007). Visuospatial areas may be especially vulnerable to conditions that can cause neurological damage, including prematurity (Braddick, Atkinson, & Innocenti, 2011). Tinelli et al. (2015) reported that parietal dysfunction may underlie some prematurity-related deficits, including impairments in time-estimation and attention to task, while other parietal functions, such as magnitude estimation and number-space mapping, are relatively unaffected. The authors suggested that the dorsal stream vulnerability predisposes premature children to specific visuospatial deficits. Rider, Weiss, McDermott, Hopp, and Baron (2016) studied visuospatial abilities among premature children of extremely low birthweight (less than 1,000 grams) and reported significant differences when compared with term children. These differences were observed when aged three and six, and data were elicited using tasks that did not demand motor responses. Brumbaugh et al. (2016) found that children born within 34–36 weeks of pregnancy performed lower than control children on perceptual visuospatial skills, processing speed, and memory. This suggests that visuospatial skills may be compromised even among nonextreme preterm children.

Interestingly, stick construction and drawing skills, which also demand dealing with visuospatial information, do not seem to particularly trouble premature children. One possible explanation is that these tasks are to be performed using concrete objects such as pens, paper sheets, and sticks. Since they rely on a physical support and are therefore somewhat related with motor capabilities, they might be considered different from tasks exclusively involving mental representation of visuospatial information.

As for language performance, scores on Language Repetition, Expression, and Comprehension are noteworthy. Not only premature children score within average range in terms of group means, but also the amount of underperformers is very low in all these subscales. These results are not consistent with literature on premature children's linguistic performance, which underscores their general language deficit (Maggiolo, Varela, Arancibia, & Ruiz, 2014; Peña, Pittaluga, & Farkas, 2010). They are, however, consistent with literature considering the effects of linguistic interventions conducted with premature children. Linguistic tasks have been shown to increase right-hemisphere activation among premature children, which may potentially reflect a compensatory mechanism that helps overcome language processing deficits (Gozzo et al., 2009; Myers et al., 2010; Rushe et al., 2004; Schafer et al., 2009). Other studies have reported that when intervened, premature children are more likely to improve on verbal comprehension deficits than on some other linguistic problems, with performance often reaching typical age-range by adolescence (Luu, Vohr, Allan, Schneider, & Ment, 2011; Luu et al., 2009; Ment et al., 2003).

In spite of their typical group-performance on Metalinguistic Skills (which measures phonological awareness), premature children do seem to be troubled by this particular dimension, with half the sample performing below the average range. This is consistent with recent findings by Hasler and Askshoomoff (2017) reporting significantly lower performance of premature children when compared with control peers. Low performance on phonological awareness may reflect the highly demanding cognitive load involved. Particularly troubling may be the simultaneous engagement of various cognitive functions and the abstraction level required to successfully complete this kind of tasks. At the developmental stage observed in this study, premature children seem not yet to be able to master this linguistic skill as proficiently as they master other linguistic aspects, intervention notwithstanding.

All premature children enrolled in this study received early therapeutic intervention. They engaged in a systematic and continuous treatment beginning at two years of age and persisting until seven years of age. Therefore, results regarding visuospatial abilities and language may very well be consequence of the implemented intervention. If this is the case, it might be said that early therapy favorably impacts on language comprehension and expression, as well as on verbal fluency. At the same time, performance on visuospatial abilities seems to be less responsive to therapy, perhaps revealing a deeper, possibly more complex deficit.

It might be worth mentioning that when compared to children in control group, premature children showed a greater tendency toward fatigue, more consecutive errors of attention, more errors following instructions, and more perseverations. This pattern was observed in spite of the movement breaks and position changes encouraged for children during the evaluation in both groups, as outlined by the test's standardized administration procedures. Also, the number and length of the assessment sessions was the same for both groups. These findings are consistent with previous studies reporting that premature children do not perform particularly well on executive functions such as inhibition, attention, and self-regulation (Brydges et al., 2018; Tatsuoka et al., 2016; Taylor & Clark, 2016).

This study has several limitations. In any study involving neuropsychological assessment, it is important to consider transcultural variables and their potential impact on performance. For example, when a neuropsychological test has been adapted for a specific population, researchers should exercise caution in applying the test to other groups with different sociocultural characteristics (Olson & Jacobson, 2015). The ENI-2 manual provides norms for a Spanish-speaking population derived from Mexican and Colombian children. In order to administer the ENI-2 to Chilean children, it was necessary to modify various items, mainly to account for local differences in vocabulary. These modifications were minor and were implemented with consent and guidance from the ENI-2 authors, but still they need to be tested within the context of a thorough validation validation/adaption process.

The presented study did not include a non-intervened control group of preterm children, which precludes disaggregating the effects of the implemented treatment from developmental effects. Another limitation is the small sample size, which implies low statistical power and invites considering presented results most cautiously. Also, the sample in this study did not include children with neurological or several cognitive conditions, and therefore results can hardly be generalized to the premature children population as a whole. Nonetheless, results may be of interest precisely because here observed premature children are not a population typically observed in literature. Most studies reporting the benefits of early interventions on premature children have observed a wide range of prematurity-driven consequences and traits, which typically include neurological/cognitive impairments. Children not affected by these frequent and severe conditions are often excluded from interventions and treatments, maybe because they are closer to typical children's performance than some neurologically impaired premature children are. This may be particularly troubling when they enter school, since they are assumed to perform within average range. Our study showed that is the case for many neuropsychological measures, but not all of them. Results suggest there is room for improvement on some dimensions and that follow-up or continued intervention might help premature children to attain normal levels on some important cognitive domains that will be at play during their first years of schooling.

Finally, findings regarding Visual Even if small, the observed sample may be deemed as representative of the population of premature children having been intervened at the Health Reference Center polyclinic. Presented results cannot be deemed as conclusive, but they can still be considered as an exploration into therapeutic effects of early interventions in an under-explored population of children not affected by severe neurological/cognitive impairments. In future studies, it would be ideal to observe a larger sample including children in different age ranges. Also, the onset of intervention might be one variable to consider (whether children started to be treated at an early stage or at a late stage). This might help to inspect the impact of early interventions on cognitive functioning. It would also be interesting to explore correlations between subscale scores and specific elements of the children's medical history (weeks of pregnancy or birthweight) and the education level of their parents, as it has been suggested in literature (Lundequist et al., 2013; Richards, Drews-Botsch, Sales, Dana, & Kramer, 2016).

Attention and Spatial Skills among premature children suggest that neurocognitive intervention in these domains is of the essence, especially considering that crucial academic activities such as reading, writing, and mathematics rely on them. Also, results seem to suggest that intervention programs might benefit from sustained, prolonged implementation. Restricting interventions to preschool period or early schooling period might turn to be inadequate inasmuch as cognitive challenges seem to linger even into adulthood (Linsell et al., 2018).

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Appendix A.

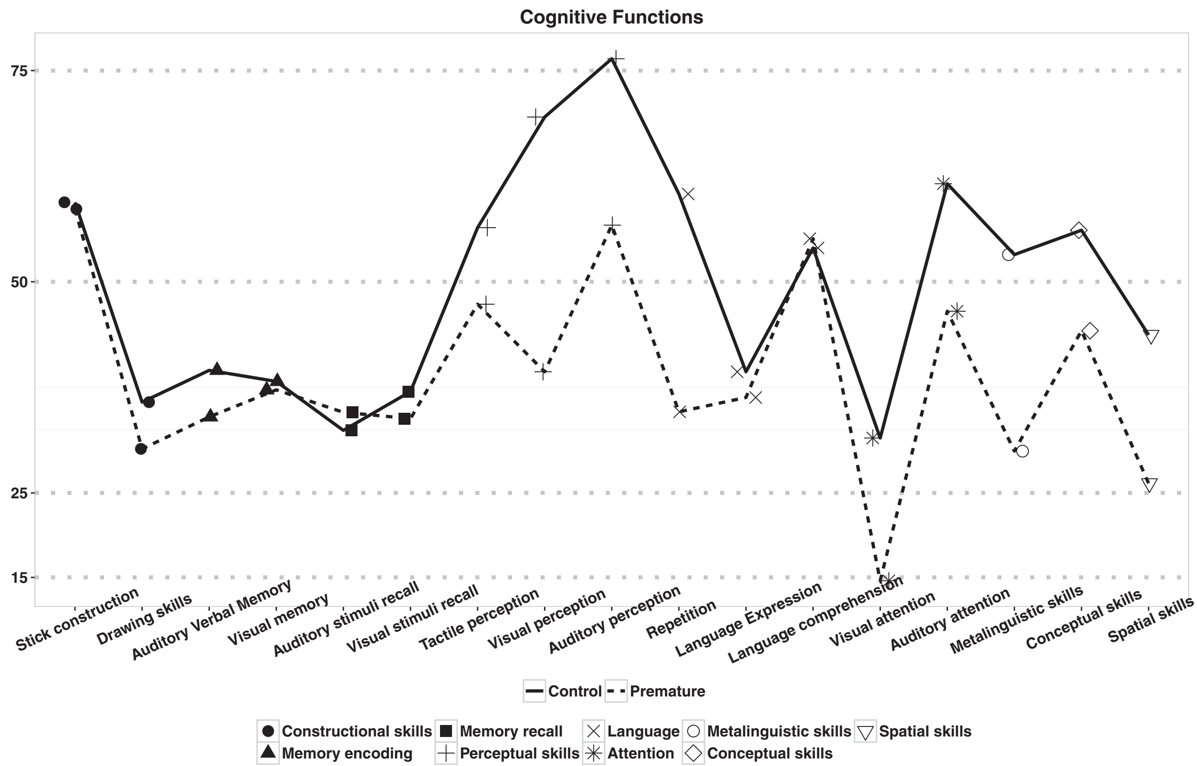

Figure A1. Mean scores for Basic Cognitive Functions subscales; y-axis represents ENI-2 percentile scores; 26–75 indicating performance within typical range; and 15 or lower indicating a deficit, according to ENI-2 norms.

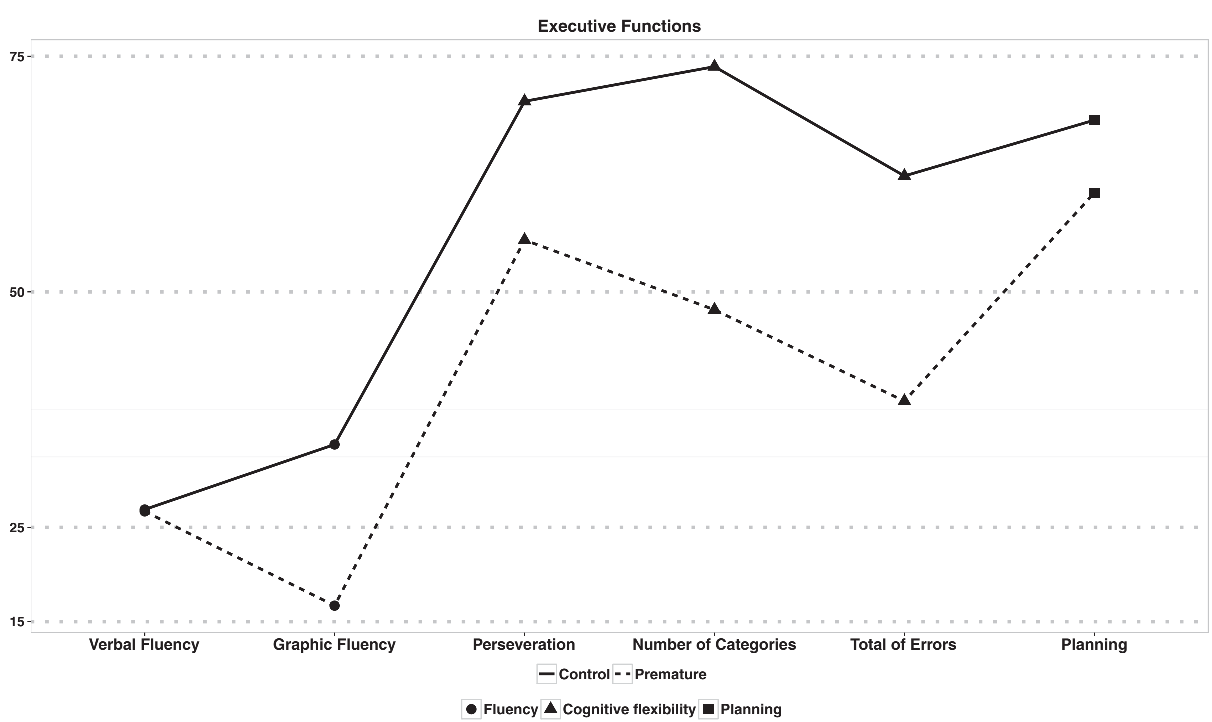

Figure A2. Mean scores for Executive Functions subscales; y-axis represents ENI-2 percentile scores; 26–75 indicating performance within typical range; and 15 or lower indicating a deficit, according to ENI-2 norms.