Interaction between Socioeconomic Status and Cognitive Development in Children Aged 7, 9, and 11 Years: A Cross-Sectional Study

Article *in* Developmental Neuropsychology · November 2018

DOI: 10.1080/87565641.2018.1554662

Carlos Burneo-Garcés
University of Granada

Francisco Cruz-Quintana
University of Granada

Miguel Perez-Garcia
University of Granada

Manuel Fernández-Alcántara
University of Alicante

DEVELOPMENTAL NEUROPSYCHOLOGY
https://doi.org/10.1080/87565641.2018.1554662

Interaction between Socioeconomic Status and Cognitive Development in Children Aged 7, 9, and 11 Years: A Cross-Sectional Study

Carlos Burneo-Garcés[a,b], Francisco Cruz-Quintana[a], Miguel Pérez-García[a], Manuel Fernández-Alcántara [a,c], Ahmed Fasfous[a,d], and Mª Nieves Pérez-Marfil[a]

[a]Mind, Brain and Behavior Research Center (CIMCYC-UGR), University of Granada, Granada, Spain; [b]Universidad de Otavalo, Otavalo, Ecuador; [c]Department of Health Psychology, University of Alicante, Alicante, Spain; [d]Department of Social Sciences, Bethlehem University, Bethlehem, Palestine, State of Palestine

ABSTRACT

The socioeconomic status (SES) of parents has a crucial influence on the cognitive development of children, but it is not clear whether this effect varies as a function of the children's age. The objective of this study was to investigate the development of children aged 7, 9, and 11 years of parents with extremely low SES in a developing country (Ecuador). Participating children were divided between a medium-SES group and a low-SES group. Statistically significant differences were observed as a function of SES group and age in verbal memory, language, and executive function, observing wider between-group differences among the 11-year-olds.

ARTICLE HISTORY
Received 6 April 2018
Revised 10 November 2018
Accepted 14 November 2018

Introduction

Cognitive development involves genetic, cerebral, cognitive, emotional, and behavioral processes (Boivin, Kakooza, Warf, Davidson, & Grigorenko, 2015; Sastre-Riba, 2006). During cognitive development, neuropsychological domains can be affected by nutritional, infectious, and toxic factors, by the upbringing of children (Harmony, 2004) and by the socioeconomic status (SES) of their parents (Aber, Jones, & Cohen, 2000; Brito & Noble, 2014; Brooks-Gunn, Klebanov, Liaw, & Spiker, 1993; Ghosh, Chowdhury, Chandra, & Ghosh, 2015).

SES is a complex construct that considers not only family income and parental education/occupation but also psychological and physical health, family environment, housing conditions, and neighborhood characteristics (Hackman, Farah, & Meaney, 2010). In particular, parental education and parental occupation were found to be responsible for more than 14% of the variance in the scores of children in executive function tests (Noble, Norman, & Farah, 2005). A larger family income has been associated with a higher level of parental education, superior housing conditions, greater cognitive stimulation at home, and an improved cognitive performance in children (Crookston, Forste, McClellan, Georgiadis, & Heaton, 2014; Hamadani et al., 2014; Mazzoni, Stelzer, Cerigni, & Martino, 2014).

A low SES is known to have a negative effect on children's development and is considered an important predictor of language and executive functions (Hackman & Farah, 2009; Noble et al., 2005). Noble et al. (2005) proposed that the effect of SES on executive function during infancy is mediated by parents' relationship with their children and their capacity to regulate stress. In another study, higher executive function scores were obtained by children who lived in better physical conditions and whose mothers had a higher level of education (Arán-Filippetti, 2011).

CONTACT Dr. Manuel Fernández-Alcántara mfernandeza@ua.es Department of Health Psychology, University of Alicante, Ctra. San Vicente, s/n, 03690 - Alicante, Spain

Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/hdvn.

The negative impact of a lower SES on neuropsychological domains is well documented (see Brito & Noble, 2014 for a review), but few data are available on the interaction between SES and age in children. One comparative study of children at the ages of 4 months, 1, and 7 years found that major neurological abnormalities emerged among lower-SES children at a younger age, suggesting a lasting influence of prenatal conditions (Hung et al., 2015). A longitudinal study of the relationship between SES and the development of memory and language in under 2-year-olds found no differences between SES groups at the ages of 9 and 15 months but recorded an inferior performance in children from families with a low educational level at 21 months (Noble et al., 2015). Main effects of age, SES, and their interaction on language, attention, and memory were found in a study of older medium- and low-SES children in two different age-groups (8–9 vs. 10–12 years) (Arán-Filippetti, 2012); however, main effects of age and SES but not their interaction have been described for executive function (working memory, flexibility, inhibition, and planning) in comparisons between the ages of 3 and 4.5 years (Hackman, Gallop, Evans, & Farah, 2015) and between the ages of 8 and 11 years (Arán-Filippetti, 2013). Taken together, these data indicate that older children with lower SES perform worse in some neuropsychological domains (e.g., language, memory, attention) but not in executive function.

However, the aforementioned studies have some important limitations. Notably, most investigations on SES and neuropsychological development have been conducted in developed countries, characterized by a long life expectancy and good levels of education and literacy (Brito & Noble, 2014; Lipina & Posner, 2012; Raizada & Kishiyama, 2010). It can be speculated that a low SES may have a greater impact on the neuropsychological development of children in countries with lesser educational and social development (Crookston et al., 2014; Lawson et al., 2017), where exposure to abuse or violence and malnutrition may be more likely (Peterman, Neijhoft, Cook, & Palermo, 2017). The influence of low SES on neurocognitive function is related to reduced linguistic stimulation and increased experience of stress, among others, and this negative influence may be stronger in developing versus developed countries (Sripada, Swain, Evans, Welsh, & Liberzon, 2014; Ursache & Noble, 2016). Previous studies on the influence of SES and age in children have also been limited to specific domains rather than performing a full neuropsychological assessment, and most have studied one or two age-groups alone. Hence, it has not been established whether the impact of SES is the same at all ages of childhood or whether it has specific effects on certain neuropsychological domains at different ages. It has been proposed that neurodevelopment is slower in low-SES children and that this difference with medium-/high-SES children widens during neurodevelopment (Brito & Noble, 2014; Grieve, Korgaonkar, Clark, & Williams, 2011). In particular, authors have described a worse performance by low-SES children in memory, attention, and language at older ages (Arán-Filippetti, 2012, 2013; Hackman et al., 2015), attributed to their longer exposure to the unfavorable conditions of a low SES (Brooks-Gunn & Duncan, 1997; Hackman et al., 2010).

With the above background, this study was designed to investigate neuropsychological development in children of 7, 9, and 11 years of age with low or medium SES from a city in a developing country (Ecuador). The study objectives were to test the following hypotheses: (1) neuropsychological performance would be inferior in children with low versus medium SES and (2) this difference would be greater at 11 versus 7 years of age in the neuropsychological domains of memory, attention, and language.

Materials and methods

Participants

The study included 274 Spanish-speaking schoolchildren from Guayaquil, the most populous city of Ecuador (INEC, 2010), divided among 7-year-olds (45 boys, 44 girls), 9-year-olds (45 boys, 46 girls), and 11-year-olds (47 boys, 45 girls). These groups were selected in order to investigate the development of each study domain between the ages of 7 and 11 years, considered as a critical period in the development of executive functions (Diamond, 2013; Farah, 2017; Mous et al., 2017). The study population was divided by their SES between: a medium-SES group (n = 133), containing 45 7-year-olds (23 boys, 22 girls), 44 9-year-olds (22 boys, 22 girls), and 44 11-year-olds (22 boys, 22 girls); and a low-SES group (n = 141) with 46 7-year-olds (24 boys, 22 girls), 47 9-year-olds (23 boys, 24 girls), and 48 11-year-olds (25 boys, 23 girls).

Sampling procedure

The study was conducted in primary schools in the city, selected to provide a balanced representation of areas with predominantly low-SES or medium-SES populations. The characterization of school catchment areas as low or medium SES and their inclusion in the study was based on multiple factors, including the private, subsidized, or public funding of the school; basic services in the area; income and employment levels; access to and use of the health system and childcare quality, among others. Following these criteria, a selection was made of three medium-SES schools (one public, one subsidized, and one private) in the North/Center parts of the city and two low-SES schools (two public schools) in an area in the South of the city called "Isla Trinitaria", predominantly inhabited by poor or extremely poor families. Random sampling was conducted among the 7-, 9-, and 11-year-old children registered at each participating school.

Inclusion criteria

Study inclusion criteria were (1) age of 7, 9, or 11 years at the time of assessment; (2) regular attendance at one of the participating schools; (3) absence of physical, psychological, and/or cognitive impairments; and (4) informed and signed consent of parent/guardian. Before evaluations of the selected children, interviews were conducted with their teachers and with their parents/guardians to verify that the above inclusion criteria were met, confirming that none had diagnosed or apparent physical or psychological disorders or evidenced major behavioral problems. The availability of an appropriate room for interviews with the children was also established. Out of the eligible children enrolled in the study, 24 were subsequently excluded due to the withdrawal of consent (n = 4) or because conditions for the assessment were not adequate due to interruptions for academic activities or examinations (n = 20).

Instruments

Socioeconomic survey

This questionnaire was administered to the parents/guardians in interviews held at the school of their children (morning and afternoon sessions). The survey was designed by the University of Chimborazo (Ecuador) and have been used in a wide range of research involving socioeconomic status in this country (see Hinojosa-Fierro, 2014 for a recent example). This instrument classifies families according to raw scores for *maternal level of education* and *social class of the head of household* and a transformed *housing risk index* score. A higher survey score indicates a lower socioeconomic level.

BENCI: computerized battery for children's neuropsychological assessment

This battery allows a comprehensive neuropsychological evaluation of processing speed, visual–motor coordination, attention, language, memory, and executive function (Lezak, Howieson, & Loring, 2004), and its computerized design facilitates and standardizes its administration and data recording (correct responses, errors, reaction time) (Cruz-Quintana, Pérez-García, Fernández-López, & Roldan-Vílchez, 2011; Cruz-Quintana, Pérez-García, Roldan-Vílchez, Fernández-López, & Pérez-Marfil, 2013) [1]. The version for Ecuadorian children was validated in a sample aged between 6 and 17 years and demonstrated good psychometric qualities (Cruz-Quintana et al., 2013). Evaluation of the test–retest reliability obtained Pearson correlation coefficients that ranged from r = .97 (verbal memory recall) to r = .34 (immediate visual memory), while Cronbach's alpha values for internal consistency ranged from α = .92 (selective attention) to α = .62 (reaction time for simple task). The convergent validity was acceptable and significant, with correlations ranging from r = .69 (Spanish Adaptation of Californian Verbal Learning Test) to r = .33 (Woodcock–Muñoz Battery). More detailed information on the psychometric properties of each test is available elsewhere (Cruz-Quintana et al., 2013; Fasfous et al., 2015).

The battery contains 14 neuropsychological tests and requires a total of 60–70 min for its completion, with a 10-min break halfway through the session (Fasfous et al., 2015). Before being evaluated, each child was familiarized with the basic computer skills required to complete the battery of tests. We followed the recommendations of Lezak et al. (2004), always following the same order of tests, alternating simple and difficult tasks, and verbal and nonverbal tests, and taking into consideration the time intervals between tests. The domains and corresponding tests in the battery are listed below.

Processing speed

1. Simple reaction time test. The child must press any key on the keyboard as fast as possible when a cross appears on the screen, and the reaction time is recorded in milliseconds (msec)

Visual–motor coordination

2. Visual–motor (A). Numbers appear on the screen and must be touched in ascending order recording the reaction time in msec. **Alternate visual–motor (B)**. Two different series (numbers and letters) appear on the screen and must be touched alternately in ascending order, recording the reaction time in msec.

Sustained attention

3. Continuous performance test (CPT). Blocks of letters appear on the screen, one after the other. The child is instructed to press a key when a given sequence is shown (for example, letter A following X). The remaining letters are distractors. The reaction time (in msec) and number of correct responses are recorded.

Memory

4. Verbal memory. After listening three times to the same series of words, the child must repeat aloud all words that he/she can remember. Correct responses in immediate and delayed recall and delayed recognition tests are recorded.
5. Visual memory. After being shown pictures of common objects, the child must state aloud all objects they can remember. Correct responses for immediate and delayed recall and delayed recognition tests are recorded.

Language

6. Verbal comprehension (images). After being shown a group of images (e.g., animals), the child must select the image that meets given criteria (animal, position, activity, and/or color). For example: "touch the frog that is next to the dog". Correct responses are recorded.
7. Verbal comprehension (shapes). After being shown a group of geometric images (small, medium, or large circles; triangles; or squares in different colors), the child must select the image that meets given criteria (shape, size, position, and/or color). For example: "touch a small blue circle". Correct responses are recorded.

8. Phonetic fluency: The child has 60 sec to state all the words he/she knows that start with a given letter. Correct responses are recorded.

Executive function

9. Working memory. After listening to sequences of mixed numbers and colors, the child must repeat the numbers and colors (first the numbers, in ascending order, and then the colors, or *vice-versa*). Correct responses are recorded.
10. Abstract reasoning. A group of a logical series is shown on the screen. The participant must select the element that completes the series, recording the reaction time (msec) and correct responses.
11. Semantic fluency. The participant is told a semantic category (e.g., colors or animals) and is given 60 sec to say aloud all of the words that he/she knows in this category. Correct responses are recorded.
12. Inhibition: Go/No-Go. Two pictures appear on the screen alternately (e.g., bear and dolphin). First, the child must press a key when one of them (bear) appears; then, after hearing a known signal, the child must press a key when the other picture (dolphin) appears. The recording time (msec) is recorded.
13. Inhibitory control and flexibility: Spatial Stroop. The screen displays a sequence of arrows pointing either left (←) or right (→). The child must press the left arrow or right arrow on the keyboard according to the direction of the arrow. The arrows can appear either on the right or left of the screen, regardless of their direction. Reaction time (msec) and correct responses are recorded.
14. Planning: theme park. A theme park displayed on the screen contains attractions with different prices and durations. The child is told that he/she has a given amount of money and must go on as many attractions as possible within a set time (each attraction can only be visited once). The number and variety of visited attractions are recorded.

Procedure

A team of six trained evaluators carried out the fieldwork during a 4-month period. Interviews with each child were held at their school during the morning in a room with adequate physical conditions for this purpose and lasted for around 90 min (between leaving and returning to the classroom). Given that basic knowledge of computer use is needed for the BENCI battery, each child received previous assessment and training in the utilization of this technology to ensure the absence of any bias due to a lack of familiarization with the test procedure. In general, no such difficulties were found in the performance of any task in the battery. Written consent was obtained from the parents/guardians of the children for their participation in the study, which was approved by the ethical committee of the University of Guayaquil (Ref.: A3/042954/11).

Data analysis

After descriptive analysis of the data, ANOVAs were conducted with 2 × 3 factorial design, considering two SES levels (medium and low) and three age levels (7, 9, and 11 years) as independent variables and BENCI results for each domain as dependent variables, followed by application of the posthoc Bonferroni test. Finally, linear regression analyses were performed to identify the SES components with greatest influence on neuropsychological variables. Given the need for multiple comparisons, the Bonferroni correction was applied to reduce the probability of a type I error, establishing the significance threshold at ≤.002 for ANOVAs and ≤.008 for linear regressions. Partial η^2 was used as an effect size measure.

Results

Differences in sociodemographic variables between groups

Results of the parental socioeconomic survey were compared between the SES groups, showing significantly higher scores (i.e., lower SES) for maternal education level [$F(1, 260) = 249.04$, $p < .001$], home risk index [$F(1, 260) = 104.91$, $p < .001$], and social class of the head of household [$F(1, 260) = 256.19$, $p < .001$] in the low-SES group, confirming the adequate classification of the children into the two groups. No significant differences were observed in these scores as a function of the child's age (see Table 1).

Effects of SES and age on neuropsychological measures

Tables 2 and 3 exhibit differences in the studied domains as a function of SES, age, and their interaction. Simple reaction time significantly differed as a function of age [$F(2, 268) = 21.46$, $p < .001$; $F(2, 268) = 25.98$, $p < .001$], finding shorter reaction times in the 11-year-old versus 7- and 9-year-old children. Reaction time in visual–motor and alternative visual–motor coordination tasks was also significantly longer for the low-SES group [$F(1, 268) = 90.34$, $p < .001$; and $F(1, 268) = 85.43$, $p < .001$, respectively]. Age had a significant effect on the CPT, finding shorter reaction times in 11-year-old versus 7- and 9-year-old children (see Table 2).

Higher verbal memory scores were obtained by medium- versus low-SES groups in immediate recall [$F(1, 268) = 25.49$, $p < .001$], delayed recall [$F(1, 268) = 15.88$, $p < .001$], and recognition [$F(1, 268) = 16.47$, $p < .001$], whereas higher visual memory scores were only obtained by the medium-SES group in immediate recall [$F(1, 268) = 21.91$, $p < .001$]. Scores for verbal memory (immediate/delayed recall and recognition) and visual memory (immediate and delayed recall) significantly differed as a function of age, with 11-year-olds performing better than the 9-year-olds in all memory tasks (see Table 2). The medium-SES group also obtained higher scores in all language tasks, including image comprehension [$F(1, 268) = 16.54$, $p < .001$], shape comprehension [$F(1, 268) = 14.72$, $p < .001$], and phonetic fluency [$F(1, 268) = 63.23$, $p < .001$]. Scores for image comprehension and phonetic fluency significantly differed as a function of age (see Table 3).

Finally, executive function scores were significantly higher for the medium- versus low-SES group in working memory [$F(1, 268) = 72.48$, $p < .001$], abstract reasoning (correct responses) [$F(1, 268) = 137.99$, $p < .001$], semantic fluency [$F(1, 268) = 43.54$, $p < .001$], and inhibitory control [$F(1, 268) = 44.68$, $p < .001$]. No statistically significant differences were found between SES groups in the Go/No-Go and planning tasks ($p > .05$ in all cases). Scores for working memory, abstract reasoning (correct responses and reaction time), semantic fluency, Go/No-Go (reaction time), inhibitory control, and planning differed as a function of age (see Table 3).

Table 1. Differences in socioeconomic characteristics as a function of group, age, and group × age interaction.

Socioeconomic characteristics	Group Medium-SES (*n* = 133) Low-SES (*n* = 141)	7 Years *n* = 91 *M* (SD)	9 Years *n* = 91 *M* (SD)	11 Years *n* = 92 *M* (SD)	*p*-Value	Partial η^2	Posthoc
Maternal level of education	Medium	1.57 (0.63)	1.56 (0.73)	1.65 (0.69)	Group**	.519	ME < L
	Low	3.37 (1.07)	3.64 (1.26)	3.58 (1.05)			
Housing risk index	Medium	1.19 (0.39)	1.33 (0.47)	1.16 (0.37)	Group**	.287	ME < L
	Low	1.86 (0.41)	1.79 (0.46)	1.67 (0.48)			
Social class level of the head of household	Medium	1.91 (0.72)	1.81 (0.66)	2.12 (0.88)	Group**	.495	ME < L
	Low	3.33 (0.57)	3.23 (0.63)	3.31 (0.62)			

SES: socioeconomic status; *M*: Mean, SD: standard deviation; ME: medium; L: low.
**$p < .01$.
A higher survey score indicates a lower socioeconomic level.

Table 2. Effects of group, age, and their interaction on processing speed, visual–motor coordination, sustained attention, and memory tests (*Batería de Evaluación Neuropsicológica Infantil Computarizada* [BENCI]).

Test	Group Medium-SES (n = 133) Low-SES (n = 141)	7 Years n = 91 M (SD)	9 Years n = 91 M (SD)	11 Years n = 92 M (SD)	p-Value	Partial η^2	Posthoc
Simple reaction time							
Median Block 1 (RT)	Medium	461.05 (85.12)	452.57 (138.35)	379.01 (94.31)	Age**	.138	(7 = 9) > 11
	Low	498.35 (131.35)	468.83 (96.44)	388.21 (70.29)			
Median Block 2 (RT)	Medium	478.86 (80.61)	459.72 (138.97)	384.15 (92.83)	Age**	.162	(7 = 9) > 11
	Low	513.11 (135.23)	481.11 (96.74)	393.74 (66.75)			
Visual–motor coordination							
Visual–motor (RT)	Medium	34,208.64 (13,234.43)	29,303.77 (11,990.16)	19,788.81 (8,635.30)	Group**	.252	ME < L
	Low	56,336.11 (23,733.43)	45,489.02 (17,752.51)	36,849.64 (16,123.05)	Age**	.160	7 > 9 > 11
Alternative visual–motor (RT)	Medium	28,154.09 (15,175.96)	20,863.73 (10,043.65)	16,180.06 (7,059.24)	Group**	.242	ME < L
	Low	52,640.26 (23,730.38)	35,643.74 (13,587.30)	26,189.13 (12,600.28)	Age**	.229	7 > 9 > 11
					Group × Age**	.041	
Sustained attention							
CPT Block 1 (RT)	Medium	520.42 (106.50)	526.77 (133.27)	469.65 (144.71)	Group*	.022	ME < L
	Low	603.83 (167.82)	545.15 (117.66)	484.26 (104.22)	Age**	.071	(7 = 9) > 11
CPT Block 2 (RT)	Medium	558.23 (143.78)	570.59 (159.39)	484.49 (157.53)	Age**	.070	(7 = 9) > 11
	Low	595.30 (164.73)	585.76 (158.27)	499.34 (105.22)			
CPT Block 3 (RT)	Medium	578.14 (161.30)	581.70 (172.61)	494.61 (164.42)	Age**	.089	(7 = 9) > 11
	Low	631.92 (182.88)	573.93 (155.65)	485.87 (110.33)			
Memory							
Verbal memory (CR)	Medium	18.16 (2.88)	24.64 (3.91)	32.34 (6.08)	Group**	.087	ME > L
	Low	16.91 (3.20)	23.19 (4.31)	26.65 (6.00)	Age**	.538	7 < 9 < 11
					Group × Age**	.049	11**
Verbal memory (delayed) (CR)	Medium	4.71 (0.97)	6.52 (1.45)	9.02 (2.13)	Group**	.056	ME > L
	Low	4.43 (0.96)	6.32 (1.56)	7.23 (1.96)	Age**	.465	7 < 9 < 11
					Group × Age **	.053	11**
Verbal memory (recognition) (CR)	Medium	10.98 (1.27)	17.09 (1.03)	22.36 (1.82)	Group*	.058	ME > L
	Low	9.80 (1.93)	16.66 (1.22)	21.27 (2.94)	Age**	.870	7 < 9 < 11
Visual memory (CR)	Medium	7.84 (1.85)	9.32 (2.40)	10.25 (2.17)	Group*	.076	ME > L
	Low	6.48 (1.97)	8.85 (2.05)	8.56 (1.98)	Age**	.189	7 < (9 = 11)
Visual memory (delayed) (CR)	Medium	5.69 (2.07)	6.66 (2.49)	7.36 (2.54)	Age**	.046	(7 = 9) < 11
	Low	6.48 (2.28)	6.77 (2.16)	7.25 (2.30)			
Visual memory (recognition) (CR)	Medium	45.62 (5.56)	45.63 (4.68)	46.02 (5.54)			
	Low	46.02 (5.03)	47.38 (2.30)	46.25 (3.62)			

SES: socioeconomic status; RT: reaction time; CR: correct response; M = Mean; SD = standard deviation; ME = medium; L = low; CPT: continuous performance test.
**p < .01; *p < .05.

Table 3. Effects of group, age, and their interaction on language and executive function tests (BENCI).

Test	Group Medium-SES (n = 133) Low-SES (n = 141)	7 Years n = 91 M (SD)	9 Years n = 91 M (SD)	11 Years n = 92 M (SD)	p-Value	Partial η^2	Posthoc
Language							
Verbal comprehension (images) (CR)	Medium	9.04 (1.00)	9.45 (0.93)	9.43 (0.79)	Group**	.058	ME > L
	Low	8.13 (1.13)	9.47 (0.78)	8.98 (0.84)	Age**	.140	7 < (9 = 11)
					Group × Age**	.042	7**
							11**
Verbal comprehension (shapes) (CR)	Medium	9.33 (0.87)	9.50 (0.70)	9.34 (0.78)	Group**	.052	ME > L
	Low	8.54 (1.46)	9.02 (1.00)	9.23 (0.86)	Age*	.028	7 = 9, 9 = 11, 7 < 11
Phonetic fluency (CR)	Medium	5.62 (2.05)	5.23 (2.12)	7.09 (2.73)	Group**	.191	ME > L
	Low	2.04 (1.97)	4.21 (2.52)	4.83 (2.72)	Age**	.122	7 < 9 < 11
					Group × Age**	.047	7**
							9*
							11**
Executive function							
Working memory (CR)	Medium	4.69 (1.49)	6.07 (1.50)	6.66 (1.46)	Group**	.213	ME > L
	Low	2.98 (1.16)	4.66 (1.52)	5.00 (2.00)	Age*	.237	7 < (9 = 11)
Abstract reasoning (CR)	Medium	14.18 (5.04)	17.09 (4.02)	20.09 (2.70)	Group**	.340	ME > L
	Low	8.89 (3.72)	15.23 (3.99)	9.81 (4.61)	Age**	.190	7 < (9 = 11)
					Group × Age**	.155	7**
							9*
							11**
Abstract reasoning (RT)	Medium	9,994.75	11,636.17 (4,896.83)	9678.99	Group**	.029	ME < L
	Low	(4,234.02)	13,857.44 (4,890.39)	(3010.15)	Age**	.067	(7 = 9) > 11
		13,195.11 (7,967.61)		9372.87			
				(3531.83)			
Semantic fluency (CR)	Medium	10.53 (2.76)	14.80 (4.51)	16.82 (4.10)	Group**	.140	ME > L
	Low	8.57 (3.04)	11.87 (3.64)	12.88 (3.85)	Age**	.271	7 < 9 < 11
Inhibition Go/No-Go Block 1 (RT)	Medium	814.52 (180.43)	743.84 (137.57)	608.20 (122.58)	Age**	.228	7 > 9 > 11
	Low	853.56 (178.54)	727.87 (169.10)	645.27 (147.35)			
Inhibition Go/No-Go Block 2 (RT)	Medium	822.96 (184.75)	761.30 (151.35)	620.70 (140.07)	Age**	.228	7 > 9 > 11
	Low	856.56 (172.13)	728.23 (140.87)	638.19 (135.02)			
Inhibition Go/No-Go Block 3 (RT)	Medium	815.75 (127.24)	756.76 (130.50)	649.93 (104.83)	Age**	.240	7 > 9 > 11
	Low	842.43 (145.92)	738.47 (120.88)	669.48 (114.43)			
Inhibition Go/No-Go Block 4 (RT)	Medium	793.60 (186.25)	730.19 (167.00)	629.24 (183.12)	Age**	.183	7 > 9 > 11
	Low	820.41 (171.20)	700.05 (132.94)	619.87 (133.35)			
Inhibitory control – Spatial Stroop (CR)	Medium	81.09 (8.86)	84.41 (10.53)	86.55 (3.87)	Group**	.143	ME > L
	Low	66.96 (14.11)	77.43 (11.29)	82.75 (9.90)	Age**	.158	7 < 9 < 11
					Group × Age **	.043	7**
							9**
							11*
Planning (visited attractions)	Medium	18.73 (2.47)	19.32 (3.23)	20.55 (4.41)	Age**	.057	7 < (9 = 11)
	Low	17.50 (2.90)	20.21 (2.46)	18.71 (2.61)	Group × Age**	.036	7*
							11*

SES: socioeconomic status; RT: reaction time; CR: correct response; M: mean; SD: standard deviation; ME: medium; L: low.
**$p < .01$; *$p < .05$.

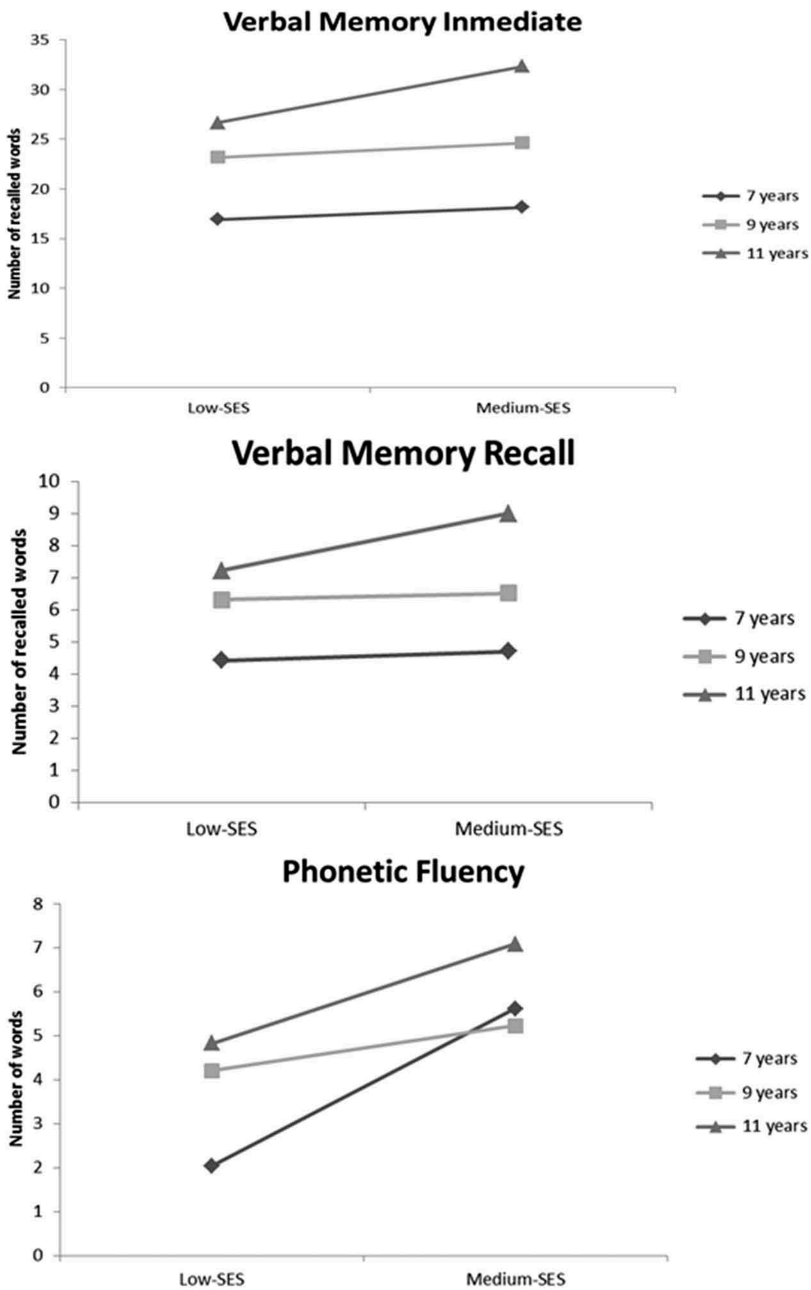

Figure 1. Graphic representation of SES × age interactions in memory and language domains. SES: socioeconomic status.

Interactions between SES and age-groups on neuropsychological measures

Statistically significant interactions were found between SES and age (see Figures 1 and 2) for verbal memory in immediate [$F(2, 268) = 6.90$, $p = .001$] and delayed recall [$F(2, 268) = 7.45$, $p = .001$], with the differences between SES groups being greater among the 11-year-old children (Table 3 and Figure 1). In the language domain, a statistically significant interaction between SES and age was observed in verbal comprehension (images) [$F(2, 268) = 5.81$, $p = .002$] and phonetic fluency [$F(2, 268) = 6.63$, $p = .002$], with the differences between SES groups being greater in the 11-year-olds than in the 7-year-olds

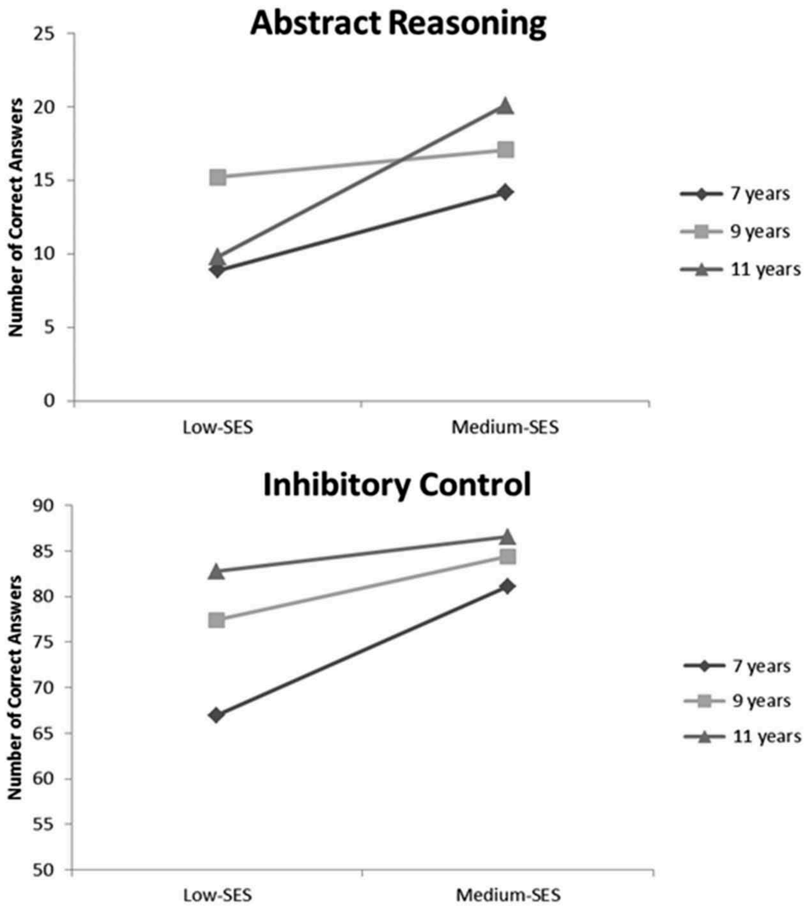

Figure 2. Graphic representation of SES × age interactions in executive function domain. SES: socioeconomic status.

(Table 3 and Figure 1). With regard to executive function, interactions between SES and age were found in abstract reasoning (correct responses) [$F(2, 268) = 24.51$ $p < .001$] and inhibitory control [$F(2, 268) = 6.10$, $p = .002$] (see Table 3 and Figure 2). In the case of abstract reasoning, the most marked differences were found in low-SES children at the age of 11 years, while differences in inhibitory control were observed between those aged 7 and 11 years (see Figure 2).

Variables showing a significant SES × age interaction were entered in simple linear regression models. All of the models showed statistically significant differences ($p < .001$ in all variables; see Table 4). Maternal level of education (standardized $\beta = -.22$, $p = .002$) and housing risk index (standardized $\beta = -.17$, $p = .007$) emerged as significant predictors of abstract reasoning, and the social class of the head of the household was a significant predictor of inhibitory control (standardized $\beta = -.22$, $p = .003$). No SES component significantly predicted scores in memory or verbal tasks.

Discussion

This study investigated the cognitive development of three age-groups (7, 9, and 11 years) of schoolchildren with medium or low SES in a developing country. The results support the first study hypothesis, because the medium-SES children obtained significantly higher scores in five out of the six neuropsychological domains studied (visual–motor coordination, sustained attention,

Table 4. Linear regression models using the score of the BENCI tasks as criterion variables and dimensions of SES and age as predictor variables.

BENCI variables	Variables	Standardized β	t	p	Inferior 95% CI	Superior 95% CI	F model	R^2	Adjusted R^2
Verbal memory immediate (CR)	Age of the child	.70	16.09	.000	2.57	3.28	$F(4, 265) = 68.38^{***}$	.512	.504
	MLE	−.10	−1.93	.054	−1.06	.01			
	HRI	−.05	−.97	.335	−2.00	.68			
	SCL	−.03	−.46	.647	−.99	.62			
Verbal memory delayed (CR)	Age of the child	.64	13.65	.000	.73	.98	$F(4, 265) = 49.17^{***}$	.430	.421
	MLE	−.09	−1.51	.133	−.33	.04			
	HRI	−.06	−1.16	.248	−.74	.19			
	SCL	.02	.40	.688	−.22	.34			
Verbal comprehension (images) (CR)	Age of the child	.22	3.77	.000	.067	.21	$F(4, 265) = 6.178^{***}$	.086	.072
	MLE	.01	0.13	.894	−.10	.12			
	HRI	−.09	−1.23	.221	−.44	.10			
	SCL	−.13	−1.70	.089	−.30	.02			
Phonetic fluency (CR)	Age of the child	.32	5.75	.000	.37	.75	$F(4, 265) = 15.10^{***}$	.188	.175
	MLE	−.18	−2.59	.010	−.67	−.09			
	HRI	−.03	−0.45	.650	−.89	.55			
	SCL	−.14	−1.90	.059	−.85	.01			
Abstract reasoning (CR)	Age of the child	.22	4.02	.000	.38	1.14	$F(4, 265) = 21.01^{***}$	.244	.232
	MLE	−.22	−3.20	.002	−1.44	−.34			
	HRI	−.17	−2.72	.007	−3.26	−.52			
	SCL	−.15	−2.13	.034	−1.72	−.07			
Inhibitory control – Spatial Stroop (CR)	Age of the child	.38	7.06	.000	2.00	3.55	$F(4, 265) = 20.48^{***}$	.239	.227
	MLE	−.12	−1.75	.081	−2.19	.13			
	HRI	−.03	−.45	.655	−3.56	2.24			
	SCL	−.22	−3.04	.003	−4.43	−.95			

MLE: maternal level of education; HRI: housing risk index; SCL: social class level of the head of household; RT: reaction time; CR: correct responses.
$^{***}p < .001$.

memory, language, and executive function) in comparison to the low-SES group. The second hypothesis was supported by the finding of three domains in which the difference between SES groups was significantly greater in 11-year-olds than in 7-year-olds: verbal memory, language (phonetic fluency), and executive function (abstract reasoning and inhibitory control).

Influence of SES on neuropsychological performance

Our results are in line with previous reports on the negative effects of low SES on neuropsychological development. Low SES was found to predict a worse neurocognitive performance in under 5-year-olds (Hackman & Farah, 2009) and in over 6-year-old children (Brito & Noble, 2014; Raizada & Kishiyama, 2010), with reports of a particular influence on domains related to language or executive function (Farah et al., 2006). Furthermore, greater poverty has been associated with worse neuropsychological performance and with alterations of gray matter development in frontal and temporal lobes (Hair, Hanson, Wolfe, & Pollak, 2015), closely related to regulation of the emotions (Luby et al., 2013).

Our findings on the negative effect of a low SES on inhibitory control, language (especially verbal fluency), memory, and executive functions confirm previous reports (Abundis-Gutiérrez, Checa, Castellanos, & Rueda, 2014; Arán-Filippetti & Richaud de Minzi, 2012; Conejero, Guerra, Abundis-Gutiérrez, & Rueda, 2018; Hackman & Farah, 2009; Ison, Greco, Korzeniowski, & Morelato, 2015; Lipina, Martelli, Vuelta, & Colombo, 2005; Noble et al., 2005). No association was found in the present study between SES and simple reaction time, CPT, or visual memory recognition, which are considered low-level or basic skills in neuropsychological assessments (Vanderploeg, 2014) and generally share a strong motor component, being linked to visual and parietal brain areas (Clayton, Yeung, & Kadosh, 2015). Little difference was observed in these domains (i.e., simple reaction time and visual–motor coordination tasks) between children with lower and higher SES (Hackman & Farah, 2009; Raizada & Kishiyama, 2010), consistent with the present finding of no significant interaction between SES and processing speed, sustained attention, or tasks with a major motor component such as Go/No-Go. In contrast, SES had a significant effect on language and executive function (abstract reasoning and motor inhibition) in our 11-year-old children. This difference between SES groups may reflect differences in how they approach the execution of tasks. It has been proposed that success in performance may be associated with response behaviors that differ between SES groups (Farah, 2017). This proposal may in part account for the unexpected lack of between-group differences in certain domains. For example, a greater between-group difference was observed in the Spatial Stroop task, which directly assesses the cognitive inhibition component, than in the Go/No-Go test, which is more closely related to the motor components of inhibition. Authors using different scoring or corrections of the Go/No-Go task indicated that these scores may also be associated with the processing of prefrontal and executive function systems (Arán-Filippetti, 2013; Hackman & Farah, 2009).

When comparing effect sizes, the SES of the children explained a large percentage of variance in the language domain, including production (phonetic fluency) and comprehension (figure comprehension), in line with previous reports (Abundis-Gutiérrez et al., 2014; Arán-Filippetti & Richaud de Minzi, 2012; Ison et al., 2015; Lipina et al., 2005).

Distinct effects of SES depending on age

According to the present findings, the effect of SES is not homogeneous but rather depends on the age of children, at least for verbal memory, language, and some components of executive function (abstract reasoning and inhibitory control). In general, greater between-group differences were found among the 11-year-olds. A similar phenomenon has been described in relation to externalizing and internalizing psychopathological symptoms in children, which appear to vary as a function of age and SES (Hackman et al., 2010; Ortiz-Andrellucchi, Peña Quintana, Albino-Beñacar, Mönckeberg Barros, & Serra-Majem, 2006). From a neuropsychological standpoint, these results are in partial agreement with those published by Hackman et al. (2015), who evaluated executive function (working memory and planning) and found no increased difference between SES groups with higher age of the children. However, the detailed evaluation of different domains in the present study revealed that other executive functions, such as abstract reasoning and inhibitory control, may indeed significantly differ as a function of SES and age.

Maternal education level, housing risk index, and social class of the head of household were the SES components with the greatest influence on neuropsychological performance scores. A similar study in South America reported that maternal educational level and housing condition were the main predictors of phonetic fluency, planning, and inhibition (Arán-Filippetti & Richaud de Minzi, 2012), and parental education has been consistently related to the performance of children in verbal fluency and abstract reasoning tasks (Ardila, Rosselli, Matute, & Guajardo, 2005). One possible explanation may be that better-educated parents provide their children with greater cognitive, social, and affective stimulation, creating greater interaction with the children and their environment (Brito & Noble, 2014). Another explanation may be that parents with higher education and SES have the opportunity to send their children to better schools, favoring an improved performance in all of these domains and skills.

Clinical implications

Our data support proposals for preventive interventions to reduce the negative effects of low SES (Arruabarrena & de Paúl, 2012; Heckman, 2006; Knudsen, Heckman, Cameron, & Shonkoff, 2006). Our finding of a greater impact of a low SES on neurodevelopment in 11-year-olds than in 7-year-olds underlines the need for interventions to be implemented in disadvantaged populations at the earliest possible age, involving schools, health centers, nursing professionals and psychologists, among other health-care providers. Possible strategies include the regular screening of children from a very young age and the incorporation into nursery and primary school curricula of stimulation programs focused on the training of executive functions and of emotional and behavior regulation skills (see García-Bermúdez et al., 2018 for a recent example).

Strengths and limitations

The cross-sectional design of our study prevents conclusions on the direct influence of age on performance. In addition, we did not elucidate the differential effects on socio-emotional and neuropsychological development of the distinct components of a low SES (e.g., poverty, malnutrition, infant abuse). We evaluated neuropsychological domains by analyzing correct responses and reaction times in the BENCI tests; however, we did not consider the measurement of errors, which would have provided useful information on impulsiveness and perseverance in the performance of tasks. Multiple comparisons were required, but the risk of a type I error was minimized by strict statistical correction, reducing the significance threshold accordingly, and systematically reporting the effect size. Our SES groups differed in the types of school they attended, with low-SES group being recruited solely from public schools and the medium-SES children from public, subsidized, and private schools; therefore, future studies should control for the type of school as a potential confounder. Finally, the Ecuadorian and Arabian versions of the BENCI battery have demonstrated adequate reliability and validity, but further research is warranted to assess its factorial structure and its invariance across samples with low and medium SES.

Conclusions

In conclusion, this study of urban schoolchildren in a developing country showed that low SES had a negative impact on their visual–motor coordination, sustained attention, memory, language, and executive function. The difference with medium-SES children was wider at the age of 11 years than at 7 or 9 years in verbal memory, image comprehension, phonetic fluency, reasoning, and inhibitory control. These data support the need for medium- and long-term preventive strategies to mitigate poverty-associated risk factors for inadequate neurodevelopment, including the regular screening of young children and a greater focus on neuropsychological stimulation in preschool and primary school programs. Further research is needed to investigate the reversibility of these neuropsychological deficits and to explore the effect of SES on the performance of older children and adolescents.

Note

1. BENCI – Spanish acronym for "Batería de Evaluación Neuropsicológica Infantil Computarizada."

Funding

This work was supported by the Spanish Agency for International Development Cooperation (AECID) [A3/042954/11] (PI: Francisco Cruz-Quintana) and Conselleria d'Educació, Investigació, Cultura i Esport de la Generalitat Valenciana (Proyectos I+D+i desarrollados por grupos de investigación emergentes) [GV/2017/166] (PI: Manuel Fernández-Alcántara).

ORCID

Manuel Fernández-Alcántara http://orcid.org/0000-0002-3481-8156

References

Aber, J. L., Jones, S. M., & Cohen, J. (2000). The impact of poverty on the mental health and development of very young children. In C. H. Zeanah (Ed.), *Handbook of infant mental health* (pp. 113–128). New York, NY: Guilford Press.

Abundis-Gutiérrez, A., Checa, P., Castellanos, C., & Rueda, M. R. (2014). Electrophysiological correlates of attention networks in childhood and early adulthood. *Neuropsychologia*, *57*, 78–92. doi:10.1016/j.neuropsychologia.2014.02.013

Arán-Filippetti, V. (2011). Funciones ejecutivas en niños escolarizados: Efectos de la edad y del estrato socioeconómico [Executive functions in school-aged children: Effects of age and socioeconomic status]. *Avances en Psicología Latinoamericana*, *29*(1), 98–113.

Arán-Filippetti, V. (2012). Estrato socioeconómico y habilidades cognitivas en niños escolarizados: Variables predictoras y mediadoras [Socioeconomic status and cognitive skills in school-age children: Predictive and mediating variables]. *Psykhe*, *21*(1), 3–20. doi:10.4067/S0718-22282012000100001

Arán-Filippetti, V. (2013). Structure and invariance of executive functioning tasks across socioeconomic status: Evidence from Spanish-speaking children. *The Spanish Journal of Psychology*, *16*, E101. doi:10.1017/sjp.2013.102

Arán-Filippetti, V., & Richaud de Minzi, M. C. (2012). A structural analysis of executive functions and socioeconomic status in school-age children: Cognitive factors as effect mediators. *The Journal of Genetic Psychology*, *173*(4), 393–416. doi:10.1080/00221325.2011.602374

Ardila, A., Rosselli, M., Matute, E., & Guajardo, S. (2005). The influence of the parents' educational level on the development of executive functions. *Developmental Neuropsychology*, *28*(1), 539–560. doi:10.1207/s15326942dn2801_5

Arruabarrena, I., & de Paúl, J. (2012). Early intervention programs for children and families: Theoretical and empirical bases supporting their social and economic efficiency. *Psychosocial Intervention*, *21*, 117–127. doi:10.5093/in2012a18

Boivin, M. J., Kakooza, A. M., Warf, B. C., Davidson, L. L., & Grigorenko, E. L. (2015). Reducing neurodevelopmental disorders and disability through research and interventions. *Nature*, *19*(527), S155–S160. doi:10.1038/nature16029

Brito, N. H., & Noble, K. G. (2014). Socioeconomic status and structural brain development. *Frontiers in Neuroscience*, *8*, 1–12. doi:10.3389/fnins.2014.00276

Brooks-Gunn, J., & Duncan, G. J. (1997). The effects of poverty on children. *The Future of Children*, *7*, 55–71. doi:10.2307/1602387

Brooks-Gunn, J., Klebanov, P. K., Liaw, F., & Spiker, D. (1993). Enhancing the development of low-birth weight, premature infants: Changes in cognition and behavior over the first 3 years. *Child Development*, *64*, 736–753. doi:10.1111/j.1467-8624.1993.tb02940.x

Clayton, M. S., Yeung, N., & Kadosh, R. C. (2015). The roles of cortical oscillations in sustained attention. *Trends in Cognitive Sciences*, *19*(4), 188–195. doi:10.1016/j.tics.2015.02.004

Conejero, Á., Guerra, S., Abundis-Gutiérrez, A., & Rueda, M. R. (2018). Frontal theta activation associated with error detection in toddlers: Influence of familial socioeconomic status. *Developmental Science*, *21*, 1. doi:10.1111/desc.12494

Crookston, B. T., Forste, R., McClellan, C., Georgiadis, A., & Heaton, T. B. (2014). Factors associated with cognitive achievement in late childhood and adolescence: The young lives cohort study of children in Ethiopia, India, Peru, and Vietnam. *BMC Pediatrics*, *14*(1), 253. doi:10.1186/1471-2431-14-253

Cruz-Quintana, F., Pérez-García, M., Fernández-López, A., & Roldan-Vílchez, L. M. (2011). *Batería de Evaluación Neuropsicológica Infantil (BENCI)* [Battery for Computerized Neuropsychological Assessment of Children (BENCI)]. Granada, Spain: Ediciones CIDER.

Cruz-Quintana, F., Pérez-García, M., Roldan-Vílchez, L. M., Fernández López, A., & Pérez-Marfil, M. N. (2013). *Manual de la Batería de Evaluación Neuropsicológica Infantil (BENCI)* [User's Manual of the Battery for Computerized Neuropsychological Assessment of Children (BENCI)]. Granada, Spain: Ediciones CIDER.

Diamond, A. (2013). Executive functions. *Annual Review of Psychology*, *64*, 135–168. doi:10.1146/annurev-psych-113011-143750

Farah, M. J. (2017). The neuroscience of socioeconomic status: Correlates, causes, and consequences. *Neuron*, *96*, 56–71. doi:10.1016/j.neuron.2017.08.034

Farah, M. J., Shera, D. M., Savage, J. H., Betancourt, L., Giannetta, J. M., Brodsky, N. L., … Hurt, H. (2006). Childhood poverty: Specific associations with neurocognitive development. *Brain Research*, *1110*(1), 166–174. doi:10.1016/j.brainres.2006.06.072

Fasfous, A. F., Peralta-Ramírez, M. I., Pérez-Marfil, M. N., Cruz-Quintana, F., Catena-Martinez, A., & Pérez-García, M. (2015). Reliability and validity of the Arabic version of the computerized battery for neuropsychological evaluation of children (BENCI). *Child Neuropsychology*, *21*(2), 210–224. doi:10.1080/09297049.2014.896330

García-Bermúdez, O., Cruz-Quintana, F., Pérez-García, M., Hidalgo-Ruzzante, N., Fernández-Alcántara, M., & Pérez-Marfil, M. N. (2018). Improvement of executive functions after the application of a neuropsychological intervention program (PEFEN) in pre-term children. *Children and Youth Services Review*. doi:10.1016/j.childyouth.2018.10.035

Ghosh, S., Chowdhury, S. D., Chandra, A. M., & Ghosh, T. (2015). Grades of undernutrition and socioeconomic status influence cognitive development in school children of Kolkata. *American Journal of Physical Anthropology*, *156*, 274–285. doi:10.1002/ajpa.22648

Grieve, S. M., Korgaonkar, M. S., Clark, C. R., & Williams, L. M. (2011). Regional heterogeneity in limbic maturational changes: Evidence from integrating cortical thickness, volumetric and diffusion tensor imaging measures. *NeuroImage*, *55*, 868–879. doi:10.1016/j.neuroimage.2010.12.087

Hackman, D. A., & Farah, M. J. (2009). Socioeconomic status and the developing brain. *Trends in Cognitive Sciences*, *13*(2), 65–73. doi:10.1016/j.tics.2008.11.003

Hackman, D. A., Farah, M. J., & Meaney, M. J. (2010). Socioeconomic status and the brain: Mechanistic insights from human and animal research. *Nature Reviews Neuroscience*, *11*(9), 651–659. doi:10.1038/nrn2897

Hackman, D. A., Gallop, R., Evans, G. W., & Farah, M. J. (2015). Socioeconomic status and executive function: Developmental trajectories and mediation. *Developmental Science*, *18*(5), 686–702. doi:10.1111/desc.12246

Hair, N. L., Hanson, J. L., Wolfe, B. L., & Pollak, S. D. (2015). Association of child poverty, brain development, and academic achievement. *JAMA Pediatrics*, *169*(9), 822–829. doi:10.1001/jamapediatrics.2015.1475

Hamadani, J. D., Tofail, F., Huda, S. N., Alam, D. S., Ridout, D. A., Attanasio, O., & Grantham-McGregor, S. M. (2014). Cognitive deficit and poverty in the first 5 years of childhood in Bangladesh. *Pediatrics*, *134*(4), e1001–e1008. doi:10.1542/peds.2014-0694

Harmony, T. (2004). Factores que inciden en el desarrollo del sistema nervioso del niño [Factors that affect the development of the child's nervous system]. In M. Corsi (Ed.), *Aproximaciones de las neurociencias a la conducta* [Approaches to behaviour neuroscience] (2nd ed., pp. 148–163). México, DF: Manual Moderno.

Heckman, J. (2006). Skill formation and the economics of investing in disadvantaged children. *Science*, *312*, 1900–1902. doi:10.1126/science.1128898

Hinojosa- Fierro, E. S. (2015). *Relación entre niveles de hemoglobina y estado nutricional en niños y niñas de 3 a 5 años beneficiarios del Proyecto Compassion Internacional Guaranda 2014* [Relationship between hemoglobin levels and nutritional status in children aged 3 to 5 years beneficiaries of the Compassion International Guaranda Project 2014] (Bachelor's thesis, Escuela Superior Politécnica de Chimborazo). Retrieved from http://dspace.espoch.edu.ec/handle/123456789/7733

Hung, G., Hahn, J., Alamiri, B., Buka, S. L., Goldstein, J. M., Laird, N., … Gilman, S. E. (2015). Socioeconomic disadvantage and neural development from infancy through early childhood. *International Journal of Epidemiology*, *44*(6), 1889–1899. doi:10.1093/ije/dyv303

Instituto Nacional de Estadísticas y Censos, INEC (2010). *Base de datos-censo de población y vivienda 2010*. Retrieved from http://www.ecuadorencifras.gob.ec/base-de-datos-censo-de-poblacion-y-vivienda-2010-a-nivel-de-manzana/

Ison, M. S., Greco, C., Korzeniowski, C., & Morelato, G. (2015). Attentional efficiency: A comparative study on argentine students attending schools from different socio-cultural contexts. *Electronic Journal of Research in Educational Psychology*, *13*(2), 343–368.

Knudsen, E., Heckman, J., Cameron, J., & Shonkoff, J. (2006). Economic, neurobiological and behavioral perspectives on building America's Future Workforce. *PNAS*, *103*, 10155–10162. doi:10.1073/pnas.0600888103

Lawson, G. M., Camins, J. S., Wisse, L., Wu, J., Duda, J. T., Cook, P. A., … Farah, M. J. (2017). Childhood socioeconomic status and childhood maltreatment: Distinct associations with brain structure. *PloS one*, *12*(4), e0175690. doi:10.1371/journal.pone.0175690

Lezak, M. D., Howieson, D. B., & Loring, D. W. (2004). *Neuropsychological assessment* (4th ed.). New York, NY: Oxford University Press.

Lipina, S., & Posner, M. I. (2012). The impact of poverty on the development of brain networks. *Frontiers in Human Neuroscience*, *6*, 238. doi:10.3389/fnhum.2012.00238

Lipina, S. J., Martelli, M., Vuelta, B., & Colombo, J. (2005). Performance on the A-not-B task of Argentinean infants from unsatisfied and satisfied basic needs homes. *Interamerican Journal of Psychology*, *39*, 49–60.

Luby, J., Belden, A., Botteron, K., Marrus, N., Harms, M. P., Babb, C., & Barch, D. (2013). The effects of poverty on childhood brain development: The mediating effect of caregiving and stressful life events. *JAMA Pediatrics*, *167*(12), 1135–1142. doi:10.1001/jamapediatrics.2013.3139

Mazzoni, C. C., Stelzer, F., Cerigni, M. A., & Martino, P. (2014). Impact of poverty on cognitive development. A theoretical analysis of two mediator factors. *Liberabit*, *20*(1), 93–100.

Mous, S. E., Schoemaker, N. K., Blanken, L. M., Thijssen, S., van der Ende, J., Polderman, T. J., … White, T. (2017). The association of gender, age, and intelligence with neuropsychological functioning in young typically developing children: The generation R study. *Applied Neuropsychology: Child*, *6*(1), 22–40. doi:10.1080/21622965.2015.1067214

Noble, K. G., Engelhardt, L. E., Brito, N. H., Mack, L. J., Nail, E. J., Angal, J., … Elliott, A. J. (2015). Socioeconomic disparities in neurocognitive development in the first two years of life. *Developmental Psychobiology*, *57*(5), 535–551. doi:10.1002/dev.21303

Noble, K. G., Norman, M. F., & Farah, M. J. (2005). Neurocognitive correlates of socioeconomic status in kindergarten children. *Developmental Science*, *8*(1), 74–87. doi:10.1111/j.1467-7687.2005.00394.x

Ortiz-Andrellucchi, A., Peña Quintana, L., Albino-Beñacar, A., Mönckeberg Barros, F., & Serra-Majem, L. (2006). Desnutrición infantil, salud y pobreza: Intervención desde un programa integral [Child malnutrition, health and poverty: Intervention from a comprehensive program]. *Nutrición Hospitalaria*, *21*(4), 533–541.

Peterman, A., Neijhoft, A., Cook, S., & Palermo, T. M. (2017). Understanding the linkages between social safety nets and childhood violence: A review of the evidence from low-and middle-income countries. *Health Policy and Planning*, *32*(7), 1049–1071. doi:10.1093/heapol/czx033

Raizada, R., & Kishiyama, M. M. (2010). Effects of socioeconomic status on brain development, and how cognitive neuroscience may contribute to levelling the playing field. *Frontiers Human Neuroscience*, *4*(3), 1–11. doi:10.3389/neuro.09.003.2010

Sastre-Riba, S. (2006). Early development and learning conditions: The role of executive functions. *Revista de Neurología*, *42*(2), 143–151.

Sripada, R. K., Swain, J. E., Evans, G. W., Welsh, R. C., & Liberzon, I. (2014). Childhood poverty and stress reactivity are associated with aberrant functional connectivity in default mode network. *Neuropsychopharmacology : Official Publication of the American College of Neuropsychopharmacology*, *39*(9), 2244. doi:10.1038/npp.2014.75

Ursache, A., & Noble, K. G. (2016). Neurocognitive development in socioeconomic context: Multiple mechanisms and implications for measuring socioeconomic status. *Psychophysiology*, *53*(1), 71–82. doi:10.1111/psyp.12547

Vanderploeg, R. D. (2014). *Clinician's guide to neuropsychological assessment*. New York, NY: Routledge Psychology Press.