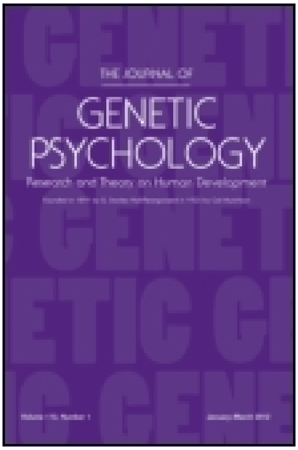

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A Structural Analysis of Executive Functions and Socioeconomic Status in School-Age Children: Cognitive Factors as Effect Mediators

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A Structural Analysis of Executive Functions and Socioeconomic Status in School-Age Children: Cognitive Factors as Effect Mediators

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ABSTRACT. Socioeconomic status (SES) is a well-known predictor of cognitive achievement and executive functioning, although the underlying cognitive mediating processes remain unclear. The authors analyze the association between different socioeconomic indicators and the executive functions (EF) of schoolchildren and the possible cognitive mediating factors of this association. The sample included 254 children aged 7–12 years from different SES. The researchers employed a battery of tests to evaluate EF, including the Kaufman Brief Intelligence Test task to measure intelligence, and the Matching Familiar Figures Test–20 to assess the reflexivity-impulsivity (R-I) cognitive style. The results indicate a significant effect of SES on all tested EF. Stepwise regression analysis showed that maternal education level and housing conditions were significant predictors of the majority of EF. Structural equation modeling showed that, although SES had effects on intelligence quotient (IQ), R-I cognitive style, and EF, the association between SES and EF is partly explained by cognitive impulsivity but not by IQ scores. Results are discussed in terms of the mediating cognitive variables that may explain the association between SES and EF and their implications for designing effective intervention programs in schools.

Keywords: child neuropsychology, cognitive impulsivity, executive functions, socioeconomic status

In the last several years, a large body of research has established that socioeconomic status (SES) is highly associated with children's cognitive development. It has been reported that children from low SES perform below their middle SES

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peers on tests of intelligence and academic achievement (Ramey & Campbell, 1991; Smith, Brooks-Gunn, & Klebanov, 1997), language (Hoff, 2003; Hoff & Tian, 2005; Noble, McCandliss, & Farah, 2007; Noble, Norman, & Farah, 2005), attention (Matute Villaseñor, Sanz Martín, Gumá Díaz, Rosselli, & Ardila, 2009; Mezzacappa, 2004), and memory (Farah et al., 2006; Matute Villaseñor et al., 2009).

Recent studies have also reported an association between SES and prefrontal/executive brain functions (Ardila, Rosselli, Matute, & Guajardo, 2005; Farah et al., 2006; Lipina, Martelli, Vuelta, Injoque-Ricle, & Colombo, 2004; Mezzacappa, 2004; Noble et al., 2007; Noble et al., 2005; Waber, Gerber, Turcios, Wagner, & Forbes, 2006). Executive function (EF) is an umbrella term for a series of higher order cognitive processes necessary for goal-directed behavior (Luria, 1966; Stuss & Benson, 1986), such as set-shifting, planning, inhibition, working memory, and fluency (Pennington & Ozonoff, 1996). These functions are thought to rely on the prefrontal cortex (PFC) and reciprocal connections with related cortical regions and subcortical brain structures (Diamond, 2002; Fuster, 1997, 2002; Goldman-Rakic, 1992; Heyder, Suchan, & Daum, 2004). Both EF and the PFC follow a prolonged course of postnatal development (Casey, Giedd, & Thomas, 2000; Diamond, 2002; Fuster, 2002) that enables early life experiences to influence higher order cognitive functions and brain development. Evidence supporting this postnatal development comes from both structural (Giedd, 1994; Giedd et al., 1999) and functional neuroimaging studies (Casey, Galvan, & Hare, 2005; Casey et al., 2000) as well as from behavioral developmental studies (for a review, see Blakemore & Choudhury, 2006).

On the basis of this evidence, research has indicated that social environmental variables may influence the development of the frontal brain regions and EF. For example, several studies using electrophysiological measures have found a maturational lag in the frontal, temporal, and occipital regions (Otero, 1994, 1997; Otero, Pliego-Rivero, Fernández, & Ricardo, 2003), left frontal hypoactivity (Tomarken, Dichter, Garber, & Simien, 2004), and alterations in PFC function (Kishiyama, Boyce, Jimenez, Perry, & Knight, 2009) in children and adolescents from low SES. In addition, event-related brain potential studies have demonstrated differences in the patterns of neural responses underlying auditory selective attention on the basis of children's SES (D'Angiulli, Herdman, Stapells, & Hertzman, 2008; Stevens, Lauinger, & Neville, 2009). Differences have also been shown in the executive system associated with SES by means of behavioral tests. Research indicates that children of low SES show a low performance in tasks that value different EF compared with children of middle SES. The effect of SES on different cognitive executive processes such as inhibitory control, working memory, verbal fluency, planning, and executive attention has been demonstrated in Spanish-speaking children (Arán-Filippetti & Richaud de Minzi, 2011; Ardila et al., 2005; Lipina et al., 2004) and in English-speaking children (Farah et al., 2006; Noble et al., 2007; Noble et al., 2005; Waber et al., 2006).

Although a large body of evidence supports the linkage between SES and EF, less is known about the specific socioeconomic indicators that may predict executive task performance. SES is a composite variable that includes measures of family income, occupational status, and parental education (Duncan & Magnuson, 2003; Ensminger & Fothergill, 2003). Researchers have suggested that these indicators may have separate effects on children's developmental outcomes (Bornstein, Hahn, Suwalsky, & Haynes, 2003; Duncan & Magnuson, 2003). For example, Noble et al. (2005) and Noble et al. (2007) found that parental education most strongly accounted for variance in language and EF task performance. Consistent with these findings, other studies have indicated that parental education is associated with children's performance in diverse tasks that measure executive functioning (Ardila et al., 2005) and tasks of attention and memory (Matute Villaseñor et al., 2009). Several studies have also examined the pathways through which SES works to the disadvantage of low-income children. Cognitive stimulation at home, the health status of the child, parenting style (Guo & Harris, 2000), environmental housing conditions and mother–child interactions (Duncan & Brooks-Gunn, 2000), and different characteristics related with neighborhood residence (Brooks-Gunn & Duncan, 1997; Duncan & Brooks-Gunn, 2000; Leventhal & Brooks-Gunn, 2000), among others, have been proposed as mediating variables between SES and children's cognitive development.

Another less examined aspect is the exploration of cognitive variables that could mediate the association between SES and executive task performance. Because EF tasks may tap other nonexecutive cognitive functions (Pennington & Ozonoff, 1996) and considering that SES is associated with disparities in wide domains of cognitive functioning, it is possible to infer that other cognitive abilities, such as language and intelligence, may partially explain the disparities in EF associated with SES. For example, previous studies conducted with children from different SES have reported that language abilities mediate the association between SES and EF (Noble et al., 2007; Noble et al., 2005).

Another variable that might mediate the association between SES and executive performance is the reflection-impulsivity (R-I) cognitive style because of the significant association that has been established between SES and R-I. It has been demonstrated that low-SES children are more impulsive, measured both by errors and response time, than their middle-SES peers (Arán-Filippetti & Richaud de Minzi, 2011; Heider, 1971; Juliano, 1977; Mumbauer & Miller, 1970; Schwebel, 1966). R-I cognitive style was introduced into the literature by Kagan, Rosman, Day, Albert, and Phillips (1964) to refer to the particular way in which a child faces tasks that demand resolution of conflicts characterized by uncertainty. The R-I construct is analyzed on a continuous two-pole scale (from reflective to impulsive) and is defined in terms of two indicators: accuracy (successes vs. errors) and latency (time delay by means of response). Reflective individuals have longer response latencies and make fewer errors than impulsive individuals because the former use more effective analytical strategies to value different response alternatives. Thus, it is believed that reflective individuals are more capable than impulsive ones when facing tasks that raise uncertainty. With respect to cognitive performance, it has been demonstrated that reflective individuals obtain higher performances than impulsive ones in attention-concentration and visual organization tasks (Brannigan, Ash, & Margolis, 1980), recognition memory tasks (Siegel, Kirasic, & Kilburg, 1973), the metamemory (Borkowski, Peck, Reid, & Kurtz, 1983), the ability to inhibit movements (Harrison & Nadelman, 1972), verbal control of inhibitory motor behavior (Meichenbaum & Goodman, 1969), problem solving (McKinney, 1975), and inductive reasoning (Kagan, Pearson, & Welch, 1966). Furthermore, it has been shown that impulsive children perform poorly on intelligence measures included in the Wechsler Intelligence Scale for Children–Revised (WISC-R) (Brannigan & Ash, 1977) and have lower academic achievement (Barret, 1977; Buela-Casal, Carretero-Dios, & De los Santos-Roig, 2000).

Therefore, because of the presence of a higher cognitive impulsivity observed in low-SES children and the established association between R-I and cognitive performance, it is possible to hypothesize that the R-I style would act as a mediating cognitive variable to partially explain the association between SES and executive performance. On the other hand, because of the well-known association between SES and IQ level (Ramey & Campbell, 1991; Smith et al., 1997) and the demonstrated association between intelligence behavior and the lateral PFC (for a review, see Gray & Thompson, 2004), IQ levels may play some role in the executive performance associated with SES.

To summarize, three main questions were investigated in this study. First, are EF, IQ, and R-I cognitive style associated with SES? Second, if so, what are the socioeconomic indicators that predict cognitive task performance? Last, do R-I and IQ scores mediate the association between SES and EF? We used structural equation modeling (SEM) to model the effects of SES on the EF of a sample of Argentinian children between 7 and 12 years of age. To measure EF, we used a battery of measures based on the dimensions proposed in previous studies (Pennington & Ozonoff, 1996; Sergeant, Geurts, & Oosterlaan, 2002).

Method

Participants

All the data used in this investigation emerge from work carried out in Santa Fe, Argentina, the capital city of the Santa Fe province. The sample was composed of 254 Argentinian children ranging in age from 7 to 12 years. All children were monolingual native Spanish speakers. The sample was divided into two basic groups according to the neighborhood and the socioeconomic coefficient of the educational establishments. The Department of Education suggests a certain socioeconomic coefficient that is determined on the basis of family income,

TABLE 1. Demographic Characteristics of the Sample

	Low-SES children			Middle-SES children		
Demographic	*n*	*M*	*SD*	*n*	*M*	*SD*
Participants	129			125		
Age, years		9.99	1.38		9.33	1.20
Gender						
Women	69			57		
Men	60			68		
SES		18.19	1.48		9.68	1.97

Note. All participants were in Grades 3–6. The higher the score on the socioeconomic status (SES) scale (Graffar–Mendez Castellano Method), the higher the poverty level.

establishing a scale that goes from *very good* to *deficient* (source: Computer System of the Department of Education of the Province of Santa Fe, Argentina). The groups are described in Table 1.

Low-SES group. The low-SES group was composed of 129 children (50.8%) of both sexes from 7 to 12 years of age who attended an urban-marginal school and resided in humble neighborhoods. The school socioeconomic coefficient, which is based on family income, was considered deficient. According to this classification, *deficient* refers to those families that do not have paid jobs or fixed salaries. Most parents in this category are unemployed or unqualified workers, laboring as street vendors or domestic workers or doing odd jobs. The neighborhoods in which this group resided had a high concentration of low-income residents with diverse housing needs. Public services (i.e., sewer, telephone, water supply network and natural gas) were not provided. Data were obtained from the neighborhood health center to ensure that the children included in the sample were not malnourished, underweight, or displaying neurological or psychiatric disorders. The school had a psychopedagogic department staffed by a psychologist, an educational psychologist, and a social worker who initiated the detection and school accompaniment of children with learning difficulties. This department determined that the evaluated children did not need pedagogic or psychological treatments or speech therapy.

Middle-SES group. The middle-SES group consisted of 125 children (49.2%) of both sexes from 7 to 12 years of age. These children attended urban schools and resided in middle-class neighborhoods. The socioeconomic coefficient of the school, which is based on family income, was good. According to this classification, *good* refers to families whose parents have paid jobs and fixed salaries. On the basis of the information collected from the school and from the parents or guardians, the children met the following inclusion criteria: (a) no clinical, neurological, or psychiatric history; (b) attended school on a regular basis; and (c) no grade repetition or need for corrective programs.

After both groups were selected, Graffar's modified scale was used (Méndez-Castellano & de Méndez, 1994) to identify differences between the groups in terms of four socioeconomic indicators: family head profession, maternal education level (MEL), main source of family income, and housing conditions (HCs). For every variable, higher scores corresponded with higher poverty. This scale was selected because it is important to consider the three defining indicators (family income, occupation status, and parental education) when analyzing the SES effect on cognitive performance.

Measures

Intellectual abilities: Kaufman Brief Intelligence Test. The Kaufman Brief Intelligence Test (K-Bit; Kaufman & Kaufman, 1990) measures verbal (crystallized) and nonverbal (fluid) intelligence and consists of two subtests: vocabulary and matrices. By summing the scores obtained in both subtests, a measure of general intelligence can be determined.

Reflection-impulsivity: Matching Familiar Figures Test. The Matching Familiar Figures Test–20 (MFFT-20; Cairns & Cammock, 1978) is a perceptive matching test measuring cognitive impulsivity. The test consists of presenting the child with a situation containing several alternative answers, of which only one is correct. The child is asked to select the alternative that is identical to the model (see Figure 1). The variables investigated are the total number of errors and mean latency of the first response. On the basis of an estimate obtained from both variables, it is possible to obtain indicators of cognitive impulsivity.

Executive functioning: Stroop Color-Word Interference Test. The Stroop Color-Word Interference Test (Golden, 1978) provides a measure of interference control and selective attention. The task includes three conditions: (a) the word condition, (b) the color condition, and (c) the color-word condition. The validity of the Stroop test as a measure of interference control has been established in numerous studies (for a review, see MacLeod, 1991).

Wisconsin Card Sorting Test. The Wisconsin Card Sorting Test (WCST; Heaton, Chelune, Talley, Kay, & Curtiss, 1993) offers a measurement of EF, particularly set-shifting. In the beginning, four stimulus cards are presented to the participant. Afterward, the participant is given a pile of extra cards and requested to match each card to one of the stimulus cards. Whenever the participant places a card, he or she is told whether the option is right or wrong, but the categories are not explained

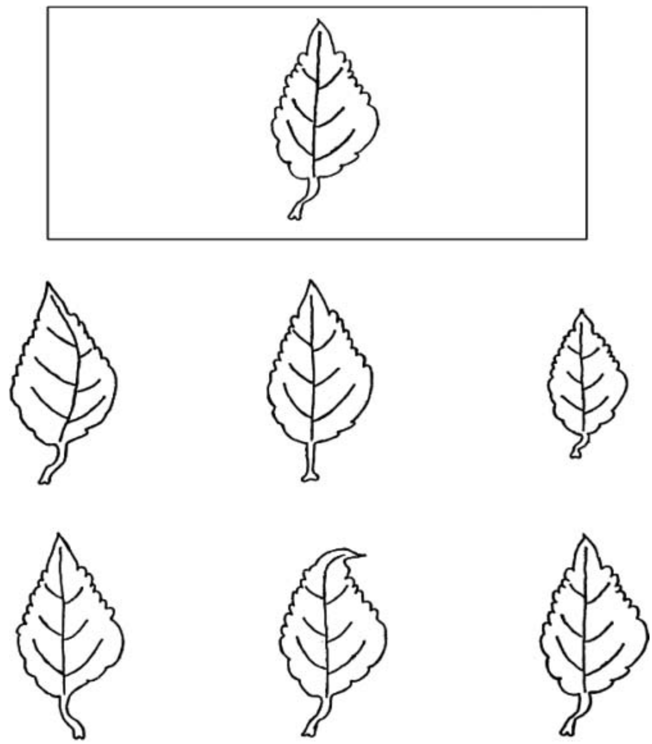

FIGURE 1. Item example 7 of the Matching Familiar Figure Test–20 (from Cairns & Cammock, 1978).

to the children while they are classifying. The variables that are investigated are the percentage of perseverative errors and the number of complete categories.

Digit span and letter-number sequencing subtests of the Wechsler Intelligence Scale for Children. The Working Memory Index of the Wechsler Intelligence scale for Children–Fourth Edition (WISC-IV; Wechsler, 2003) is composed of two core subtests: digit span and letter-number sequencing. Digit Span is composed of two parts: the digit forward task and the digit backward task. Letter-number sequencing comprises 10 items of three trials each and involves retention and active information manipulation.

Porteus Maze Test. The Porteus Maze Test (Porteus, 1965) involves controlled attention and measures the child's planning ability. It is composed of 12 mazes that differ in complexity. In each maze, the participant must trace the way from a starting point to an exit and must avoid blind alleys and dead ends, with no backtracking allowed.

Controlled Oral Word Association Test. The FAS version of the Controlled Oral Word Association Test (COWAT; Benton & Hamsher, 1978) is used to measure phonological verbal fluency. The test asks participants to produce all possible words starting with the letters *F*, *A*, and *S* (FAS) within 60 s, excluding proper names and alternate endings of the same word. This task offers a measure of executive functioning because it requires inhibitory processes, self-monitoring, effort, and initiation (Henry & Crawford, 2004; Ruff, Light, Parker, & Levin, 1997).

Ethical Procedure

First, an interview was requested with the school principals, who received an explanation of the characteristics of the investigation. Then, we asked for authorization from the children's parents or legal guardians clarifying that the participation was deliberate and anonymous. Last, we obtained written consent from the parent or legal guardians of each child participating in the study. We individually tested each participant in the school area for three sessions lasting up to 30–40 min per session.

Statistical Analysis

Four multivariate analysis of variance (MANOVAs) were conducted to examine group-related SES characteristics and group cognitive performance according to SES. To evaluate the relationship between the SES indicators and cognitive performance, stepwise regression analysis was performed. All data were analyzed using the SPSS version 15.0. Last, SEM was performed to test three theoretical models by means of the program AMOS Graphics 16.0 (Arbuckle, 2007). The goodness of fit level of the models was evaluated using the chi-square statistic and the following indexes of adjustment: the goodness of fit index (GFI), the adjusted goodness of fit index (AGFI), and the Bentler-Bonett normed fit index (NFI). Finally, the root mean square error of approximation (RMSEA) was calculated for each model to test the degree of error. Monte Carlo estimates of sample size requisites for SEM suggested that a sample size of 200 would be enough for simple models (Tanaka, 1987).

Results

Socioeconomic Status

MANOVA results indicated a significant overall effect of group (Hotelling's $T = 8.237$), $F(4, 249) = 512.760$, $p = .000$, partial $\eta^2 = .892$. When observing univariate analyses of variance, significant differences were found for the family head profession, $F(1, 252) = 719.920$, $p = .000$, partial $\eta^2 = .741$; the maternal education level, $F(1, 252) = 1562.573$, $p = .000$, partial $\eta^2 = .861$; the main source of family income, $F(1, 252) = 654.378$, $p = .000$, partial $\eta^2 = .722$; and housing conditions, $F(1, 252) = 736.770$, $p = .000$, partial $\eta^2 = .745$. Children of families belonging to the low-SES group obtained higher average values for the four analyzed indicators.

Intellectual Abilities According to SES

MANOVA indicated a statistically significant overall difference among groups (Hotelling's $T = 4.098$), $F(3, 250) = 341.541$, $p = .000$, partial $\eta^2 = .804$. Specifically, these differences were found in intellectual verbal abilities, $F(1, 252) = 861.567$, $p = .000$, partial $\eta^2 = .774$; intellectual nonverbal abilities, $F(1, 252) = 530.244$, $p = .000$, partial $\eta^2 = .678$; and general intelligence, $F(1, 252) = 1028.662$, $p = .000$, partial $\eta^2 = .803$, of the K-Bit. As noted in Table 2, low-SES children obtained significantly lower scores than their middle-SES peers.

TABLE 2. Children's Performance on the Cognitive Measures According to SES

	Low SES		Middle SES	
Variable/indicators	*M*	*SD*	*M*	*SD*
Intelligence				
Verbal	64.36	12.33	104.05	8.87
Nonverbal	67.83	8.88	89.40	5.62
General IQ	58.94	9.92	94.26	7.39
Reflection-impulsivity				
Cognitive Impulsivity	2.86	1.53	–0.06	1.70
Executive functions				
WM	25.96	3.72	35.34	3.81
Stroop word color	20.80	6.72	24.97	5.82
WCST-PPE	31.17	15.08	13.82	7.16
WCST-NCC	2.57	1.28	5.14	1.30
Planning	8.39	2.27	12.03	1.86
Phonological fluency (FAS)	11.05	5.20	17.59	7.28

Note. SES = socioeconomic status; WM = Working Memory (Wechsler Intelligence Scale for Children–Fourth Edition); WCST-PPE = Wisconsin Card Sorting Test Percentage of Perseverative Errors; WCST-NCC = Wisconsin Card Sorting Test Number of Complete Categories.

R-I According to SES

MANOVA indicated a statistically significant overall difference among groups (Hotelling's $T = .891$), $F(3, 250) = 74.244$, $p = .000$, partial $\eta^2 = .471$. Specifically, these differences were for cognitive impulsivity, $F(1, 252) = 208.132$, $p = .000$, partial $\eta^2 = .452$; number of errors, $F(1, 252) = 137.625$, $p = .000$, partial $\eta^2 = .353$; and mean latency, $F(1, 252) = 82.219$, $p = .000$, partial $\eta^2 = .246$, of the MFFT-20. Low-SES children demonstrated greater cognitive impulsivity in relation to their middle-SES peers (see Table 2), as the former committed a higher quantity of errors (M low SES = 32.74, SD = 12.59; M middle SES = 16.86, SD = 8.55) and exhibited short latencies in giving answers (M low SES = 143.50, SD = 71.36; M middle SES = 281.56, SD = 156.99).

Performance on EF According to SES

MANOVA results indicated a statistically significant overall difference among groups (Hotelling's $T = 2.189$), $F(6, 247) = 90.116$, $p = .000$, partial $\eta^2 = .686$. Specifically, these differences were for working memory, $F(1, 252) = 393.738$, $p = .000$, partial $\eta^2 = .610$; Stroop color word sheet, $F(1, 252) = 27.800$, $p = .000$, partial $\eta^2 = .099$; percentage of perseverate errors of the WCST, $F(1, 252) = 135.713$, $p = .000$, partial $\eta^2 = .350$; number of complete categories of the WCST, $F(1, 252) = 250.189$, $p = .000$, partial $\eta^2 = .498$, planning $F(1, 252) = 192.774$, $p = .000$, partial $\eta^2 = .433$; and phonological fluency $F(1, 252) = 68.214$, $p = .000$, partial $\eta^2 = .213$. Compared with their middle-SES peers, low-SES children obtained lower scores on every EF analyzed task and committed a higher number of perseverative errors on the WCST (see Table 2).

Multiple Regressions

To identify the indicator(s) that predict performance in the cognitive evaluated tasks, stepwise regression analysis, including the four SES indicators, was performed. Please note that the higher the score in each indicator, the higher the poverty level.

For cognitive impulsivity, MEL explained 42.6% of the variance, and HCs explained an additional 3%. The final model accounted for 45% of variance. As can been seen in Table 3, MEL was the main predictor with a positive predictive contribution. Thus, the higher the value of the maternal education level (indicator of low maternal education level), the higher the child's cognitive impulsivity was.

For most of the EF analyzed, MEL was the strongest predictor, followed by HCs, both with a predictive negative contribution. The prediction was only positive for the percentage of perseverative errors of the WCST (see full results in Table 3).

TABLE 3. Stepwise Regression Results for Cognitive Tasks

			ANOVA for model				
Variables	R^2	ΔR^2	*df*s	*F*	β	*t*	*p*
Cognitive impulsivity							
Step 1							
MEL	.426	.426	1, 252	186.842***	.653	13.669	.000
Step 2							
MEL	.457	.031	2, 251	105.455***	.384	4.507	.000
HCs					.321	3.774	.000
Working memory							
Step 1							
MEL	.557	.557	1, 252	317.082***	–.746	–17.807	.000
Step 2							
MEL	.586	.029	2, 251	177.434***	–.488	–6.564	.000
HCs					–.309	–4.158	.000
Stroop word color							
Step 1							
MEL	.107	.107	1, 252	30.250***	–.327	–5.500	.000
WCST: Percentage of preservative errors							
Step 1							
MEL	.340	.340	1, 252	129.637***	.583	11.386	.000
Step 2							
MEL	.360	.020	2, 251	70.565***	.365	3.953	.000
HCs					.260	2.816	.005
WCST: Number of complete categories							
Step 1							
MEL	.453	.453	1, 252	208.756***	–.673	–14.448	.000
Step 2							
MEL	.479	.026	2, 251	115.448***	–.426	–5.111	.000
HCs					–.295	–3.544	.000
Planning							
Step 1							
MEL	.376	.376	1, 252	152.032***	–.613	–12.330	.000
Step 2							
MEL	.391	.015	2, 251	80.622***	–.427	–4.738	.000
HCs					–.223	–2.474	.014
Phonological fluency (FAS)							
Step 1							
MEL	.221	.221	1, 252	71.602***	–.470	–8.462	.000

Note. MEL = maternal education level; HCs = housing conditions. The *df* for every *t* is 253.
$^{***}p < .001$.

Structural Equation Models

We specified and compared three structural equation models. First, because our intent was to identify whether cognitive impulsivity is a separated variable or a function within the construct of EF, the first two models were compared. As indicators for SES, we include the two indicators (MEL and HCs) that predicted cognitive impulsivity and EF according to our multiple regressions results.

In Model 1, depicted in Figure 2, SES is related to one first-order construct that includes cognitive impulsivity (errors and latency) as an indicator of executive functioning construct. The structural portion of Model 2, illustrated in Figure 3, is similar to Model 1 except that SES is related to two separate first-order constructs representing cognitive impulsivity and EF construct. Also notice that EF has a direct SES effect in addition to the indirect SES effect through the cognitive impulsivity latent factor. Because Model 2 fits better than Model 1, it can be suggested that cognitive impulsivity is a separated but related variable from EF, and both received SES effects. In addition, because EF had indirect cognitive impulsivity effects, this last variable could be considered a mediator through which SES affects EF. The structural portion of Model 3 is illustrated in Figure 4. This model includes SES effects on IQ, cognitive impulsivity and EF as well as indirect SES effects on EF, using children's IQ and cognitive R-I style.

From Table 4, a good model fit can be seen for Models 2 and 3. Because the chi square obtained for the three models is significant, a corrected calculation, χ^2/df, was used. In Models 2 and 3, the indexes GFI and AGFI obtain values

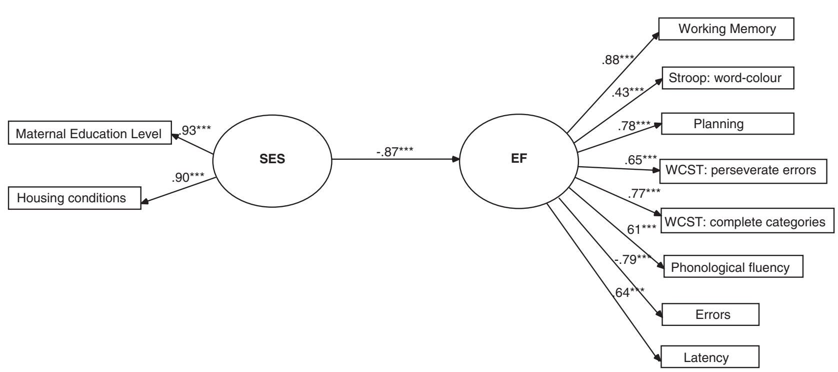

FIGURE 2. Structural equation model (Model 1) including cognitive impulsivity (number of errors and latency of the Matching Familiar Figure Test–20 [Cairns & Cammock, 1978]) as an executive function. SES = socioeconomic status; EF = executive functions; WCST = Wisconsin Card Sorting Test. ******p* < .001.

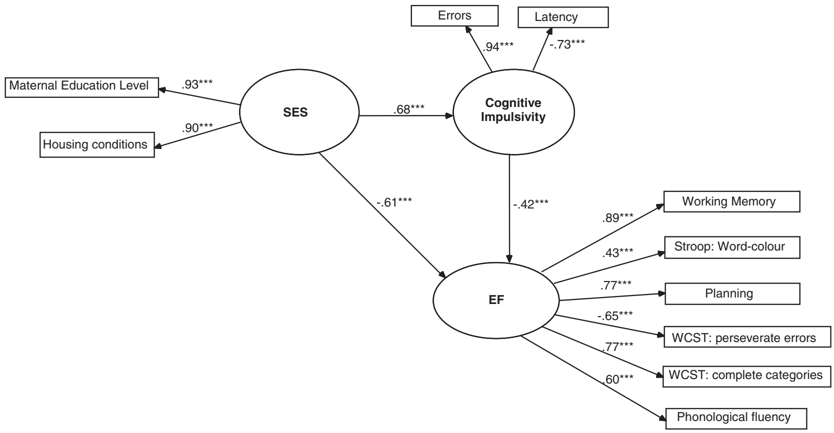

FIGURE 3. Structural equation model (Model 2) in relation to the influence of socioeconomic status (SES) and cognitive impulsivity on executive functioning (EF). WCST = Wisconsin Card Sorting Test. $^{***}p < .001$.

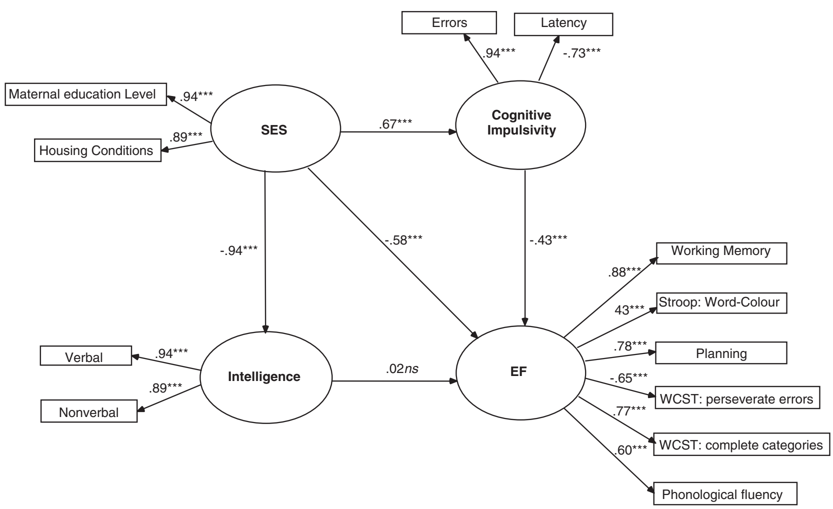

FIGURE 4. Structural equations model (Model 3) in relation to the direct effects of socioeconomic status (SES) on executive function (EF) and indirect SES effects on EF through cognitive impulsivity and intelligence. WCST = Wisconsin Card Sorting Test. $^{***}p < .001$; *ns* = not significant.

TABLE 4. Fit Indexes for Models

Model	χ^2	*df*	χ^2/df	GFI	AGFI	NFI	RMSEA
1	100.1	33	3.03	.92	.87	.93	.09
2	50.9	31	1.64	.96	.93	.96	.05
3	84.7	48	1.76	.95	.91	.96	.05

Note. In each model, $N = 254$. GFI = goodness of fit index; AGFI = adjusted goodness of fit index; NFI = Bentler-Bonett normed fit index; RMSEA = root mean square error of approximation.

over .9, and the RMSEA is below .08; therefore, both models are considered to have a good adjustment. Nevertheless, Model 2 fits better than either Model 1 or Model 3, as determined from the GFI, AGFI, NFI, and RMSEA indexes. These results suggest that SES had effects on cognitive impulsivity (R-I) and direct and indirect effects on EF through cognitive R-I style. Also note in Model 3 that although IQ received a strong direct SES effect, it had no significant effect on children's EF performance. Thus, the model of better adjustment allows us to infer that the executive performance associated with SES may partially result from the influence of different socioeconomic variables, such as MEL and HCs, which will eventually act directly on executive performance and indirectly trough specific cognitive mediating factors such as cognitive impulsivity, but not by IQ scores.

Discussion

This study provides support for the hypothesis stating that SES is associated with children's EF task performance. First, a review of the available literature provides sufficient foundations for the belief that SES may play a role in the development of PFC and EF. Second, empirical evidence was found to be consistent with this hypothesis. The findings demonstrated that low-SES children performed significantly poorer than their middle-SES peers on all EF tasks analyzed in this study. Consistent with previous research (Ardila et al., 2005; Farah et al., 2006; Lipina et al., 2004; Mezzacappa, 2004; Noble et al., 2007; Noble et al., 2005; Waber et al., 2006), our data suggest that SES is associated with EF performance levels in children. Because substantial evidence within the neuropsychological field indicates that the PFC plays a critical role in the executive processing (Diamond, 2002; Fuster, 1997, 2002), it is feasible to hypothesize that these regions might be sensitive to childhood experience and SES. Supporting this hypothesis, Kishiyama et al. (2009) found that social disparities affects PFC function in low-SES children and this relationship could be explained by the influence of multiple factors associated with low-SES nurturing conditions, such as a reduced access to cognitively stimulating materials and experiences and higher levels of stress.

In relation to intellectual skills, the low-SES group demonstrated low values for verbal, nonverbal and general intelligence. As pointed out in previous studies (McLoyd, 1998; Ramey & Campbell, 1991; Smith et al., 1997), these results also suggest an association between intellectual skills and SES. The poor performance obtained by low-SES children seems to demonstrate a profile characterized by a poor capacity to relate concepts and to develop abstract nonverbal reasoning (fluid intelligence) skills as well as difficulties in linguistic skills referring to vocabulary, the formation of verbal concepts, and the flow of linguistic information (crystallized intelligence). In line with these results, previous studies have indicated an association between a child's SES and the development of different linguistic processes (e.g., level of vocabulary [Hart & Risley, 1995; Hoff, 2003; Noble et al., 2007], phonological awareness and syntactic knowledge [Noble et al., 2005]).

With respect to cognitive impulsivity (as measured by the MFFT-20), low-SES children showed significant differences in relation to their middle-SES peers. According to our results, the low-SES group made significantly more errors with short latencies than the middle-SES group. This data confirms the results reported by previous studies that found a high proportion of impulsive children from low-socioeconomic or disadvantageous cultural sectors (Arán-Filippetti & Richaud de Minzi, 2011; Heider, 1971; Juliano, 1977; Mumbauer & Miller, 1970; Richaud de Minzi, 2007; Schwebel, 1966).

Regarding socioeconomic variables that may predict cognitive achievement, our findings indicate significant association between MEL and most of the measures of children's executive functioning. In line with previous research (Noble et al., 2007; Noble et al., 2005), parents' educational level was the factor most associated with EF performance. Likewise, previous studies conducted with infant populations have demonstrated a significant association between parental education level and the development of attention, memory (Matute Villaseñor et al., 2009), and performance on different tasks that measure EF (Ardila et al., 2005; Klenberg, Korkman, & Lahti-Nuuttila, 2001). Although our study did not analyze the pathways through which maternal education disadvantages children's cognitive functioning, it is possible to infer from evidence obtained in previous investigations the existence of diverse variables associated with SES that might explain and mediate this association. For example, this association could be explained by the cognitive interaction and language used at home, which would differ according to maternal SES. Previous studies have reported differences in mother–child cognitive interactions according to maternal socioeconomic level (Hoff-Ginsberg, 1991; Ninio, 1980; Peralta & Salsa, 2001; Peralta de Mendoza, 1997) and MEL (de Tejada & Otálora, 2006). Therefore, because SES would have an effect on mother–child interactions and because it has been demonstrated that cognitively stimulating mother–child interactions are significant precursors of children's impulse control and self-regulatory competence (Olson, Bates, &

Bayles, 1990), interaction style could mediate the association between maternal SES and cognitive development. In addition, it has been suggested that mothers of higher socioeconomic level, in comparison with mothers of middle SES, create linguistically enriched environments for their children (Hoff, 2003) because they talk more and use longer sentences and greater lexical variety in different settings (Hoff-Ginsberg, 1991). Taken together, it could be hypothesized that low MEL may influence a child's cognitive development through different pathways. Because of reduced amounts of enriching mother-child interactions and use of cognitive self-regulation strategies, low-SES mothers might not offer external verbal tools to promote a gradual development of private speech and self-control, functions that are essential for the development of EF. Hughes and Ensor (2009) found that individual differences in 4-year-old children's EF performance could be predicted on the basis of the degree to which mothers become involved in open-ended questions and encourage, compliment, and support children during structured activities.

However, because SES is a composite measure, other socioeconomic mechanisms may be at work to produce SES inequalities in children's cognitive development. Our results indicate that poor housing conditions, implying fewer resources for enhancing cognitive development and more environmental stressors, also play a significant role in executive performance. Consistently, Santos et al. (2008) found that housing with inadequate sanitary conditions and low MEL, among other variables, are negatively associated with children's cognitive performance. This association between home environment and cognitive development could be explained by the influence of diverse variables related to housing characteristics. For instance, Evans (2004) defined those homes in which children live in a situation of poverty as being noisier, presenting overcrowding, and being of lower quality and higher instability. The present study also showed that houses in which low-SES children live present inadequate sanitary conditions, limited space, poor quality, and overcrowding. From these data, it is possible to hypothesize that the housing environment plays a fundamental role in cognitive development, mainly because it determines access to learning opportunities and the resources needed to stimulate children's development. As indicated in previous studies, low-SES children have less access to books, they dedicate less time to reading, their families are less likely to participate in school activities, and they have less exposure to stimulating materials and experiences that are significant for their development (Bradley, Corwyn, McAdoo, & García Coll, 2001; Evans, 2004). Taken together, the physical conditions of the home, mother–child interactions, and learning opportunities are important mediators between the familial income and cognitive outcomes of children (Brooks-Gunn & Duncan, 1997; Duncan & Brooks-Gunn, 2000).

Regarding cognitive mediating factors, because of the existing association between R-I and SES, it is important to consider whether cognitive impulsivity precedes executive task performance and, consequently, functions as a mediator variable, or whether it might be considered a function within the EF construct affected by SES. It seems important to establish this distinction because if this type of impulsivity is a separate but related construct to that of the EF, it might be considered a mediating variable. Thus, acting on the R-I cognitive style could improve the low executive performance associated with SES. If we analyze the results of the SEM, we can see when we include cognitive impulsivity as another variable inside EF, the indexes of adjustment are less satisfactory than when cognitive impulsivity is considered a mediator between SES and EF. Therefore, cognitive impulsivity can be considered a mediator to explain the executive functioning associated with SES. Likewise, it is reasonable to consider whether IQ levels may influence the executive performance associated with SES, as for the well-known association between SES and IQ (McLoyd, 1998; Ramey & Campbell, 1991; Smith et al., 1997); hence, IQ levels were included in the final model. The results indicate that although the association between SES and IQ is strong, these abilities do not explain the disparities in EF associated with SES. These results are consistent with previous findings that suggest a direct effect of different child disorders on EF beyond the mediation of IQ. For example, previous studies have found that children with early-treated phenylketonuria (Welsh, Pennington, Ozonoff, Rouse, & McCabe, 1990), preterm children (Aarnoudse-Moens, Smidts, Oosterlaan, Duivenvoorden, & Weisglas-Kuperus, 2009; Böhm, Smedler, & Forssberg, 2004), and children with attention deficit hyperactivity disorder (see Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005) show significant deficits on some EF tests even after controlling for intelligence. Similarly, a previous study conducted with young adults with fetal alcohol syndrome found that several EF tests are directly affected by prenatal alcohol damage and do not reflect IQ deficits (Connor, Sampson, Bookstein, Barr, & Streissguth, 2000).

In summary, according to our results, MEL and HCs account for a high proportion of the variance of EF performance. In addition, this association is partially mediated by specific cognitive functions, such as cognitive impulsivity, but not by IQ scores. These findings have implications for clinical and educational approaches and are valuable for two main reasons. First, they represent an important step in understanding the social environmental variables that may influence executive processes in children. Second, our analysis indicates specific cognitive mechanisms that may produce SES disparities in executive task performance.

The understanding of mediating cognitive factors enables the design of effective school intervention programs to reduce the impact of poverty on cognitive and brain development. This understanding is important because recent studies have found positive results regarding the possibility of improving executive functioning by using intervention programs, such as *Tools of the Mind*. *Tools* is a curriculum-based intervention program created by Bodrova and Leong (2007) to promote the development of academic, social-emotional, and cognitive self-regulation skills in children, through the implementation of different strategies that allow teachers to support children's development. Diamond, Barnett, Thomas, and Munro (2007) evaluated the *Tools* intervention program used with children of lower SES and found that self-regulation and EF could be improved through exercise. Barnett et al. (2008) also indicated an improvement in the executive performance of 3- and 4-year-old children by means of the *Tools* curriculum. Similarly, we designed a curriculum intervention program to work with low-income urban school districts (Arán-Filippetti & Richaud de Minzi, 2011). This program integrates cognitive strategies in the school curriculum and emphasizes the teaching of activities that improve EF and promote the use of self-regulatory private speech. It is important to note that these intervention programs highlight the teaching of self-regulation strategies, which are thought to enhance self-control and, therefore, to reduce cognitive impulsivity (Meichembaum & Goodman, 1971). Therefore, this fact represents another indicator of cognitive impulsivity as a mediating variable between SES and executive development.

This study contributes to the understanding of the relationship between SES and EF; nevertheless, it is necessary to specify some limitations. First, the sample was limited to Argentinian children from 7 to 12 years of age, which limits the generalizability of the results to children of other countries and different ages. However, the data presented in this study regarding the association between SES and EF are similar to data in other studies of Spanish-speaking children of different ages and countries (Ardila et al., 2005; Lipina et al., 2004) and English-speaking children (Farah et al., 2006; Noble et al., 2007; Noble et al., 2005). Second, other possible mediating factors of the association between SES and cognitive performance, such as parental and child stress levels and the health conditions of the mother and child during the first years of life, were not controlled. Nevertheless, other factors were considered, such as the nutritional status of the child and the absence of neurological or psychiatric disorders (inclusion criteria). Last, in this study, we analyzed what specific socioeconomic indicators predict cognitive performance; however, it is necessary to deeply analyze how these indicators operate and to examine the diverse social environmental factors that could mediate this association. It is important to indicate that the results presented here, as well as those from other studies previously mentioned, point to MEL as one of the variables most associated with children's cognitive performance. As this relationship comes into focus, it leads to the analyses of different variables associated with MEL such as the style of cognitive interaction, the language used at home and the cognitive stimulation given to children.

It is advisable to carry out intervention studies both in educational and in familiar settings as they offer a better understanding of the role of the environment and experience in cognitive change. Because our results highlight the influence of cognitive impulsivity on executive task performance, intervention studies that analyze this aspect represent another important line of future investigation.

In sum, it is possible to conclude that (a) SES is highly associated with children's EF task performance, (b) the principal socioeconomic indicators that predict EF are MEL and HCs, and (c) the association between these socioeconomic indicators and executive task performance can be partly explained by means of cognitive mediating factors, such as cognitive impulsivity, but not by IQ level. It is possible that SES fulfils a decisive role in the development of EF but acts through specific socioeconomic factors and cognitive mediating variables.

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AUTHOR NOTES

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