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Cognitive Predictors of Reading Comprehension in Children from Diverse Socio-educational Contexts

Predictores cognitivos de la comprensión de textos en niños de diversos contextos socio-educacionales

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ABSTRACT

Socioeconomic disparities exert a substantial influence on children's reading development, yet the cognitive mechanisms mediating this relationship remain understudied in Latin American contexts. This study examines how executive functions (EF) and reading fluency mediate the effects of the Level of Educational Opportunities (LEO)—a school-level SES index—on reading comprehension in 348 Argentine primary-school students. Using a digital battery, selective attention, cognitive flexibility, fluid intelligence, and reading comprehension were assessed. Children in low-LEO schools showed poorer EF performance, slower reading speed, and lower comprehension. Path analysis revealed two independent mediation pathways: a fluency-based route (LEO → reading speed → comprehension) and a cognitive route (LEO → EF → fluid intelligence → comprehension). Age mirrored this dual mediation. These findings underscore that school-level socioeconomic environments shape reading outcomes through executive-reasoning skills and fluency, offering actionable targets for intervention to reduce literacy gaps in disadvantaged settings.

Keywords: Reading Comprehension; Executive Functions; Educational Inequality; Cognitive Development; Fluid Intelligence; Reading Fluency; School Socioeconomic Context

RESUMEN

Las desigualdades socioeconómicas impactan fuertemente en el desarrollo lector infantil, aunque los mecanismos cognitivos subyacentes han sido poco explorados en contextos latinoamericanos. Este estudio analiza cómo las funciones ejecutivas (FE) y la fluidez lectora median los efectos del Nivel de Oportunidades Educativas (NOE)—un índice socioeconómico escolar—sobre la comprensión lectora en 348 estudiantes argentinos de nivel primario. Se evaluaron atención selectiva, flexibilidad cognitiva, inteligencia fluida y comprensión lectora mediante una batería digital. Los estudiantes de escuelas con NOE bajo mostraron menor desempeño en FE, lectura más lenta y menor comprensión. El análisis de senderos identificó dos vías de mediación independientes: una basada en la fluidez (NOE → velocidad de lectura → comprensión) y otra cognitiva (NOE → FE → inteligencia fluida → comprensión). La edad replicó esta mediación dual. Los resultados evidencian que el contexto socioeducativo escolar influye en la comprensión lectora a través de habilidades de razonamiento ejecutivo y fluidez, señalando rutas clave para intervenciones que mitiguen las brechas en alfabetización en entornos vulnerables.

Palabras Clave: Comprensión Lectora; Funciones Ejecutivas; Desigualdad Educativa; Desarrollo Cognitivo; Inteligencia Fluida; Fluidez Lectora; Contexto Socioeconómico Escolar

INTRODUCTION

Reading comprehension is a complex skill foundational to academic success (Clinton-Lisell *et al.*, 2022). Yet international and national assessments show marked deficits among Latin American children, especially in Argentina, where COVID-19 disruptions exacerbated preexisting gaps. According to PISA, 53% of Argentinian students could not comprehend moderately complex texts (OECD, 2023). Likewise, APRENDER data showed that only 56% demonstrated satisfactory reading skills in 2021—a 19.3% decline from pre-pandemic levels—with the steepest drop among lower-SES students, of whom only 28.9% reached satisfactory performance (Catri *et al.*, 2021). This is alarming given that nearly 70% of Argentinian children live in poverty (UNICEF, 2023). Considering extensive evidence linking cognitive skills and reading comprehension (Butterfuss & Kendeou, 2018; Duke & Cartwright, 2021) and their sensitivity to home (Romeo *et al.*, 2022; Farah *et al.*, 2017) and school SES contexts (Sirin, 2005; Tan *et al.*, 2023), we briefly review the pathways connecting these constructs within a bioecological framework.

Contribution of Linguistic and Cognitive Skills to Reading Comprehension

The Simple View of Reading proposes that comprehension results from combining word recognition and language comprehension (Hoover & Tunmer, 1986, 2020). The Rope Model specifies subskills within both domains—vocabulary, verbal reasoning, grammar, phonological awareness, and decoding—which become increasingly integrated (Scarborough, 2001). Cutting *et al.* (2015) expanded this model by incorporating executive functions (EF) as domain-general skills that support coordination between recognition and comprehension. The Active View of Reading (Duke & Cartwright, 2021) further emphasizes overlap between decoding and language comprehension, connected through bridging processes such as vocabulary and fluency, and highlights readers' active deployment of EFs to coordinate strategies, sustain goals, and monitor execution. Reading requires attentional control and working memory to maintain and update meaning representations, as well as inhibition of irrelevant information, flexible shifting among subprocesses, planning and monitoring progress. Similarly, the DIER model (Kim, 2020) describes EF—particularly working memory and attentional control—as distal, low-level processes that sustain foundational language skills. Across models, EF support the efficient management of linguistic and cognitive processes underlying comprehension.

EFs comprise cognitive processes essential for goal-directed behavior, including working memory, cognitive flexibility, and inhibition (Miyake, 2000, 2012). Working memory maintains and manipulates information, and updating involves monitoring and changing its contents (Miyake *et al.*, 2012). Shifting enables transitions between mental sets (Diamond, 2013; Miyake *et al.*, 2000), while inhibition suppresses irrelevant stimuli and responses (Diamond, 2013; Dajani & Udin, 2015). Diamond (2013) additionally identifies higher-order processes—reasoning, problem solving, and planning—as dependent on these core functions. She conceptualizes fluid intelligence as encompassing reasoning and problem-solving subcomponents of EF: "Fluid intelligence is the ability to reason, problem solve, and to see patterns or relations among items (...). It includes both inductive and deductive logical reasoning (...) It is synonymous with the reasoning and problem-solving subcomponents of EFs" (p. 17). Others argue that fluid intelligence can be considered a generalized form of cognitive flexibility (Birney & Beckmann, 2022). Although this classification is debated—e.g., Friedman (2006) showed uneven relations with core EF components—our goal is not to resolve EF taxonomy but to examine contributions of lower- and higher-level processes to reading comprehension. Given robust evidence linking

EF and academic skills (Peng *et al.*, 2019), our strong claim is not that fluid intelligence is an EF component, but that it recruits and interacts with core EF processes as a higher-level ability. Thus, associations between EF and fluid intelligence in our results align with Diamond's model but are not definitive.

The unity and multidimensionality of EF remain debated. Although models commonly distinguish inhibition, working memory, and flexibility (Miyake *et al.*, 2000), numerous studies show that these dimensions do not always separate clearly and that their factorial structure varies as a function of age, context, and task type (Friedman & Miyake, 2017). Measurement issues further complicate the field, as many EF tasks exhibit low convergent validity, modest intercorrelations, and substantial influence from non-executive processes—processing speed, academic knowledge, and perceptual–motor demands—limiting their ability to isolate "pure" EF (Karr *et al.*, 2018). The task impurity problem also persists, with tasks intended to measure the same EF often behaving inconsistently. Overall, evidence suggests EF may not constitute a fully coherent system but rather a heterogeneous set of partially overlapping skills with contested boundaries.

EF appear in reading models because successful comprehension requires flexible attention, suppression of distractions, integration of information in working memory, and strategic planning—capacities grounded in EF (Butterfuss & Kendeou, 2018; Duke & Cartwright, 2021; Kim, 2020). Meta-analytic evidence supports EF contributions across development (Follmer, 2018), often mediated partly (Chang, 2020) or fully (Spencer *et al.*, 2020) by bridging processes such as vocabulary and fluency. Evidence regarding fluid intelligence is more mixed. It accounted for twice as much variance as working memory in the one-year development of reading comprehension among Argentinian fourth graders (Vernucci *et al.*, 2021). It also predicted reading comprehension and speed independently of EF in third- and fourth-graders (Johann *et al.*, 2020). Conversely, some studies report no contribution to comprehension in primary-school children (López-Escribano *et al.*, 2013; Tabullo *et al.*, 2022) or find declining effects in later grades as crystallized intelligence gains prominence (Cotton & Crewter, 2009). Notably, fluid intelligence predicted comprehension in a large Latin American adolescent sample after controlling for home and school SES (Flores-Mendoza *et al.*, 2015). Its involvement may depend on text complexity or language skill deficits (e.g., vocabulary or fluency constraints), becoming more relevant under heightened cognitive demands. Having established EF's theoretical and empirical relevance to reading, we now consider how SES shapes cognitive and reading outcomes.

Socioeconomic effects on Cognitive and Reading Skills Development

The bioecological model provides a framework for understanding how contextual, cultural, and environmental factors shape cognitive and language development (Bronfenbrenner & Ceci, 1994; Romeo, 2022). Within this model, SES operates as a distal factor influencing cognitive and academic trajectories through multiple proximal conditions. SES affects cognitive and language skills via two broad pathways. First, stress exposure, material deprivation, limited cognitive stimulation, and parenting practices shape executive and memory systems, contributing to SES-related differences in cognitive control (Farah, 2017; Johnson *et al.*, 2016). Second, SES impacts language and reading development through differences in child-directed speech and home literacy environments, with SES-related variations in brain structure and function reflecting these inputs (Romeo, 2022). These experiences interact with neuroplasticity during sensitive periods, generating SES disparities in cognitive and reading outcomes.

Evidence from Argentina and Latin America consistently shows strong SES associations with executive function (EF) performance. In Argentina, preschoolers with unsatisfied basic needs show poorer planning, inhibitory control, and cognitive flexibility than higher-SES peers (Lipina *et al.*, 2004). Among school-age children, maternal education, household crowding, and housing quality predict lower working memory, inhibition, and flexibility (Arán-Filippetti, 2011; Arán-Filippetti & Richaud de Minzi, 2012). Latin American studies from Brazil and Chile similarly report robust SES gradients in inhibitory control, working memory, planning, and global cognition (Piccolo *et al.*, 2016; Sbicigo *et al.*, 2013). Recent findings indicate that these gradients persist after adjusting for age and schooling, occur in both urban and rural contexts, and are mediated by home environment quality and cognitive stimulation (Freitas *et al.*, 2022; Guerra *et al.*, 2021).

Although home SES strongly predicts cognitive, reading, and academic performance (Korous *et al.*, 2020), school socio-educational context is also a powerful predictor—sometimes more so than home SES (Tan *et al.*, 2023). Evidence suggests that school SES influences cognition through both institutional resources and peer characteristics (Ready & Reid, 2018). Schools with fewer resources may offer fewer structured, cognitively rich learning opportunities to scaffold EF development, whereas well-resourced schools provide more consistent instructional support, routines, and teacher interactions. Peer norms also matter: classrooms with higher academic engagement and stronger behavioral expectations impose more frequent “regulatory challenges” (e.g., inhibiting distractions, planning), potentially promoting EF growth. Conversely, schools with lower peer regulation may provide fewer such developmental opportunities.

A growing literature identifies EF as a mediator of SES effects on academic outcomes. Longitudinal studies show that EF partially mediates the impact of home SES on achievement in primary school (Lawson *et al.*, 2017; Mooney *et al.*, 2024). Although most research is based on WEIRD samples (Nielsen *et al.*, 2017), two studies with Spanish-speaking Latin American children found that EF partly explained differences in academic performance between high- and low-SES groups (Escobar *et al.*, 2018; Korzeniowski *et al.*, 2016). From a bioecological perspective, different SES environments expose children to varying levels of cognitive stimulation (parent–child interactions, cultural access, home literacy) and stressors (nutrition deficits, overcrowding, unmet basic needs, violence). These conditions influence EF development through cognitive experience and stress-related neuroplasticity in prefrontal and limbic systems. In turn, EF differences may affect reading comprehension by determining how efficiently children integrate word reading and language comprehension, supporting the flow from decoding to text-level integration. The bioecological model also highlights school as a central microsystem shaping cognitive and reading development; school environments may even compensate for home SES disadvantages (Hackman *et al.*, 2015). A recent review identified stress exposure, emotional support, cognitive stimulation, and broader school and neighborhood conditions as key mediators and protective factors. Cognitive stimulation mediated SES associations with EF, language, and academic outcomes, and school-level factors—educational expectations, classroom quality, and teacher–student relationships—significantly shaped SES–achievement links (Rakesh *et al.*, 2024).

However, most of these studies did not measure reading comprehension specifically. Except for Lawson *et al.* (2017), who used the Woodcock–Johnson passage comprehension test, prior work primarily addressed lower-level reading skills (Escobar *et al.*, 2018; Korzeniowski *et al.*, 2016) or did not specify reading measures (Mooney *et al.*, 2024). Thus, evidence on which EF components mediate SES effects on children's reading comprehension remains limited.

Considering the Socioeducational Environment Through the Level of Educational Opportunities Scale

In Argentina, research has documented how socioeconomic conditions shape children's linguistic and literacy environments (Rosemberg & Alam, 2021; Rosemberg *et al.*, 2020). SES strongly influences early reading acquisition (Diuk *et al.*, 2019; Signorini & Piacente, 2003), and when early gaps remain unaddressed, they widen over time, affecting higher-order skills such as reading comprehension (Abusamra *et al.*, 2020).

Building on this evidence, several Argentinian studies have examined reading disparities using the Level of Educational Opportunities (LEO) construct (Abusamra *et al.*, 2010, 2014, 2025; Abusamra, Miranda *et al.*, 2020). LEO is a composite index capturing multiple school-level conditions: the socioeconomic composition of students; repetition, absenteeism, and dropout rates; infrastructure quality (libraries, laboratories, computer rooms, physical education spaces); provision of afternoon snacks; and access to extracurricular activities. LEO thus reflects educational conditions beyond student SES and is especially relevant in Argentina's highly segmented school system (Kessler & Assusa, 2020; Núñez *et al.*, 2021; Tiramonti, 2019). Across multiple studies, LEO strongly predicts performance in reading, writing, and reading comprehension (Abusamra *et al.*, 2010, 2014; Abusamra, Miranda *et* *al.*, 2020), consistent with findings from national assessments indicating that school-level socioeconomic and infrastructural conditions critically shape literacy development.

In highly segregated school systems such as those in Argentina and Chile (Escobar *et al.*, 2018; Hernández & Raczynski, 2015; Valenzuela *et al.*, 2014), children from low-SES homes are more likely to attend low-LEO schools, which have fewer resources to compensate for early cognitive or literacy differences, thereby risking the maintenance or amplification of early gaps. This underscores the need to examine links between cognitive development, reading outcomes, and LEO.

PRESENT STUDY

Although EF are consistently identified as mediators of SES effects on academic skills, no prior study has examined the relations among LEO, executive functioning, and reading comprehension in spanish-speaking children. The main objective of this study was to analyze associations between high- and low-level EF (Diamond, 2013) and reading comprehension in Argentinian children from diverse LEO schools, and to test whether EF mediate LEO-related differences in comprehension and reading times. EF measures included selective attention (Registered Behavior Tool), shifting (Trail Making Test B), and fluid intelligence (Raven). Reading comprehension was assessed using a computerized version of the LEE test (Defior *et al.*, 2006). We hypothesized that: (1) students from higher-LEO schools would show better EF, higher reading comprehension, and faster reading times; (2) reading comprehension and reading times would improve with better EF; and (3) EF would mediate LEO-related differences in comprehension. We also examined whether EF contributions varied by age. Finally, we sought to extend evidence on SES, cognition, and literacy beyond WEIRD contexts by examining reading comprehension in a Spanish-speaking sample from a country characterized by a highly segmented school system and high child-poverty rates, addressing a gap in previous research that focused primarily on lower-level reading skills.

METHODS

Participants

A total of 362 primary school students (ages 6–11) participated. Fourteen participants were excluded because their reading times were identified as outliers (more than 3 standard deviations), leaving a final sample of 348 (46.3% girls; M = 9.24 years, SD = 1.16). Students were in 2nd (22.4%), 3rd (27.9%), 4th (20.1%), or 5th (29.6%) grade and recruited from four schools in Mendoza, Argentina—three private and one public—classified as “medium” or “low” SES based on the educational opportunities scale (Ferreres *et al.*, 2010). Medium

LEO students made up 57.5% of the sample. All had normal or corrected vision and no diagnosed developmental, psychiatric, learning, or reading disorders.

Following institutional consent, families were invited to participate. They received an informed consent form detailing objectives, procedures, voluntary nature, and anonymity of participation, in accordance with national law. No personal data were stored. The study is part of the "Learning as a Physical Process" project, under the "Brain and Reading" line. The protocol and informed consent were approved by the Comité Institucional de Bioética, Hospital Municipal de Agudos Dr. L. Lucero (Bahía Blanca, Argentina), and aligned with the Declaration of Helsinki (World Medical Association, 2013), APA guidelines (2010), and Argentine regulation 5344/99 (CONICET).

Instruments

Level of Educational Opportunities (LEO). Schools were classified using the scale by Abusamra *et al.* (2009, 2020, 2025) and Ferreres *et al.* (2010). Level 1 (low) schools have: predominantly low SES students, high proportion of repeaters (>30%), absenteeism (≥14%), dropouts, provision of breakfast/snacks, limited infrastructure, and few or no extracurricular activities. Level 2 (medium) school: predominantly middle SES students; lower repeaters (6–29%), absenteeism (≤7%), dropouts; moderate infrastructure and some extracurricular activities. Level 3 (high) schools have predominantly middle- to high-SES students; minimal repeaters (<5%), low absenteeism (≤7%), no dropouts, good infrastructure, and extracurricular activities.

Semi-structured interviews were conducted with school directors and teachers to obtain detailed information on institutional resources, pedagogical activities, and characteristics of the student population. According to Abusamrá's (2009) opportunity-level classification, two of the participating schools categorized corresponded to the lowest and next-lowest educational-opportunity strata (level 1).This characterization was based on the fact that these schools met criteria for: predominantly low-SES student population, absenteeism ≥14%, provision of breakfast/snacks to reinforce students' nutrition and few or no extracurricular activities. The remaining two schools met criteria for level 2 (medium), based on: predominantly middle-SES students, absenteeism (≤7%), moderate infrastructure and some extracurricular activities. This characterization was consistent with the classification assigned by the General Direction of Schools of Mendoza under Ley 9031 and its regulatory Decree Nº 250/18, which classified our level 1 institutions as "urbano marginal" (urban marginalized school) and our level 2 schools as "urbano" (urban), respectively, based on objective socio-geographic indicators such as territorial vulnerability, access to essential public services, and patterns of absenteeism and grade repetition.

Evaluation of Cognitive Skills and Reading Comprehension

All tasks were administered digitally using the SIAAEval software (developed by Centro Integral de Neurociencias Aplicadas, CINA, Argentina), a platform designed to operate offline in order to accommodate frequent connectivity limitations in school environments. SIAAEval records response times, scores, and audio data, and integrates several modules to support standardized and secure data collection. These modules include: (a) automatic generation of participant records with secure data storage; (b) audio capture when required by the testing protocol; and (c) automatic generation of individual test reports, including total and item-level response times and scores.

The battery comprised tasks assessing attention, executive function, fluid intelligence, and reading. The digital versions of these instruments have been previously implemented and studied in Argentine populations, demonstrating adequate methodological relevance and contextual validity. Pilot studies were conducted for each test, finding significant correlations between children's scores in the digital versions of the tasks and their original pencil and paper formats Prior research has validated the use of SIAAEval as a digital data collection tool in educational and cognitive settings, supporting its reliability and applicability in school-based assessments (Gasaneo *et al.*, 2024; Iaconis *et al.*, 2021, Del Punta. *et al.* 2023, Rodriguez *et. al.*, 2025).

Fluid Intelligence. Assessed using the digital version of Raven's Colored Progressive Matrices (Raven, 1965), adapted from the classic pen-and-paper format. The test comprises 36 items across three difficulty levels, where children select the missing part of a figure matrix. It measures general mental capacity (g-factor), specifically fluid intelligence—reasoning/problem-solving in novel situations, largely independent of experience (Catel, 1971). In Diamond's (2013) framework, it reflects higher-order EF. Children choose their responses using a numeric keypad, and performance was operationalized as the number of correct responses ($\omega = .806$). Specifically, the digital adaptation of the Progressive Matrices Test has been supported by local studies documenting its psychometric stability in Argentine school contexts. Rossi-Casé *et al.* (2016). Internationally, recent studies have further validated the digital administration of Raven's Progressive Matrices, incorporating complementary technologies such as eye-tracking and machine learning models. For example, Ma and Jia (2024) demonstrated the feasibility and robustness of this approach, confirming its alignment with the methodological framework adopted in the present study.

Selective Attention. Assessed via the Registered Behavior Tool (RBT) (Gasaneo *et al.*, 2024) which measures selective and sustained attention, as well as the ability to identify similarities/differences. Its design is similar to the CARAS test (Thurstone & Yela, 1985, 2012), and high correlations have been found between them ($r = .668$, $p < .001$). It requires children to attend and compare four robot faces to detect the one that differs from the test. Robot faces can differ on their eyes, brows, mouth or their antennas. Responses were made using a numeric pad. The task consists of 40 trials, and performance is operationalized as the number of correct responses (ɯ = .889).

Shifting. Assessed using the Trail Making Test B (TMT-B) within the Trail Making Test (TMT) framework (Kortte *et al*., 2002). The tests requires the subject to trace a path connecting an alternating series of letters and numbers in ascending order (1-A-2-B…), which are distributed across a sheet or paper, without lifting their papel. The digital version presents the numbers and letters on a screen, and requires children to connect them by clicking on them with the use, following the specified order. Digital versions of this test have already been tested and validated in the local context (Linari *et al*., 2022). Performance was measured as total time to complete the test, in seconds (logarithmically corrected for statistical analysis). This test assesses both processing speed and EF-set shifting skills.

Reading Comprehension. Age-appropriate texts were chosen from reading comprehension subtest of the LEE test (Defior *et al*., 2006, $0.71 < \alpha$ .78), which evaluates both literal and inferential multiple-choice questions. Children read the text twice on the computer screen—once aloud, then silently—and answered 6 multiple-choice comprehension questions. Reading comprehension was measured as correct responses; reading times were calculated as time taken to read aloud divided by text length (to normalize for word count across grades).

Procedure

The assessments were conducted within the school setting, in a space designated by the institution and during school hours. Each child was individually paired with an evaluator who provided standardized instructions for each task and ensured the child's understanding before proceeding. The evaluator remained beside the child throughout the entire testing session, offering continuous support and ensuring consistent administration conditions. The assessment was completed in one session, which lasted around 40 minutes.

All tasks were completed individually using a computer. Responses were recorded via either a mouse or a numeric keypad, depending on the specific requirements of each test. Visual stimuli were presented against a white background with black elements, except for the Colored Progressive Matrices test, in which the images were displayed in color. During administration, each child was seated approximately 50 to 60 cm from the computer screen to ensure optimal viewing conditions.

Data Analysis

Analyses were conducted in JAMOVI. Pearson correlations explored associations among variables. Effects of grade, gender, and LEO on cognitive skills, reading comprehension, and reading times were assessed via MANOVAs and follow-up ANOVAs. TMT-B times and reading times (per word) were log-transformed. A hierarchical linear regression tested contributions of cognitive skills and reading times to reading comprehension. Step 1: Gender, grade, and LEO. Step 2: Cognitive skills (selective attention, shifting, fluid intelligence). Step 3: Reading times to explore potential mediation via reading times Multivariate outliers (standardized residuals >|3|) were checked using casewise diagnostics (Cousineau & Cartier, 2010); none were found. Assumptions of normality, homoscedasticity, linearity, and error independence (Durbin-Watson: 1.85–1.91) were met. Multicollinearity was not a concern (VIFs: 1.02–1.64). Adjusted R^2 and standardized coefficients with CIs are reported.

A path analysis was conducted using PATHj (JAMOVI's implementation of lavaan; Galluci, 2021) to model direct/indirect effects of grade, LEO, and cognitive skills on reading times and comprehension. LEO was the exogenous categorical predictor, and age was additionally included to account for its effects. Endogenous predictors were: Selective attention, shifting, fluid intelligence, reading time. Reading comprehension was the outcome variable. Model fit was evaluated using χ^2, CFI, TLI, RMSEA, and SRMR (Xia & Yang, 2019). Given that LEO was a categorical predictor, the Diagonally Weighted Least Squares estimator was used (Li *et al.*, 2016), and bootstrap estimation (10,000 samples) was applied to test significance of direct, indirect, and total effects with 95% bias-corrected CIs. We also tested whether age (as a developmental proxy) moderated the contributions of cognitive skills or reading fluency to comprehension using the MedMod JAMOVI module with 10,000 bootstrap sampling.

RESULTS

Descriptive statistics and bivariate correlation analysis can be found in the *supplementary materials*

Cognitive ability differences by grade and LEO

The MANOVA revealed significant main effects of grade (Wilk's λ = .663, F(9,803) = 14.24, p < .001) and LEO (Wilk's λ = .886, F(3,332) = 14.20, p < .001), indicating that overall cognitive performance varied both across school grades and socioeconomic context. In contrast, gender did not exert a significant influence (p = .245), and no interactions emerged. Follow-up ANOVAs were therefore conducted for each cognitive measure to characterize these patterns in greater detail. Table 1 presents ANOVA coefficients for these analyses, and a more detailed description is provided in the *supplementary materials.*

All cognitive measures exhibited a similar pattern of results: performance improved with grade and was systematically better among medium-LEO students, with no significant interactions or gender effects (see Table 1). For selective attention, this trend was not fully linear: second graders performed significantly worse than fifth graders graders (p < .001, d = –0.631) but the comparison between second and third graders did not reach significance (p = .051, d = –0.417). Shifting efficiency improved markedly across grades: second graders exhibited substantially slower completion times relative to all older groups groups (p < .002, 0.689 < d < 1.735), and additional improvements were observed from third to fourth (p = .011, d = 0.546), third to fifth (p < .001, d = 1.046), and fourth to fifth grades (p = .021, d = 0.501). Fluid intelligence scores increased steadily across grades, with second graders performing below all older groups (p < .001, d = –0.319) and additional gains observed from third to fourth (p < .001, d = –0.487), third to fifth (p < .001, d = –0.934, and fourth to fifth grades (p = .05, d = –0.448). In all cases, medium LEO-students outperformed low-LEO (see Figure 1).

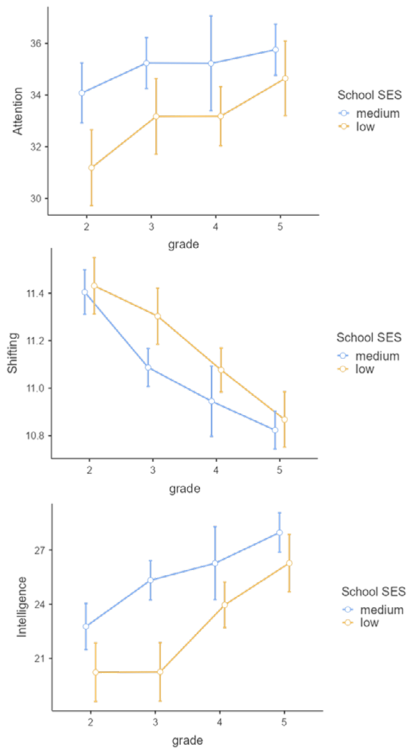
Table 1:
Cognitive ability and Reading Comprehension differences by grade and LEO

Cognitive or Reading measure	Grade Effect (F, p, ω2)	LEO Effect (F, p, ω2)	Direction of differences
Selective attention (RBT)	F(3,332) = 5.332, p = .001, ω^2 = .034	F(1,332) = 16.630, p < .001, ω^2 = .041	Performance increases across school grades; Medium LEO > Low LEO
Shifting (TMT B)	F(3,332) = 42.685, p < .001, ω^2 = .258	F(1,332) = 6.883, p < .001, ω^2 = .012	Mark improvements across school grades; Medium LEO > Low LEO
Fluid intelligence (Raven)	F(3,332) = 23.688, p < .001, ω^2 = .153	F(1,332) = 28.377, p < .001, ω^2 = .061	Performance increases across school grades; Medium LEO > Low LEO
Reading Comprehension	F(3,332) = 26.643, p < .001, ω^2 = .172	F(1,332) = 19.541, p < .001, ω^2 = .041	Performance increases across school grades; Medium LEO > Low LEO
Reading Times	F(3,332) = 35.399, p < .001, ω^2 = .220	F(1,332) = 22.604, p < .001, ω^2 = .046	Performance is faster in high school grades; Medium LEO < Low LEO

Note. *Only significant effects are reported. Gender and all interaction terms were nonsignificant (p > .09).*

Figure 1

Cognitive skill scores by grade and LEO.



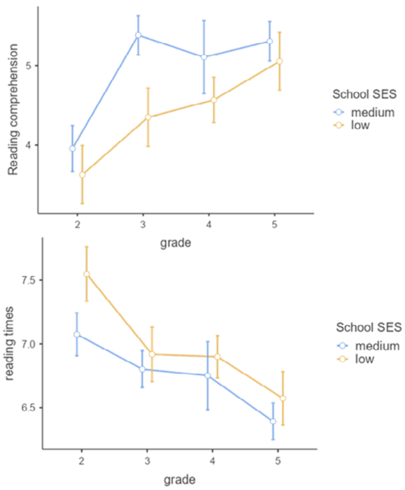
Note: Fig 1. shows estimated marginal means from the ANOVAs of selective attention (top), shifting (medium) and intelligence (bottom) scores by grade and LEO. Error bars represent 95% confidence intervals.

Reading comprehension differences by grade and LEO

Reading skills behaved similarly to cognitive skills, with main effects from grade and LEO and no gender or interaction effects (see Table 1). Comprehension improved substantially with schooling and was consistently higher in children from medium-LEO schools. Second graders performed markedly below third-, fourth-, and fifth-grade students ($p < .001$, $-1.359 < d < -1.057$). In addition, children from medium-LEO schools outperformed their peers from low-LEO schools ($p < .001$, $d = 0.524$), highlighting the contribution of socioeconomic context to reading understanding (see Figure 2). Reading speed became progressively faster with grade: second graders read significantly more slowly than children in third, fourth, and fifth grades ($p < .001$, $0.648 < d < 1.616$). Additionally, fifth graders read more quickly than both third and fourth graders ($p < .001$, $0.668 < d < 0.968$), reflecting sustained gains in reading fluency across late elementary years. As with comprehension, children from medium-LEO schools displayed faster reading times overall (see Figure 2).

Figure 2

Reading comprehension scores and reading times by grade and LEO



Note: Fig 2. shows estimated marginal means from the ANOVAs of reading comprehension (top), and reading times (bottom) scores by grade and LEO. Error bars represent 95% confidence intervals.

To account for potential intra-school sources of variation, we estimated a series of linear mixed-effects models predicting each study variable (cognitive skills, reading times, and comprehension). Grade, LEO, and gender were included as fixed effects, and "school" was modeled as a random intercept and as a random slope for each fixed effect. The Likelihood Ratio Tests comparing models with and without the random effects were not significant in any case, indicating that intra-school variance did not explain additional variability in the outcomes (0.06 < LRT < 11.14, p > .504).

Regression model of reading comprehension

After controlling the effects of gender, grade and LEO, the inclusion of selective attention (ΔR^2 = .032, p < .001), cognitive flexibility (ΔR^2 = .012, p = .019), fluid intelligence (ΔR^2 = .020, p = .003) and reading times (ΔR^2 = .028, p < .001) significantly contributed to explain variance. In the final model (R^2 = .260, $F(7,340)$ = 18.4, p < 0.001), comprehension increased with grade (β = .133, p = .028, CI [0.014 0.252]), LEO (β = -.211, p = .042, CI

[-0.416 -0.007]), selective attention (β = .136, p = .011, CI [0.031 0.240]), fluid intelligence (β = .159, p = .007, CI [0.043 0.275]) and reading times (β = -.202, p < .001, CI [-0.311 -0.093]) (see Table 3.).

Table 2.

Regression analyses of reading comprehension scores

										CI	
Model	**Predictor**	**R2**	**F**		**ΔR2**	**F**		**Std β**		**Lower**	**Upper**
1	Gender	.174	25.4	***				-.126		-0.320	0.067
	LEO							-.497	***	-0.693	-0.301
	Grade							.357	***	-0.261	0.453
2	Attention	.205	23.3	***	.032	14.13	***	.189	***	0.090	0.287
3	Shifting	.215	20	***	.012	5.51	*	-.135	*	0.248	-0.021
4	Intelligence	.233	18.6	***	.020	9.12	**	.180	**	0.063	0.298
5	Reading times	.260	18.4	***	.028	13.28	***	-.202	***	-.311	-.093

*Note. LEO: Leve of educational opportunities (medium as reference). * p < .05, ** p < .01, *** p < .001*

Path analysis model of reading comprehension

We applied a path analysis model to test for direct and indirect contributions of LEO and cognitive skills over reading times and reading comprehension. Age and LEO were entered as exogenous variables; selective attention, shifting and fluid intelligence and reading times were endogenous predictors and reading comprehension was the outcome variable (see Figure 3). The model fitted our data well (χ^2 (7) = 9.65, p = .209; CFI = 0.996 TLI = 0.988; RMSEA = 0.033, SRMR = 0.031). The model significantly predicted reading comprehension (R^2 = .307, *Wald* $\chi^2(2)$ = 109.1), reading times (R^2 = .303, *Wald* $\chi^2(2)$ = 99.4), fluid intelligence (R^2 = .457, *Wald* $\chi^2(4)$ = 156.4), shifting (R^2 = .339, *Wald* $\chi^2(3)$ = 135.5) and selective attention (R^2 = .069, *Wald* $\chi^2(2)$ = 28) (p < .001). Reading comprehension was directly predicted by reading times, and intelligence. Reading times were in turn predicted by LEO and age. Fluid intelligence was predicted by shifting, attention, LEO and age. Shifting was predicted by attention, and both cognitive variables were predicted by grade and LEO (see table 3.). Significant indirect effects were observed as well. Age effects on reading comprehension were mediated by intelligence, reading times, and the effects of attention and shifting on intelligence. In turn, the effect of LEO on reading comprehension was mediated by fluid intelligence, reading times and the impact of attention and shifting on fluid intelligence (see Table 4.).

We tried a model that included direct effects of LEO, age, shifting and attention effects on reading comprehension (mirroring the results of linear regression), but the effects turned out non-significant (p > 0.091), and the chi-square difference did not reach significance ($\Delta\chi^2$ (8) = 9.16, p = .33). We concluded that this full model did not improve fit.

Table 3.
Path analysis: direct effects

				95% Confidence Intervals				
Outcome	**Predictor**	**Estimate**	**SE**	**Lower**	**Upper**	**β**	**z**	**p**
Reading comprehension	Intelligence	0.0920	0.01296	0.0673	0.11820	0.389	7.10	<.001
Reading comprehension	Rtimes	-0.6025	0.10819	-0.8303	-0.40205	-0.304	-5.57	<.001
Intelligence	Age	0.8789	0.22872	0.4473	1.32447	0.205	3.84	<.001
Intelligence	LEO	-1.8846	0.46763	-2.7496	-0.92855	-0.188	-4.03	<.001
Intelligence	Shifting	-3.1617	0.87420	-5.0738	-1.55892	-0.250	-3.62	<.001
Intelligence	Attention	0.4429	0.08303	0.2685	0.58608	0.381	5.33	<.001
Shifting	LEO	0.0950	0.04355	0.0150	0.18833	0.120	2.18	0.029
Shifting	Age	-0.1731	0.01715	-0.2068	-0.13992	-0.511	-10.09	<.001
Shifting	Attention	-0.0164	0.00441	-0.0253	-0.00848	-0.179	-3.73	<.001
Rtimes	LEO	0.3280	0.07092	0.1972	0.47596	0.273	4.62	<.001
Rtimes	Age	-0.2508	0.02690	-0.3042	-0.19879	-0.490	-9.32	<.001
Attention	Age	0.5967	0.18561	0.2776	0.98949	0.162	3.21	0.001
Attention	LEO	-1.8642	0.44076	-2.7661	-1.12124	-0.216	-4.23	<.001

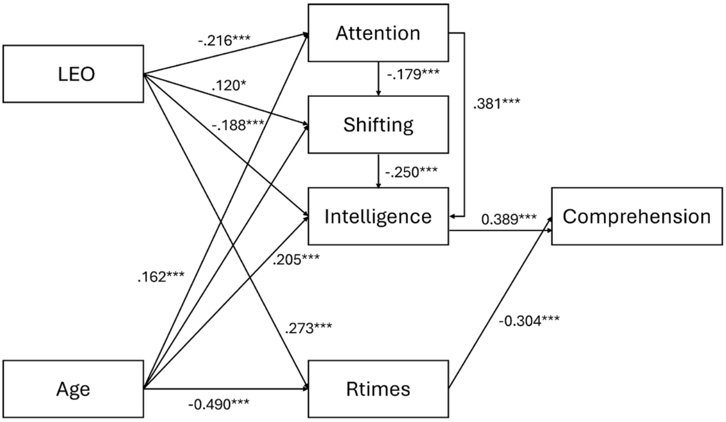
Notes. LEO: Level of Educational Opportunities (medium as reference); Rtimes: reading times.

Table 4.
Path analysis: indirect effects

Description	Estimate	SE	Low CI	Up CI	β	z	p
Age ⇒ Intelligence ⇒ Reading comprehension	0.081	0.024	0.041	0.137	0.080	3.325	<.001
Age ⇒ Shifting ⇒ Intelligence ⇒ Reading comprehension	0.050	0.016	0.024	0.092	0.050	3.097	0.002
Age ⇒ Rtimes ⇒ Reading comprehension	0.151	0.035	0.092	0.229	0.149	4.324	<.001
Age ⇒ Attention ⇒ Intelligence ⇒ Reading comprehension	0.024	0.009	0.011	0.047	0.024	2.788	0.005
Age ⇒ Attention ⇒ Shifting ⇒ Intelligence ⇒ Reading comprehension	0.003	0.001	0.001	0.009	0.003	1.998	0.046
LEO⇒ Intelligence ⇒ Reading comprehension	-0.173	0.052	-0.299	-0.086	-0.073	-3.315	<.001
LEO⇒ Shifting ⇒ Intelligence ⇒ Reading comprehension	-0.028	0.014	-0.068	-0.007	-0.012	-1.907	0.056
LEO⇒ Rtimes ⇒ Reading comprehension	-0.198	0.054	-0.339	-0.114	-0.083	-3.649	<.001
LEO⇒ Attention ⇒ Intelligence ⇒ Reading comprehension	-0.076	0.025	-0.142	-0.038	-0.032	-3.006	0.003
LEO⇒ Attention ⇒ Shifting ⇒ Intelligence ⇒ Reading comprehension	-0.009	0.004	-0.021	-0.004	-0.004	-2.256	0.024
Shifting ⇒ Intelligence ⇒ Reading comprehension	-0.291	0.088	-0.493	-0.132	-0.097	-3.293	<.001
Attention ⇒ Intelligence ⇒ Reading comprehension	0.041	0.009	0.023	0.058	0.148	4.482	<.001
Attention ⇒ Shifting ⇒ Intelligence ⇒ Reading comprehension	0.005	0.002	0.002	0.010	0.017	2.556	0.011

Notes. LEO: Level of Educational Opportunities (medium as reference); Rtimes: reading times.

Figure 3
Path analysis diagram



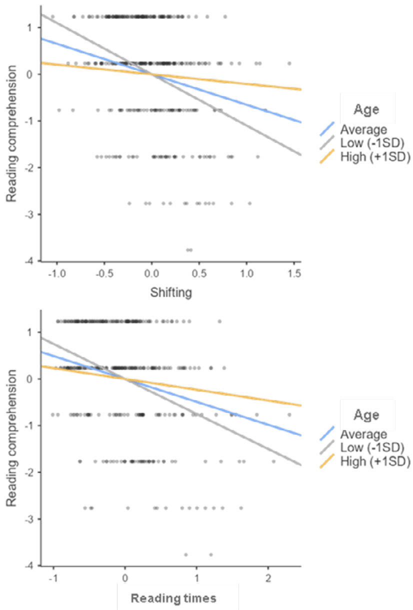
*Note: Fig. 3 shows the structure of direct and indirect effects of sociodemographic and cognitive skill predictors of reading comprehension scores. Read. Compreh.: reading comprehension scores (number of correct responses). Path analysis coefficients are shown. *p < .05, **p < .01, ***p < .001.*

Moderation analysis of cognitive skill contributions to reading comprehension

To examine cognitive effects on comprehension across ages, we ran different moderation analyses using each ability as predictor, children's age as moderator and comprehension as outcome variable. Shifting effects were moderated by age (*Estimate* = 0.385, $Z = 3.09$, $p = .002$), being significant at lower (-1 SD) (*Estimate* = -1.100, $Z = -4.85$, $p < .001$) and average (*Estimate* = -0.653, $Z = -3.74$, $p < .001$), but not at older ages ($p = .329$). The same pattern was observed for reading times (*Estimate* = 0.224, $Z = 2.68$, $p = .007$). Comprehension improved with faster reading times at lower (-1 SD) (*Estimate* = -0.750, $Z = -5.62$, $p < .001$) and average ages (*Estimate* = -0.491, $Z = -4.49$, $p < .001$), but not at older ages ($p = .139$) (see Figure 4).

Figure 4

Slope analysis of moderation effects.



Note. Fig. 4 shows the moderation effects of children's age on the contribution of Shifting (top) and Reading times (bottom) to reading comprehension scores. The different lines show the slopes for children's age average (mean), low (one standard deviation below the mean mean) and high (one standard deviation above the mean) values of the moderator (children's age). Scores are presented in a Z scale.

DISCUSSION

This study is, to our knowledge, the first to examine whether cognitive skills mediate LEO effects on reading comprehension in a Spanish-speaking sample. As expected, children from low-LEO schools showed weaker selective attention, shifting, and fluid intelligence, slower reading, and poorer comprehension. The path model confirmed two independent mechanisms through which the school context influences comprehension: a fluency pathway, in which environmental condition support (or limit) reading speed, which in turn is directly related to comprehension; and a cognitive pathway, in which attention and shifting support fluid intelligence, which ultimately accounts for a substantial portion of reading performance. Both pathways also explain the effect of age, suggesting that reading development does not depend solely of maturation but on educational opportunities that foster cognitive and reading-related skills. These findings indicate that socioeducational context shapes cognitive and reading trajectories, with school-level SES exerting a significant influence on academic performance. Here, "socioeducational" refers specifically to school-level SES (LEO), not individual home SES. Because the design is correlational and cross-sectional, causal and directional interpretations remain tentative.

LEO-Related Cognitive Skill Differences

Children in low-LEO schools underperformed in selective attention, shifting, and fluid intelligence, with moderate effect sizes. The absence of grade interactions suggests that gaps evident in second grade remained through later years, indicating that schooling did not reduce them. This pattern is consistent with prior research showing School-SES effects on cognition. Salas and Pascual (2023) reported lower EF and vocabulary in children from vulnerable schools, with School SES more strongly predicting comprehension than home SES. Ready and Read (2018) likewise found that School SES and school ethnic composition negatively affected EF development, particularly for children entering kindergarten with low EF, potentially due to differences in resources, peer interactions, and teacher–student cultural alignment. Escobar *et al.* (2018) similarly reported lower EF in low-SES schools, linking these effects to stress, income, home environment, parent–child interactions, and parental education. In contrast, Flores-Mendoza *et al.* (2021) found no SES association with Raven performance in adolescents, arguing for biologically driven intelligence; such discrepancies may reflect age-related changes in SES effects.

SES differences are typically interpreted as distal influences operating through proximal environmental factors—nutrition, stimulation, parenting, and stress—that shape neural development in executive, memory, and emotional systems during sensitive periods (Noble *et al.*, 2015; Johnson *et al.*, 2016). LEO captures both the SES profile of a school's population and school-level environmental characteristics (teacher–student interactions, resources, infrastructure), though it does not index individual home SES. Differences between low- and medium-LEO groups likely emerge from combined inequalities in school and home environments. A recent review highlighted opportunities for cognitive stimulation as a key mechanism explaining SES-related EF differences (Rakesh *et al.*, 2025), reinforcing LEO's utility for characterizing socioeducational influences on cognition and literacy.

Results suggest early SES-related EF disparities are not compensated by later schooling. Considering the impact of schools' material, human and pedagogical resources on children's cognitive development (Peng & Kievit, 2020), we suggest that investing in schools with vulnerable conditions may increase their LEO, boosting their potential to compensate for early developmental gaps. School-based EF training programs also show promise—particularly when implemented early—but far-transfer to academic skills is limited unless integrated into classroom instruction. More targeted computerized interventions tend to have narrow and short-lived effects (Gunzenhauser & Nückles, 2021). Teacher–student interactions also substantially influence EF: structured, emotionally supportive classrooms enhance EF performance (Vandenbroucke *et al.*, 2017). Thus, teachers are optimal targets for interventions, both for incorporating EF-supportive practices and improving classroom climate. Early cognitive stimulation programs may also reduce gaps, with long-term benefits depending on sustained stimulation throughout primary school (Camilli *et al.*, 2010).

LEO-Related Reading Comprehension Differences

Medium-LEO children showed better comprehension and faster reading, with no interaction with grade, and omega-squared indicated moderate effects. As with EF, schooling did not reduce this reading gap, which remained evident in older students. Prior LEO studies report similar patterns in primary and secondary school (Abusamra *et al.*, 2010, 2014). Other research also documents poorer comprehension in low-SES schoolchildren (Flores-Mendoza *et al.*, 2021; Salas Pascual *et al.*, 2023). Salas Pascual *et al.* noted that school-SES effects became non-significant once linguistic variables were included, suggesting that language environments and literacy inputs (books, curricula, leisure reading) underlie comprehension differences.

From a bioecological perspective, SES effects on language and literacy begin at home, shaped by literacy environments, child-directed speech, parent–child interactions, and shared reading practices (Head-Zauche *et al.*, 2016; Romeo, 2022). Genetic influences on reading comprehension appear stronger in high-SES contexts but attenuated in low-SES environments, where material, technological, and social constraints may overshadow individual and familial contributions (Hart *et al.*, 2013). Early and primary schooling can help reduce these gaps but may fall short in low-LEO contexts (Abusamra *et al.*, 2022; Escobar *et al.*, 2018). This is further complicated by the inconsistent use of evidence-based reading instruction —particularly phonics— (Castles *et al.*, 2018) in Argentine schools (Fonseca, 2022). Ensuring systematic use of effective methods is critical, especially because low-SES students benefit most from phonics-based approaches (NICHD, 2000; Romeo, 2022).

Several evidence-based interventions developed for Argentina could help address LEO-related reading gaps, such as the “LEE comprensivamente” program (Gottheil *et al.*, 2019; for a review, see: Roldan & Zabaleta, 2021), but their efficacy depends on accurately identifying weaknesses in word recognition or language comprehension (Roldan & Zabaleta, 2021). Family-based interventions also provide cost-effective ways to improve reading skills (Dahl-Leonard, 2025), particularly in Latin America (Stone *et al.*, 2019). Leisure reading programs, such as summer reading interventions, have shown positive effects on comprehension (Kim, 2006; Guryan *et al.*, 2014; see meta-analysis in Nakanishi, 2015). Early family-focused programs may reduce reading gaps, and incorporating reading interventions into teacher training may help schools address these difficulties. However, the most pressing issue in Argentina is the consistent implementation of evidence-based reading instruction. The next section examines the links between LEO, EF, and reading comprehension and their implications for policy.

Cognitive Skill mediation of LEO-Related Comprehension Differences

Our path analysis explained about 30% of the variance in reading comprehension and speed, a moderate-to-large effect consistent with previous literature (García & Cain, 2014). LEO and age effects on comprehension were completely mediated by reading times and fluid intelligence. Medium-LEO children showed core EF, which contributed to higher intelligence, and faster reading speed, which in turn were associated with better comprehension. These relationships were stable across age, though moderation analyses showed weaker effects of shifting and reading times in older children, likely due to reduced cognitive demands as reading becomes more automated.

These results align with the Active View of Reading (AVR; Duke & Cartwright, 2021; see also Kim, 2020), which holds that reading processes are supported by EF components such as attentional control, working memory, inhibition, flexibility, and planning. They also converge with meta-analytic evidence of EF contributions to comprehension across development (Follmer, 2018). From a bioecological perspective, SES-related literacy differences arise from home microsystem factors (e.g., HLE, parenting style, stress) and school microsystems factors (material resources, infrastructure, climate, teacher–student relations, teacher training). Contemporary reading models propose that EF help coordinate word recognition and language comprehension processes (Duke & Cartwright, 2021) or support lower-level reading skills that indirectly affect comprehension (Kim, 2020). Our model showed that LEO-related variance in comprehension was fully accounted for by reading times and cognitive skills, indicating that EF and fluency form the pathway linking LEO to comprehension.

We observed a hierarchical mediation pattern: shifting and attention influenced comprehension through fluid intelligence, consistent with Diamond's (2013) model, where fluid intelligence reflects higher-order reasoning supported by lower-level EF components. Fluid intelligence likely indexes children's capacity to manage cognitive resources during reading. This aligns with findings from Vernucci *et al.* (2021), Salas Pascual *et al.* (2023), Flores-Mendoza *et al.* (2021), and Peng and Kievit (2020). However, some studies report independent effects of SES and intelligence (Flores-Mendoza *et al.*, 2021), no SES–intelligence association (López-Escribano *et al.*, 2013), or no fluid intelligence effect on comprehension (Tabullo *et al.*, 2022), and others argue that its contribution diminishes as crystallized intelligence becomes more relevant (Cotton & Crewther, 2009). Fluid intelligence may be particularly important when reading remains cognitively demanding, such as in low- reading experience contexts. Overall, our findings suggest that lower-level EF support fluid intelligence, which showed the strongest association with comprehension. These contributions were not mediated by reading speed, implying they relate more to language comprehension (semantic retrieval, integration, syntax processing, inference making). Their persistence in older grades suggests that reading continues to impose cognitive demands and that children with better resource management still benefit from higher fluid intelligence. In contrast, the role of flexibility decreased with age, perhaps as children become more adept at switching between information types during reading.

Causal interpretations should be made cautiously. While most studies examine EF as mediators of SES–achievement relations (e.g., Escobar *et al.*, 2018; Mooney, 2024), growing evidence suggests a bidirectional link between EF and reading (Peng & Kievit, 2020). The transactional hypothesis proposes that cognitive skills support learning, while long-term structured instruction in reading and math provides ongoing cognitive training that ends up improving these skills. SES may modulate these effects, with low-SES students benefiting less due to their lower access to learning opportunities at home and high-quality school teaching environments. We found no evidence of such moderation ($\Delta R^2 < .001$, $p > .365$), but a synergistic relationship between comprehension and cognitive skills may still exist, as reading constitutes a problem-solving activity requiring EF. Additional caution pertains to the interpretation of fluid intelligence itself, as some evidence suggests it reflects academic experience, familiarity with test-like tasks, or motivational factors characteristic of higher-achieving students (Peng & Kievit, 2020; Ritchie *et al.*, 2018). Reading times also predicted comprehension directly, reflecting the role of fluency. Fluency bridges decoding and language comprehension (Duke & Cartwright, 2021), and is a strong predictor especially in younger children (García & Cain, 2014). Faster reading indicates more efficient decoding, freeing resources for integration. Other studies show that shifting and EF influence fluency (Ober *et al.*, 2020) and that decoding mediates the shifting–comprehension link (Spencer *et al.*, 2020), partly through EF-supported orthographic mapping (Duke & Cartwright, 2021). Because these studies were conducted in English, Spanish's transparent orthography may reduce EF demands, yielding smaller effects. Moderation analyses showed that reading-speed effects were stronger in younger children, for whom decoding is still effortful. Mediation pathways involving fluency did not involve cognitive skills, suggesting that LEO-related differences in reading speed stem more from language-related factors, such as HLE, instructional methods, and school reading practices. As reading speed was a significant mediator of LEO effects, fluency-based interventions may improve comprehension, although their effectiveness tends to be highest in one-on-one formats, with implications for cost-effectiveness (Hudson *et al.*, 2020).

Our findings extend prior Latin American studies examining SES mediators of academic performance (Escobar *et al.*, 2018; Korzeniowski *et al.*, 2016) by focusing specifically on comprehension, identifying two mediation pathways (reading times; EF → fluid intelligence), and demonstrating that LEO effectively captures school SES composition and associated developmental conditions. Given that LEO effects did not vary by grade, SES-related developmental differences emerging early in schooling may remain largely unchanged, likely reflecting systemic educational segmentation. Nonetheless, a recent review shows that classroom climate, teacher–student relationships, and teacher expectations modulate SES–achievement links, offering targets for intervention (Vandenbroucke *et al.*, 2017).

Considering implications for education policies, the overall LEO effect highlights the need to invest in school infrastructure and human resources to improve literacy outcomes. The mediation pathways suggest two complementary strategies for low-LEO contexts: promoting leisure reading and implementing comprehension programs, and applying cognitive training protocols. Both require teacher implementation, and cognitive training in particular depends on alignment with classroom activities and curricula. Classroom climate and emotionally supportive teacher–student interactions also promote cognitive development by providing stable, stimulating, lower-stress environments (Vandenbroucke *et al.*, 2017), and teacher expectations—which tend to be lower for low-SES students—further modulate SES effects on learning (Wang *et al.*, 2018).

Study Limitations

The main limitation is the study's cross-sectional and correlational design, which precludes causal inference. Longitudinal research is needed to confirm the observed developmental trajectories. While the directionality of our effects is congruent with previous studies, it cannot be considered as confirmatory evidence of causality, and bidirectional effects between EF and reading skills cannot be discarded. The associations among executive functions, intelligence, fluency, and comprehension likely involve reciprocal developmental influences that could only be tested with longitudinal data. A second limitation is the absence of individual-level home SES data, which prevents direct comparison with LEO effects. However, the study's focus was on school-level effects, and the findings show that LEO explains reading comprehension differences through its impact on cognitive skills. Future studies should compare the predictive power of LEO and home-SES to disentangle their contributions. Another further concern is the representativeness of our sample. Though sample size was adequate for our analysis, it was drawn from a limited number of schools in a single urban region, and therefore is not representative of the broader Argentine or Latin American population. School-level indicators such as LEO may operate differently in rural contexts or under other regional educational policies, thus limiting generalizability. Future studies should include vocabulary and decoding measures, which may also mediate

SES effects (Spencer *et al.*, 2020), as well as direct working memory assessments, given its known role in reading comprehension (Peng *et al.*, 2018). Combining performance-based and behavioral EF measures may enhance prediction (Canet-Juric *et al.*, 2022). Inclusion of teacher-level factors (e.g., expectations, motivation, mindset) could improve understanding of school-context effects).

CONCLUSIONS

Despite its limitations, this study helps address a key gap by examining the SES → EF → reading comprehension pathway in a Spanish-speaking Latin American sample—an understudied context relative to work in WEIRD populations or focused solely on lower-level reading processes. Our findings show that the LEO construct captures meaningful school-SES variation and that LEO-related differences in comprehension are fully mediated by reading speed and cognitive skills, two distinct and potentially malleable targets for intervention.

From a policy standpoint, the persistent educational segregation of the Argentine system appears to sustain early SES-related disparities in cognitive and reading development. Strengthening and systematizing evidence-based reading instruction could improve resource allocation and help reduce gaps among low-SES students. The identified mediation pathways suggest that interventions should target both reading skills and EF, with sustained impact only when teacher-directed and embedded in daily classroom practice. Programs that support equitable teacher expectations, improve classroom climate, and foster emotionally supportive interactions may further enhance cognitive stimulation. Early family-based initiatives, such as shared reading programs, offer a cost-effective way to reduce initial literacy disparities before school entry.

Reading comprehension is a foundational competency that extends beyond academics, enabling access to information, informed decision-making, and opportunities for personal, professional, and civic development. Promoting its consolidation from early schooling is therefore essential for fostering autonomy, responsibility, and social awareness. This perspective highlights the need for interventions that strengthen specific skills while ensuring educational and family environments that support children's integral development.

Finally, these results should not be interpreted from a deficit perspective. Instead, they emphasize Bronfenbrenner's view of the central role of microsystems—particularly families and schools—in shaping developmental trajectories and as primary targets for educational and social policy. Our results highlight the need to strengthen both explicit and systematic reading instruction (particularly phonological instruction and text-based work) and the development of executive-function skills in the classroom, as both contribute uniquely to comprehension. As cognitive and language skills remain environmentally malleable across childhood, these findings identify two actionable pathways for interventions designed to narrow SES-related disparities in literacy development.

Declaration of Conflict of Interest

The authors declare that they have no conflict of interest.

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Data availability Statement

Manuscript data is available upon reasonable request.

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