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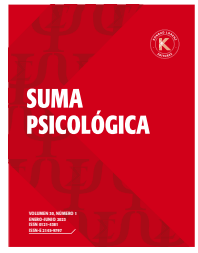

The role of executive functions in the comprehension of expository and narrative texts by high school students

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Reading comprehension, executive functions, adolescence, narrative text, expository text

Abstract Introduction: Reading comprehension is a complex skill that involves several linguistic and cognitive processes. While the evidence indicates that expository texts are more difficult and cognitively demanding than narrative texts, the contribution of core executive functions to comprehension has seldom been compared between these genres, particularly in adolescents. The present study examined the association of executive functions with expository and narrative text comprehension in Argentinean high school students, while controlling for their verbal skills. **Method:** One hundred and twenty-one 12 to15-year-old high school students participated in our study (75.2% of them were girls). Participants completed pencil and paper tests in reading comprehension (TLC-II), vocabulary (BAIRES) and reading efficacy (TECLE), as well as computerised tests in shifting, inhibition and verbal and visuospatial working memory from the Cognitive Self-Regulation Test Battery (TAC). **Results:** We found lower comprehension scores in the expository text. Shifting and verbal working memory were predictors of reading comprehension beyond verbal skills, but we did not observe significant differences between text types. Comprehension in general was lower for third-year students. **Conclusion:** In accord with the literature, we observed greater difficulties for expository text comprehension, and a general contribution of shifting and working memory to both types of text. We found no conclusive evidence of differences in this association between text types. Third-year students' comprehension might have been affected by the impact of the pandemic on their schooling trajectory.

El rol de las funciones ejecutivas en la comprensión de textos expositivos y narrativos en estudiantes de secundaria

PALABRAS CLAVE
Comprensión de textos, funciones ejecutivas, adolescencia, texto narrativo, texto expositivo

Resumen Introducción: la comprensión de textos es una habilidad compleja que involucra diversos procesos lingüísticos y cognitivos. Si bien la evidencia indica que los textos expositivos son más difíciles y cognitivamente demandantes que los narrativos, la contribución de las funciones ejecutivas a la comprensión de ambos rara vez se ha comparado en adolescentes. Este artículo

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examinó la asociación de las funciones ejecutivas con la comprensión de textos expositivos y narrativos en estudiantes de secundaria argentinos, controlando sus habilidades verbales. **Método:** ciento veintiún estudiantes de secundaria de entre 12 y 15 años (75.2% mujeres) participaron del estudio, los cuales realizaron pruebas de comprensión de textos narrativo y expositivo, vocabulario, eficacia lectora, y de flexibilidad cognitiva, inhibición, memoria de trabajo verbal y visoespacial. **Resultados:** encontramos puntajes de comprensión más bajos en el texto expositivo. La flexibilidad y la memoria de trabajo verbal fueron predictores de la comprensión de textos más allá de las habilidades verbales, sin observarse diferencias significativas por tipo de texto. La comprensión fue más baja en los alumnos de tercer año en general. **Conclusiones:** en línea con la literatura, se observó una mayor dificultad en la comprensión del texto expositivo, y una contribución general de la flexibilidad y la memoria de trabajo a la comprensión de ambos textos. No se encontró evidencia concluyente de diferencias en esta asociación por tipo de texto. La comprensión de los estudiantes de tercero puede haber sido afectada por el impacto de la pandemia en su trayectoria educativa.

Reading comprehension involves a variety of linguistic processes, ranging from word recognition to word-to-text integration (Perfetti & Stafura, 2014), summarised by the *Simple View of Reading* model as the interplay between word decoding and language comprehension (Hoover & Tunmer, 2018). These components represent processes related to: (1) detection and decoding of orthographic information and (2) access to meaning and integration with previous knowledge, respectively. Two specific language skills have been identified as the main contributors to these components: vocabulary and reading fluency (encompassing prosody as well as accuracy and automaticity of text reading). Recent models have proposed that these skills constitute bridging processes that help to connect both word recognition and language comprehension during reading (Duke & Cartwright, 2021). In addition to verbal skills, reading comprehension requires the allocation of cognitive processes, such as executive functions (EF) (Butterfuss & Kendeou, 2018), and metacognitive skills such as reading strategies, which have been synthesised by the *Active View of Reading* model (Duke & Cartwright, 2021). These authors propose that reading is an active and strategic process, requiring readers to deploy their executive skills in order to coordinate the various processes and text elements required for successful reading, as well as to keep themselves engaged with the text. EFs are a set of high-level cognitive processes that allow individuals to regulate their thoughts, emotions, and actions during goal-directed behaviour (Friedman & Miyake, 2017). The most influential model proposes that EFs are distinguishable from each other, although partially related: working memory (WM) updating, shifting (also known as "cognitive flexibility") and inhibition (Friedman & Miyake, 2017; Miyake et al., 2000). WM is a short-term system that allows the maintenance and manipulation of verbal and visuospatial information. WM updating refers to the ability to monitor, add, or remove contents from this system. Shifting involves switching between concepts, strategies, mental processes, and stimuli to adapt responses to situational demands. Inhibition is the ability to suppress interference in order to achieve a goal. It includes the control of interference generated by distracting or task-irrelevant internal or external stimuli and the suppression of automatic or prepotent, but task-irrelevant, responses (Diamond, 2013).

According to the Active View of Reading (Duke & Cartwright, 2021), reading engages EFs when directing attention to specific aspects of the text (attentional control), updating a text model while decoding incoming words (WM), suppressing distracting information (inhibitory control), shifting between cognitive processes (cognitive flexibility) and planning and monitoring reading goals. Butterfuss and Kendeou (2018) summarise EF contributions to reading comprehension. WM provides a cognitive workspace to keep information from the incoming input, integrating it with the unfolding text representation and prior knowledge. In this way, WM allows (and constrains) model construction and inference generation (Borella & de Ribaupierre, 2014; Nouwens et al., 2021; Peng et al., 2018). Shifting supports changing mental sets and the formation of new concepts, integrating new and sometimes unexpected input with the unfolding text representation. In addition, it aids forward inference-making processes (by selecting and alternating between relevant pieces of information), alternating between reading strategies, and engaging in metacognitive processing, such as monitoring one's own comprehension (Johann et al., 2020; Yeniad et al., 2013). Finally, inhibition helps avoid the activation of irrelevant information, be it from environmental stimuli or long-term memory systems (i.e., interference control; Diamond, 2013), supporting relevant text representation construction and preventing WM overload (Borella & de Ribaupierre, 2010). Evidence indicates that EFs consistently contribute to reading comprehension in children, adolescents, and adults (for a meta-analysis, see Follmer, 2018). However, there have not been many studies that consider and compare these three core EFs in adolescents. A recent study found a direct contribution of WM to passage comprehension, while the effect of inhibitory control was mediated by decoding skills (Ober et al., 2019). Other studies found only indirect effects of WM and shifting, completely mediated by adolescents' language comprehension and/or decoding skills (Kieffer et al., 2021; Spencer et al., 2020). A recent series of studies (Avramovich & Reary, 2022, 2023) examined reading com-

prehension and EFs in adolescents with and without ADHD, finding higher EF difficulties in the ADHD group explained its lower reading comprehension performance, and that verbal and discourse-specific EF measures were better predictors of ADHD reading comprehension difficulties.

Text genre is an important factor for comprehension. Several theories predict that narrative texts should be easier to understand and recall than expository texts (for a meta-analysis, see Mar et al., 2021). Narrative texts are written for entertainment purposes and possess a familiar chronological structure. Expository texts are designed for informational and educational purposes and consist of descriptions, definitions, and ideas supported by an argumentative structure. Thus, narrative texts are generally more familiar (Gardner, 2004) and rely on more common background knowledge (Graesser et al., 2003), whereas expository texts imply higher cognitive demands because of their greater structural complexity, information density and specific prior knowledge requirements (Best et al., 2008). Evidence indicates easier comprehension of narrative texts, both in children and adults (Mar et al., 2021), and points to the involvement of different linguistic and cognitive skills in each case (Clinton et al., 2020). Evidence suggests expository texts are more demanding for inference making processes (Clinton et al., 2020), and also that language inference and EF planning skills were stronger predictors of expository (compared to narrative) text comprehension (Eason et al., 2012). This implies that those EFs more strongly implicated in inference-making processes (such as WM and shifting) should be more associated with expository comprehension. In addition, expository texts are more demanding in terms of structural complexity and prior background knowledge, which also suggests greater WM demands to support integrating long-term memory contents with the ongoing mental representation of the text. On the other hand, Demagistri et al. (2014) found an association between adolescents' expository text comprehension, WM, and inhibition, while Abusamra et al. (2020) found a contribution of inhibition to narrative comprehension. Nevertheless, these studies did not compare both text types (nor did they consider shifting). A study that compared the EF predictors of primary school (1st to 4th grade) children's reading comprehension, reported a specific association of WM, planning, shifting and inhibition with expository text performance (Wu et al., 2020); while another study conducted with 4th to 6th graders from Argentina observed contributions of WM to both texts (Canet-Juric et al., 2022). However, these tests relied on parent-report questionnaires instead of cognitive test performances. We were unable to find a study that directly compared the contribution of the three core EF processes to both texts' comprehension in adolescents, although we did find one that compared expository and narrative text production (Lundine et al., 2018) indicating cognitive skills (including EFs) were stronger predictors of the quality of expository text compositions among adolescents.

Despite the abundant evidence of EF contributions to reading, their specific role in adolescents' narrative and expository text comprehension has yet to be determined. The present study aimed to examine the association of WM, shifting, and inhibition with expository and narrative comprehension in Argentinean high school students, while controlling for their language comprehension and decoding skills. Considering the aforementioned theoretical and empirical differences between genres, we expected to find lower performances and higher EF contributions for the expository text. This genre should increase working memory load (in terms of integration with previous knowledge and inference making), flexibility load, for shifting between relevant information sources in the text and inhibition load, because it requires more attentional focus due to its greater structural and lexical complexity. The relevance of this question is further highlighted by the fact that approximately 51% of Latin American adolescents scored below basic reading proficiency skills on their PISA evaluation, and reading scores in Argentina have declined since the year 2000 (OECD, 2019).

Method

Participants

One hundred and twenty-one 12 to 15-year-old high school students (75.2% of them girls; *M* age = 13.87, *SD* = 0.91 years) participated in our cross-sectional correlational study. The sample was selected by convenience. Students attended a public high school in Mendoza (Argentina) and were from the 1st (*n* = 44), 2nd (*n* = 36) and 3rd (*n* = 41) year courses. Most of their mothers (60%) and fathers (51.5%) had completed university or tertiary studies, while the remainder had completed secondary education. The participants had no history of developmental, neurological, or psychological disorders, dyslexia, or learning difficulties.

Instruments

The Cognitive Self-Regulation Test Battery (Batería de Tareas de Autorregulación Cognitiva [TAC]; Introzzi & Canet-Juric, 2019). This computer platform is designed for the evaluation of EFs across a wide age range. It has shown adequate internal and external validity (Richard et al., 2020). The tasks included in this battery have been used in previous studies in which the relationships between EFs and text comprehension were analysed (e.g., Andrés et al., 2022, Vernucci et al., 2017). The following tasks were included in the present study:

Perceptual Inhibition. Participants must detect the presence of a target stimulus (a blue square) among a varying number of perceptually similar distractors (blue circles, red squares). The number of distractors varies from trial to trial (i.e., presenting 4, 8, 16, 32 distractors), and the target is present in half of the trials. Participants must press the "Z" key if the target is present and the "M" key if it is absent. Performance was measured as the mean response latency difference between the conditions with the highest and lowest cognitive load (32 and 4 distractors, respectively), higher scores indicate worse performance (Cronbach's α = .60). The task has shown good indicators as a measure of perceptual inhibition (Canet Juric et al., 2021; Richard et al., 2017, 2020). According to Diamond (2013), perceptual inhibition may be considered as synonymous with inhibitory control at the level of (selective) attention, and the type of task used here would evaluate the interference control of unwanted perceptual stimuli for the current task. Impor-

tantly, interference control has been associated with performance in reading comprehension (e.g., Borella et al., 2010; Borella & de Ribaupierre, 2014).

Visuospatial Working Memory (VSWM). This task consists of the presentation of a 4×4 square matrix in which stimuli ("X") of different colours appear sequentially. Participants are asked to remember the location of the stimuli as a primary task, while also indicating the colour of the stimuli in a palette in a secondary, interference task, immediately after each stimulus disappears from the screen. Successively, participants must recall the location of the stimuli by pointing to the locations in which these were presented. Performance is measured as the maximum number of elements recalled before committing two consecutive mistakes (α = .60).

Shifting. The task is a modified version of the arrows task, based on the task-switching paradigm. It presents a hand on the left or right side of the computer screen, pointing with its index finger either straight down or at a 45° angle toward the opposite side. Participants must press a key ("Z" or "M"), according to the side the hand is pointing to. The task presents congruent trials, where the hand is pointing straight down and participants should respond on the same side as the hand (ipsilateral), and incongruent trials, where the hand is pointing toward the opposite side and participants should respond on the opposite side of the hand (contralateral). The task consists of three blocks. The congruent block presents only congruent trials, and the incongruent block presents only incongruent trials. The mixed block allows assessing shifting ability; it presents both congruent and incongruent trials, thus requiring to efficiently switch between incompatible rules (i.e., responding on the same side of the stimulus, or responding on the opposite side). An Inverse Efficiency index (IE = response times / (1 – Error proportion) was calculated from those trials where both the response type (ipsilateral and contralateral to stimulus location) and the response site (left key or right key) change with respect to the previous one. Higher scores indicate worse performance.

Backwards Digit-Span (adapted from Barreyro et al., 2019). Verbal WM was assessed through a computerised version of the backwards digit span, adapted to the PCIBEX Farm platform from the BIMeT-V working memory battery by Barreyro et al. (2019) (α = .84). Performance was operationalised as the number of correct responses.

The BAIRES Vocabulary Test (Cortada de Kohan, 2004). The BAIRES test has been standardised and validated for collective vocabulary assessment in our population. We applied the abbreviated form, which consists of two tasks, Synonyms (choose the correct synonym for the target word) and Definitions (choose the correct definition for the target word), of 17 items each (α = .70).

The Collective Test of Reading Efficacy (Test Colectivo de Eficacia lectora [TECLE], Ferreres et al., 2011). The aim of the test is to synthesise the main parameters of reading (decoding accuracy and speed, sentence comprehension and cognitive resource management) in a single measure, defined as *reading efficacy*. The test consists of 64 sentences in which the last word is missing. The participant's task is to select the correct ending among four options: one correct, another similar but semantically incorrect word, another phonologically close non-word, and finally an orthographically close non-word. The score is the result of the sum of correct answers that each participant achieves within five minutes (maximum score = 64) (α = .92). We will use the term "reading efficacy" to refer to the construct measured by the TECLE test throughout the manuscript.

The Reading comprehension test (Abusamra et al., 2014). The expository and narrative screening tests from the Test "Leer para Comprender II" were administered. The test is based on the Multicomponent Reading Model from De Beni et al. (2003). The texts were age-appropriate for adolescents, according to their reading curricula and the INFLESZ algorithm (Barrio-Cantalejo et al., 2008). The expository text was entitled "Perdón, me parece que te casé con el testigo" ["Sorry, I think I married you to the witness"], and it was a newspaper article (length: 379 words). The narrative text was a short story entitled "La aldovranda en el mercado" ["The aldovranda at the market"] (length: 575 words). Each test is followed by 10 multiple-choice questions with 4 alternatives. In all cases, there is only one correct answer and the remainder have different degrees of semantic proximity to it (α > .65). Performance was measured as the number of correct responses. In addition, they were interpreted categorically according to normative data as: *optimal*, *sufficient*, *weak* or *very weak*.

Procedure

Data collection was carried out in two sessions (per classroom) that took place in April 2022. In the first session, conducted in the classroom, students completed the reading comprehension (expository and narrative texts counterbalanced between classrooms), reading efficacy, and vocabulary tests in pencil and paper format. In the second session, they completed the neuropsychological tests in the computer lab, on individual computers. All participants were informed that their participation would be voluntary, anonymous and that they could withdraw from the experiment at any time, without any negative consequences. Students' assent, as well as their parents' informed consent, was obtained before the study. To preserve confidentiality, no personal information was included in our databases.

This study was conducted following the ethical principles for research with human subjects recommended by the Declaration of Helsinki (World Medical Association, 2013), as well as the ethical guidelines for research with human participants of the American Psychological Association (2010), following ethical regulation 5344/99 of the National Scientific and Technical Research Council of Argentina (CONICET) and was approved and supervised by CONICET's committee.

Statistical analyses

Statistical analysis was carried out using JAMOVI software. First, we provide a descriptive analysis of our study variables, focusing on the quantitative and qualitative analysis of reading comprehension performance (using factorial ANOVA and chi-squared test, respectively). Associations between variables were examined by Spearman correlation coefficients. To identify significant predictors of reading comprehension, a hierarchical linear regression model was

carried out. The outcome variable was the total number of correct responses (including both texts). The first step of the model included gender, high school grade, verbal skill (vocabulary and reading efficacy) measures and Text Type (narrative and expository). High school grade is a three-level ordinal variable (1st, 2nd or 3rd year) and is dummy-coded in the model with 1st year as reference. Text type is a dichotomous variable, dummy-coded with expository as reference. The second step included EF measures (perceptual inhibition, response inhibition, verbal and spatial WM, shifting). The third step included the interactions between language skills (vocabulary and reading efficacy) and Text Type, and the fourth included the interactions of Text with EF measures. Casewise diagnostics were applied to deal with outliers (standardised residuals ±3). Since no outliers were detected, no data was removed from the analysis. Assumptions of normality, homoscedasticity, and linearity were verified by inspection of normal quantile plots of residuals, standardised residuals scatter plots, and observed versus predicted values, respectively. Independence of er-

Table 1. Descriptive statistics of study variables

Variable	Grade	Gender	Mean	*SD*	Minimum	Maximum
Expository	1	Boys	6.00	2.70	1.00	10.00
		Girls	7.11	1.46	3.00	9.00
	2	Boys	6.18	1.68	3.00	8.00
		Girls	7.44	1.76	4.00	10.00
	3	Boys	6.50	2.37	3.00	9.00
		Girls	6.74	1.86	2.00	10.00
Narrative	1	Boys	7.56	3.15	1.00	10.00
		Girls	8.14	1.64	4.00	10.00
	2	Boys	7.00	3.49	0.00	10.00
		Girls	8.96	1.26	4.00	10.00
	3	Boys	7.63	1.71	6.00	10.00
		Girls	7.39	2.11	0.00	10.00
TECLE	1	Boys	47.67	9.89	36.00	64.00
		Girls	46.29	10.12	18.00	63.00
	2	Boys	53.73	11.81	32.00	64.00
		Girls	53.16	10.77	20.00	64.00
	3	Boys	42.13	9.56	25.00	55.00
		Girls	53.26	10.47	28.00	64.00
BAIRES	1	Boys	9.67	3.45	5.00	14.00
		Girls	8.93	4.75	2.00	17.00
	2	Boys	10.50	3.35	6.00	17.00
		Girls	11.67	3.50	6.00	19.00
	3	Boys	15.33	2.74	11.00	20.00
		Girls	13.42	3.31	7.00	22.00
Shifting	1	Boys	10.11	1.25	8.10	11.48
		Girls	10.39	3.09	6.79	23.22
	2	Boys	9.08	1.67	6.59	11.60
		Girls	9.25	1.50	7.25	13.71
	3	Boys	8.43	1.25	6.39	10.23
		Girls	8.82	1.48	5.88	12.96
VSWM	1	Boys	2.71	1.33	1.00	4.00
		Girls	2.49	1.87	1.00	7.00
	2	Boys	2.90	2.02	1.00	5.00
		Girls	3.04	1.79	1.00	6.00
	3	Boys	3.14	2.38	1.00	7.00
		Girls	3.26	1.85	1.00	6.00
VWM	1	Boys	5.29	2.27	1.00	8.00
		Girls	6.03	2.41	1.00	10.00
	2	Boys	7.33	2.00	5.00	11.00
		Girls	7.67	2.17	3.00	11.00
	3	Boys	6.71	3.02	2.00	10.00
		Girls	7.35	2.30	1.00	11.00
PInhibition	1	Boys	350.43	223.54	12.00	892.00
		Girls	439.49	215.9	15.00	891.00
	2	Boys	465.3	210.45	217.00	899.00
		Girls	527.96	219.39	161.00	891.00
	3	Boys	465.23	223.32	154.00	985.00
		Girls	496.39	268.84	167.00	972.00
RInhibition	1	Boys	131.22	60.23	14.00	308.00
		Girls	112.16	61.35	15.00	310.00
	2	Boys	117.23	80.32	4.00	274.00
		Girls	111.35	78.72	2.00	267.00
	3	Boys	110.32	99.32	8.00	511.00
		Girls	109.44	100.84	10.00	511.00

(*Continued*)

Note. Grade: 1 = 1st year, 2 = 2nd year, 3 = 3rd year. Expository: expository text comprehension; Narrative: narrative text comprehension: TECLE: reading efficacy performance; BAIRES: vocabulary performance; Shifting: TAC shifting test performance; VSWM: TAC visuospatial working memory performance; VWM: verbal working memory performance (digit span); PInhibition: TAC Perceptual inhibition performance; Rinhbition: TAC Response inhibition (calculated from shifting task – see procedure). * $p < .05$, ** $p < .01$, *** $p < .001$.

ror assumption was met for all models (1.93 < Durbin-Watson < 2.01). Variance inflation factors indicated that multicollinearity was not a concern in any of the models (1.02 < VIFs < 1.28). Adjusted R-squared values and standardised coefficients (with their corresponding confidence intervals) are reported. We tested for mediation of vocabulary score effects over total comprehension scores by WM and shifting using a mediation analysis. We carried out the test using the medmod module of the JAMOVI statistical software. We applied bias-corrected bootstrapping methods (n = 10 000 samples) to estimate confidence intervals for the effects.

Results

Descriptive statistics

A complete list of descriptive statistics for the study variables can be found on Table 1. According to the qualitative interpretation of reading comprehension scores, the proportion of students with optimal or satisfactory comprehension scores was similar among course years for expository texts (1st: 59.1%, 2nd: 66.6%, 3rd: 53.7%; χ^2 = 7.4, p = .290), but lower in third year students for narrative texts (1st: 54.6%, 2nd: 63.9%, 3rd: 26.8%; χ^2 = 17.7, p = .007). The proportion of boys and girls with high comprehension scores was not significantly different for expository (χ^2 = 3.38, p = .066) or narrative (χ^2 = 0.157, p = .692) texts. A quantitative analysis indicated that comprehension scores were consistently higher for narrative texts, F(1, 118) = 31.593, p < .001, $\eta 2p$ = .211.

Associations between study variables

A Spearman correlation matrix for reading and EF measures is provided on Table 2. Shifting scores improved with expository comprehension (note that lower shifting scores indicate better performance), while VWM performance increased with both text scores. Expository and narrative comprehension were positively correlated, as well as vocabulary and reading efficacy skills. Shifting was negatively correlated with both WM measures, which were in turn positively correlated with each other. In addition, vocabulary scores increased with shifting and VWM performance (see Table 2 for details).

Regression analysis of reading comprehension scores. The first regression model was significant (R^2 = 0.126, F(6, 181) = 5.51, p < .001). Comprehension scores were higher for the narrative text (β = 0.457, p < .001), better for girls (β = 0.532, p = .002) and lower in 3rd year compared to 1st year students (β = -0.549, p = .004). In addition, they increased with vocabulary (β = 0.175, p = .029). The inclusion of EF measures improved explained variance (R^2 = 0.179, ΔR^2 = 0.073, p = .007, F(11, 176) = 4.71, p < .001). Comprehension scores improved with VWM (β = 0.179, p = .019) and shifting (β = -0.206, p = .011), while the effect of vocabulary was no longer significant. The inclusion of language or EF measure interactions with text type (ΔR^2 = 0.017, p = .143 and ΔR^2 = 0.004, p = .954, respectively) did not improve fit significantly. Since vocabulary scores were positively associated with WM and shifting (see Table 3), we examined whether their effects on comprehension might have been mediated by these EF measures. A mediation analysis indicated a significant indirect effect of vocabulary on comprehension that was fully mediated by VWM (β = 0.081, Z = 3.028, p = .002).

Discussion

We examined the contribution of EFs to expository and narrative text comprehension among high school students. As expected, narrative text comprehension was consistently better, suggesting higher cognitive demands from the expository text. Furthermore, specific correlations were observed between expository comprehension performance, WM, and shifting scores. Hierarchical regression analysis indicated general contributions of WM and shifting to reading comprehension, with no evidence of differential associations between these EFs and each text type. In addition, third-year students exhibited greater comprehension difficulties. We discuss these findings in detail below.

Table 2. Spearman correlations matrix

	1	2	3	4	5	6	7	8	9
1. Expository	—								
2. Narrative	0.512***	—							
3. TECLE	-0.036	0.114	—						
4. BAIRES	0.081	-0.048	0.232*	—					
5. Shifting	-0.202*	-0.064	-0.116	-0.302**	—				
6. VSWM	0.073	0.014	0.088	0.112	-0.306**	—			
7. VWM	0.354***	0.193*	0.045	0.363***	-0.363***	0.211*	—		
8. PInhibition	0.034	-0.013	0.076	-0.105	-0.067	-0.029	0.137	—	
9. RInhibition	0.016	0.083	-0.072	-0.184	0.141	-0.009	-0.041	-0.023	—

Note. Expository: expository text comprehension; Narrative: narrative text comprehension: TECLE: reading efficacy performance; BAIRES: vocabulary performance; Shifting: TAC shifting test performance; VSWM: TAC visuospatial working memory performance; VWM: verbal working memory performance (digit span); PInhibition: TAC Perceptual inhibition performance; Rinhbition: TAC Response inhibition (calculated from shifting task – see procedure). * p < .05, ** p < .01, *** p < .001.

Table 3. Regression analysis of reading comprehension scores

							95% Confidence Interval	
Model	**Predictor**	**Estimate**	***SE***	***t***	***p***	**Stand. Estimate**	**Lower**	**Upper**
1								
	Gender:							
	Girls vs Boys	**10.930**	**0.3507**	**3.116**	**0.002**	**0.5325**	**0.1953**	**0.870**
	Grade:							
	2° vs 1° year	-0.0768	0.3766	-0.204	0.839	-0.0374	-0.3994	0.325
	3° vs 1° year	**-11.276**	**0.3862**	**-2.920**	**0.004**	**-0.5493**	**-0.9206**	**-0.178**
	BAIRES	**0.0847**	**0.0386**	**2.197**	**0.029**	**0.1748**	**0.0178**	**0.332**
	TECLE	0.0202	0.0131	1.542	0.125	0.1100	-0.0307	0.251
	Text:							
	Exp vs Nar	**0.9362**	**0.2799**	**3.345**	**< .001**	**0.4561**	**0.1871**	**0.725**
2								
	Gender:							
	Girls vs Boys	**123.894**	**0.36627**	**3.383**	**< .001**	**0.6036**	**0.2514**	**0.9557**
	Grade:							
	2° vs 1° year	-0.51925	0.38682	-1.342	0.181	-0.2530	-0.6248	0.1189
	3° vs 1° year	**-146.609**	**0.38756**	**-3.783**	**< .001**	**-0.7142**	**-10.868**	**-0.3416**
	BAIRES	0.02388	0.04086	0.584	0.560	0.0493	-0.1171	0.2157
	TECLE	0.02070	0.01289	1.606	0.110	0.1127	-0.0258	0.2513
	Text:							
	Exp vs Nar	**0.93617**	**0.27126**	**3.451**	**< .001**	**0.4561**	**0.1953**	**0.7169**
	Shifting	**-0.24166**	**0.09366**	**-2.580**	**0.011**	**-0.2065**	**-0.3644**	**-0.0486**
	VWM	**0.14807**	**0.06260**	**2.365**	**0.019**	**0.1790**	**0.0297**	**0.3284**
	VSWM	0.01123	0.07484	0.150	0.881	0.0102	-0.1242	0.1446
	RInhibition	0.00149	0.00114	1.304	0.194	0.0922	-0.0474	0.2319
	PInhibition	-5.73e−4	4.72e-4	-1.214	0.226	-0.0857	-0.2250	0.0536

Note. Exp expository text; Nar: narrative text: TECLE: reading efficacy performance; BAIRES: vocabulary performance; Shifting: TAC shifting test performance; VSWM: TAC visuospatial working memory performance; VWM: verbal working memory performance (digit span); PInhibition: TAC Perceptual inhibition performance; Rinhbition: TAC Response inhibition (calculated from shifting task – see procedure). Significant effects are highlighted in bold.

The advantage of narrative text comprehension is in line with previous evidence indicating that this genre is easier to process in terms of familiarity, vocabulary, structure, and background knowledge (Clinton et al., 2020, Mar et al., 2021). While we would not have expected generally lower comprehension scores in third-year students, this finding can be interpreted in terms of the effect of the COVID-19 pandemic on their schooling trajectories. While first and second-year students were also reached by lockdown measures, their high-school reading experience could have been less (or not at all) affected because they were finishing elementary school. Third-year students had to adapt to changes in the reading curricula within the context of remote schooling, being more exposed to its inherent difficulties and shortcomings. In this sense, the data from the national assessments of learning in Argentina (Ministerio de Educación de la Nación, 2023a, 2023b) indicate that children who were in the last year of primary education in 2021 showed a marked decline in reading performance compared to the latest available assessment: 44% of students did not reach a satisfactory reading level compared to 24.7% registered in 2018. The data for this population show an improvement in 2022 compared to the previous year: students who did not reach the satisfactory level fell to 25.9%. Likewise, regarding secondary school students (who were in the last two years), in 2019 there were 38.3% who did not reach a satisfactory level of reading, compared to 43% in 2022. These data allow us to think that students who finish primary education and enter secondary school would show performance recovery to a level close to that of the pre-pandemic, while students who were in secondary school during the pandemic show a negative effect on achievement in reading.

The contributions of VWM and shifting to general reading comprehension are congruent with theoretical models (Butterfuss & Kendeou, 2018; Duke & Cartwright, 2021) and empirical evidence (Follmer, 2018). VWM allows integrating written and inferred propositions and contents from long-

term memory with the unfolding mental representations of the text, thus allowing model construction and inference-making (Demagistri et al., 2014; Ober et al., 2019). It should be noted that other VWM measures that impose higher linguistic demands than the digit span (such as the reading span test) tend to show higher associations with reading comprehension (Peng et al., 2018). In addition, a meta-analysis showed that the contribution of WM to reading comprehension is more domain-general (involving the central executive) at early stages of reading acquisition and more domain-specific (involving the verbal component) for more experienced readers (Peng et al., 2018). Future studies might consider comparing the association of different WM components with reading comprehension.

Shifting allows flexibly switching attention across sources of relevant information, alternating between reading strategies, adequate forward inference-making, and updating the mental model with unexpected input (Butterfuss & Kendeou, 2018). Its role in reading comprehension is supported by studies of children (Wu et al., 2020), adolescents (Kieffer et al., 2021), and adults (Georgiou & Das, 2018). Regression analysis showed that these contributions were significant after controlling the effects of language comprehension and decoding skills, suggesting that they go beyond these core linguistic processes.

We find it interesting to observe a significant total mediation of vocabulary effects on text comprehension by VWM. This diverges from recent studies that reported indirect EF effects on adolescents' comprehension that were partially (Ober et al., 2019) or completely (Kieffer et al., 2021) mediated by verbal skills. The Active View of Reading (Duke & Cartwright, 2021) contemplates an indirect contribution of EFs to reading comprehension, mediated by their role in word recognition and language comprehension processes. Despite the vast evidence of a link between language and EF skills, the directionality of this relation throughout development has not been established yet (Shokrkon & Nicoladis, 2022). Therefore, we believe longitudinal studies examining the interplay between EFs and language would shed more light on their interaction in adolescents' reading comprehension.

Regarding the aim of comparing the specific contributions of EFs to expository and narrative text comprehension, our regression model did not provide sufficient evidence that these effects differed between texts, since Text Type × EF interactions were not significant. Different results were reported by Wu et al. (2020), who found that the EF contribution was mostly confined to expository text comprehension in children. While they worked with a smaller sample (n = 94), they also ran separate models for expository and narrative comprehension; therefore, they were unable to directly compare EF effects in each case. Since our null results are not conclusive, further research on larger samples is warranted to elucidate this particular question.

Unlike previous studies (Abusamra et al., 2020, Demagistri et al., 2014), we were unable to find significant associations of perceptual or response inhibition with adolescents' reading comprehension. This difference might stem from these studies employing a verbal inhibition task (the Hayling test) while we examined the suppression of non-verbal information. Previous works have pointed out that evidence of the contributions of inhibition processes to reading is mixed, probably due to the variability in the measures and the sub-components considered as well as a potential domain-specificity of the effects (Follmer & Sperling, 2018).

Altogether, our results may be considered in line with the Active View of Reading conceptualisation of the role of EFs in reading comprehension (Duke & Cartwright, 2021), although we did not find a significant contribution of inhibitory control processes. It is worth noting that this model considers Miyake's core processes as domain-general EFs, and proposes that language-specific EFs (such as verbal inhibition) and reading-specific EFs (such as graphophonological-semantic cognitive flexibility; Cartwright et al., 2020) might play a role in comprehension, beyond domain-general executive processes. This could be addressed in future studies.

We should point out some limitations in our study. While the sample size was adequate for multiple linear regression, a larger N would have allowed us to conduct more complex and complete analyses, such as structural equation modelling. The high proportion of girls, as well as the non-probabilistic nature of our sample, might hinder the generalisability of our results. Regarding our reading task, despite their popularity multiple-choice tests have been criticised as measures of reading comprehension, because multiple-choice items offer limited predetermined answers, tend to be easier that open-ended questions, can sometimes be answered without reading the corresponding text passages and might be examining different comprehension processes (Ozuru et al., 2007; Rauch & Hartig, 2010). Therefore, our findings would benefit from replications using open-ended reading comprehension tests. Regarding our EF measures, perceptual inhibition and VSWM tasks showed relatively low (though still acceptable, see Taber, 2018) Cronbach's alpha values. In addition, future studies might consider including more language-related EF tasks, such as a verbal inhibition task. Along the same line, other EF constructs (such as planning or self-monitoring) beyond Miyake's model might be explored. The contribution of the episodic buffer component of WM (Baddeley et al., 2021) might be particularly relevant to consider. Future studies might benefit from including measures of emotional and motivational factors relevant to reading experience (such as reading enjoyment or intrinsic motivation) and consider comparing the contribution of EFs to the reading comprehension of adolescents from diverse socioeconomic backgrounds.

To sum up, we found that comprehension of expository texts was more challenging among high school students and that VWM and shifting contributed to comprehension of both texts after controlling for verbal skills. These results might be considered by educators and educational psychologists in order to improve reading curricula by including efficient reading strategies or even EF interventions. In addition, we were surprised to find worse reading outcomes in older students, which might reflect the impact of social distancing on their high school trajectory during the years of the COVID-19 pandemic.

Data availability

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Compliance with ethical standards

Conflict of interest statement. All authors declare that they have no conflict of interest.

Funding. This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Ethical approval. All procedures performed in studies involving human participants were in accordance with the ethical standards of the CONICET research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent. Informed consent was obtained from the parents of all individual participants included in the study.

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