Associations between Reading Comprehension, Print Exposure, Executive Functions and Academic Achievement in Argentinean University Students

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Funding information: This study was part of the project "Relations between reading comprehension, language brain processing and academic performance in university students", carried out by the Psychology Research Program of the Faculty of Humanities and Economic Sciences, at the Pontificia Universidad Católica Argentina.

Conflict of interest: The authors declare that they have no conflicts of interest.

Resumen

La comprensión lectora es una habilidad cognitiva compleja de vital importancia para el éxito académico en todos los niveles educativos. La evidencia indica que involucra habilidades lingüísticas específicas, como la fluidez de lectura o el vocabulario, así como procesos cognitivos como las funciones ejecutivas. Adicionalmente, se ha observado que la frecuencia y magnitud de la lectura a lo largo de la vida puede estimular su desarrollo. La contribución relativa de estos factores ha sido escasamente estudiada, en particular en poblaciones hispanohablantes. El presente trabajo tuvo por objetivo analizar las relaciones entre comprensión de textos, hábitos de lectura y funcionamiento cognitivo, y su impacto en el rendimiento académico, en estudiantes universitarios. El rendimiento en la tarea de comprensión lectora fue el principal predictor del rendimiento académico, y se verificó su vínculo con la magnitud de exposición a textos de ficción y el inicio temprano en la lectura recreativa. Adicionalmente, el vocabulario y la fluencia fonológica (que evalúa el funcionamiento ejecutivo aplicado a la recuperación de información verbal) se asociaron significativamente a la comprensión de textos. Los resultados destacan la importancia de la comprensión de textos para el éxito académico en el nivel universitario y señalan el potencial de la lectura recreativa para estimularla.

Palabras clave: comprensión lectora, funciones ejecutivas, rendimiento académico, hábitos de lectura, Test de Reconocimiento de Autores.

Summary

Reading comprehension is a complex cognitive ability of crucial importance for academic achievement across all education levels. It has been shown to rely on specific linguistic abilities, like reading fluency and vocabulary, and cognitive processes such as executive functions. In addition, it has been observed that reading comprehension improves with reading frequency and the amount of lifelong exposure to texts. However, the contribution of these variables has seldom been examined simultaneously, particularly in Spanish speaking populations. The present study aimed to analyze the relationship between reading comprehension, reading habits and cognitive functioning, and their influence on academic achievement in Argentinean university students. Reading comprehension performance was the main predictor of academic success, and its main predictors were fiction exposure and an earlier beginning of leisure reading. Furthermore, vocabulary and phonological fluency (which evaluates executive functioning applied to verbal information recall) were significantly associated to reading comprehension. These results highlight the importance of reading comprehension for academic achievement at the university and show the potential of leisure reading to improve it.

Keywords: reading comprehension, executive functions, academic achievement, reading habits, Author Recognition Test.

Introduction

Reading comprehension is a complex and crucial cognitive ability for learning and academic achievement (Meneghetti et al., 2006; Royer et al., 1990). Perfetti and Stafura (2014) describe two influential cognitive models of reading comprehension: one concerning an enriched level of representation beyond the text literal meaning, the reader's situation model (Van Dijk & Kintsch, 1983), and the other considering the cognitive dynamics of reading comprehension, the construction-integration model (Kintsch, 1988). The emphasis of the first model is on the multiple representational levels that comprise the mental model of a text: 1) a superficial code of words and syntactic relations, 2) a propositional structure and 3) a situational model that represents the text and includes pragmatic, linguistic and world knowledge. The second model describes reading comprehension as an interactive combination of top-down (knowledge-driven) and bottom-up (word-based) processes. On the same line, Rumelhart's interactive model (1994, 2004) claims that reading is a bidirectional process where several sources of information (sensory, semantic, syntactic, pragmatic, etc.) interact during text recognition and comprehension. These interaction loops combine bottom-up decoding and lexical-semantic retrieval, and top-down predictions of upcoming words, based on previous context. According to Rumelhart, the most proficient comprehenders are those who can combine the available sources of information to recognize and process the text more efficiently. This claim can be considered congruent with neuroscience studies of predictive processing during language and reading comprehension (for a review, see Kuperberg, 2013). In addition to describing these models, Perfetti and Stafura (2014) integrate their hypotheses in a Reading Systems Framework, with a special focus

on the lexical component and its interaction with text representations. The rationale for the prominence of the lexical subsystem stems from the centrality of lexico-semantic representations as the output of word identification and the input to comprehension processes. In this sense, efficient access to lexical representations and efficient retrieval of word information (morphological, syntactic, semantic, etc.) contribute directly to comprehension. Two complementary hypothesis regarding comprehension proficiency can be derived from this view: more skilled comprehenders should be better at understanding individual words, integrating them to mental text models and acquiring information about word-forms and meanings from word-learning events (Perfetti & Stafura, 2014).

It has been shown that reading comprehension depends on more basic and intrinsically linguistic abilities, such as oral language comprehension and reading fluency (the ability of reading individual or text-embedded words in a fast and accurate way). Several studies of adolescents and young adults show that vocabulary knowledge plays a significant role in text comprehension (Braze et al., 2007; Cunningham et al., 1990; Lundquist, 2004; Ransby & Swanson, 2003; Yovanoff et al., 2005). In particular, a large-scale study showed that high level abilities, like vocabulary, were stronger predictors of reading comprehension than low level abilities (such as decoding and spelling) in adults (Landi, 2010). Regarding reading fluency, strong correlations with reading comprehension performance have been reported (Daane et al., 2005; Pinnell et al., 1995; Rasinski et al., 2005), and it has been proposed that low reading fluency increases cognitive demands on working memory, reducing information processing resources.

On the other hand, there is evidence that non-linguistic cognitive abilities, such as executive functions, are also involved in reading comprehension. The term “executive functions” (Graham et al., 2007; Lezak et al., 2012) is applied to a wide range of skills required for initiating and sustaining an independent goal-oriented behavior. These functions include: planning and execution control, attentional and inhibitory control, cognitive flexibility and working memory (Baddeley, 2012, Denckla, 1989; Miyake, Emerso & Friedman, 2000). A recent meta-analysis (Follmer, 2017) found a moderate association between text comprehension and executive functioning, and reported variations of this effect among its subcomponents. Several studies have found significant associations between the following executive processes and reading comprehension, in children, adolescents and adults: planning (Georgiou & Das, 2016), cognitive flexibility (Cartwright, 2007, Colé et al., 2014; Kieffer et al., 2013; Nouwens et al., 2016), inhibitory control (Borella et al., 2010) and working memory (see the following meta-analysis: Carretti et al., 2009; Daneman & Merikle, 1996). It has been proposed that larger verbal working memory facilitates comprehension by enabling simultaneous reading-related processes (decoding of unfamiliar words, semantic information retrieval, recall of recently read text and anticipation of upcoming words). This claim is congruent with the associations between verbal working memory and reading comprehension tasks have been observed in skilled and struggling readers (Carpenter & Just, 1988; Daneman & Carpenter, 1980; Swanson & Jerman, 2007).

Reading comprehension is also influenced by environmental factors, such as the access to reading materials and lifelong exposure to different kinds of texts. In particular, it has been observed that the magnitude of print exposure is associated to vocabulary (Frijters, Barron, & Brunello, 2000), verbal fluency (Stanovich & Cunningham, 1992) and reading comprehension (Cipielewski & Stanovich, 1992). A meta-analysis of a wide range of studies in children and university students found strong associations between objective print exposure measures and abilities like decoding, spelling and reading comprehension (Mol & Bus, 2011). On the same line, Landi (2010) found that print exposure was strongly associated with vocabulary and text comprehension, and that these three variables loaded into a common factor (which was independent from low level skills) in a principal component analysis. Therefore, these results indicate that lifelong exposure to texts is an important factor in reading comprehension development. It should be noted that the aforementioned studies have relied in a specific instrument to estimate lifelong print exposure to literature, the Author Recognition Test (ART) (Cunningham and Stanovich, 1990), a survey where subjects have to discriminate between real and foil fiction (or non-fiction) author names. This measure has been found more accurate and sensitive than conventional surveys about reading frequency and habits (Acheson et al., 2008; Marschark et al., 2012; Stanovich & Cunningham, 1992).

Since all education levels require reading and learning from expository texts, it would be expected that reading comprehension is associated with academic success (or failure). Quite in fact, it has been observed that reading comprehension performance is a good predictor of academic performance, both in the university (Royer et al., 1990) and in primary school (Meneghetti et al., 2006). A study conducted in Brazil found correlation coefficients ranging between 0.46 and 0.72 between reading comprehension and GPAs (grade point averages). At a local level, a regression analysis including reading comprehension, IQ and critical thinking ability showed that comprehension alone explained 40% of the GPA variance in middle and university level students (Difabio de Anglat, 2005). A later study (Difabio de Anglat, 2008) found a 0.51 correlation between performance in the comprehension of an academic text and the student's final grades in a university subject.

Considering the aforementioned results, we set out to study the contribution of print exposure, reading habits, linguistic and cognitive abilities to reading comprehension, and its association with academic performance. In order to assess text-level comprehension and inference making abilities, we chose a *cloze* task (Taylor, 1953). In a standard cloze task, subjects have to fill in the gaps in a text where one out of five words has been suppressed, inferring the missing words from all available sources of information (such as semantic, syntactic or pragmatic information, available from clause, proposition, sentence, passage or text levels, as well as their own knowledge on the topic) (Condemarín & Milicic, 1988; Difabio de Anglat, 2008). Cloze tasks have been recommended as valid measures of reading comprehension in adults (Alderson, 2000; Gellert &E**l**bro, 2012), and significant correlations have been found between cloze task and standard question-based reading

comprehension tests (Alderson, 2000; Yamashita, 2003, Sadeghi, 2010, Williams et al., 2011). In particular, cloze tests have been found to be sensitive to text integration and inference making beyond word decoding, vocabulary and single sentence comprehension (Gellert and Ebro, 2012). According to Yamashita (2003), cloze tasks are measuring *"language-related knowledge and abilities including syntactic or grammatical knowledge and both lower-level (e.g., clausal and sentential) and higher-level (e.g., intersentential and textual) reading comprehension"* (Yamashita, 2003). On the other hand, standard measures of reading comprehension rely on cloze procedures, such as the WJPC (Woodcock et al., 2001) (which requires completing the gap in a series of paragraphs), or the of the TLC ("Reading to comprehend") battery inferences subtest, developed for Spanish-speaking children in Argentina (Abusamra et al., 2010). In addition to being a suitable measure of text-level reading comprehension in adults, studies from Brasil (Olivera & Santos, 2006) and Argentina (DiFabio de Anglat, 2008) showed that cloze task performance was a significant predictor of academic achievement in university students. The work by DiFabio de Anglat (2008) provided a cloze task based on a text that was: 1) relevant to social sciences curricula (allowing to control for student's previous knowledge on the topic), 2) representative of the style, contents and difficulty of the academic literature our subjects were exposed to and 3) tested on a sample of students from the same city than our experiment participants. Therefore, we selected this specific version of the task for the present study.

Even though previous literature established the existence of links between reading comprehension, and linguistic abilities, executive functions and print exposure, the relative contributions of these three domains has never been considered simultaneously. In addition, the associations between recreational reading, text comprehension and executive functions have seldom been studied in adult Latin American populations. Furthermore, no study to date has analyzed print exposure with an ART specifically aimed to measure fiction reading in Spanish speaking samples. This lack of available evidence calls for further research, particular in the context of the current replication and reproducibility crisis that has been acknowledged in the field of psychology and social sciences in general (Rodgers & Shrout, 2018; Świątkowski & Dompnier, 2017). In the same line, cross-cultural replication requires instruments that are suitable to the target populations (Milfont & Klein, 2018). In order to address these issues, we included a previously validated ART task for Spanish speakers (Tabullo, et al., 2018), and compared it with a conventional reading habits survey, to see which one was more predictive of text comprehension and academic achievement. Regarding text comprehension, we also included a previously validated cloze task (Difabio de Anglat, 2008) that had been previously tested in a sample of local university students.

In sum, the objectives of the present work were: 1) to analyze the association between comprehension of an expository text from the social sciences curricula, objective and self-report measures of print exposure, language abilities (vocabulary and reading speed) and executive functioning (working memory, cognitive flexibility and verbal

fluency) in a sample of Argentinean psychology university students, 2) to analyze the relation between the aforementioned variables and academic achievement.

Methods

Participants

Participants (n = 95, 69 of them female) were psychology students from the Pontificial Catholic University in Mendoza, Argentina. Participant's ages ranged between 19 and 51 years old (*M* = 23.48, *SD* = 5.3 years). Participants were recruited from classes in the second (25.5%), third (22%), fourth (11%) and fifth (41.5%) year of the psychology career. While all subjects completed the first stage of the study, a subgroup of 31 (22 female, *M* = 24.3, *SD* = 7.2) completed an additional second stage, consisting on a cognitive evaluation.

None of the participants declared to have been previously diagnosed with: learning problems, dyslexia, neurologic or psychiatric disorders, nor were they taking medication at the time of the study. This information was collected in a survey before the first stage of the study. Their participation was voluntary and anonymous, and all of them signed an informed consent that described the study characteristics and aims, confidentiality of data and the possibility of leaving at any time, without consequence. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Instruments and measures

1. Reading comprehension: *cloze task*

Reading comprehension score was operationalized as the percentage of correct responses in a cloze task (Condemarí & Milicic, 1988; Taylor, 1953). Standard cloze procedures require readers to fill in the blanks coherently in a text where one of every five words has been suppressed. We adapted the test from a previous work (Difabio de Anglat, 2008), where it showed significant correlations with academic performance of local university students. The type of text was expository and its content (research designs) was part of the Research Methodology curricula (therefore, only those participants who took and completed this course were selected). In this way, we ensured that all participants shared similar background knowledge of the text content, since it was representative of the typical academic material the subjects are exposed to during their studies. The test contained a total of 60 gaps; therefore, the highest possible number of correct responses was 60. The task was group-administered to students in the classroom. Responses were considered correct if the participant provided the exact same word of the original text or a coherent synonym.

2. Self-reported Reading habits and print exposure measures

2.1. Ad hoc Reading habits survey

In order to assess the student's reading habits, we developed and ad hoc survey based on the Reading Habits Self Report (Acheson et al., 2008). Participants were asked about the time when they started reading recreationally (from parent-shared reading in their infancy to university), the number of books they have in their personal

library (except those required for work or study), the number of books did they finished in the last 6 months, and the typical weekly average of hours they spent reading the following materials (in a 0-7 hours or more likert scale): academic texts (study or work related), magazines, newspapers, web sites, e-mails, fiction and non-fiction texts.

2.2. Author Recognition Test (ART)

Despite the popularity of self-report measures to assess habits and attitudes towards reading, this kind of questionnaires is susceptible to social desirability biases, and to the subject's lack of accuracy to estimate the frequency of their own behaviors. The Author Recognition Test (ART) (Cunningham and Stanovich, 1990) was designed as an alternative, objective measure of print exposure. It consists on a list of authors, half of them actual fiction (or non-fiction) writer's names, half of them foils, which is given to the subjects with the instruction of marking only those names they recognize as writers (regardless of whether they read their work). This instrument has been validated as a useful measure of print exposure (Stanovich & Cunningham, 1992; West et al., 1993), and is a good predictor of a range of linguistic abilities (Mol & Bus, 2011). Since no Spanish version of ART was available at the time of the study, we administered one developed in our own lab and validated in a previous study (see Tabullo, Navas and García, 2018). Our ART consisted of 18 fiction writer names and 18 foils. The Real authors list included Literature Nobel prize winners (like Albert Camus, Haruki Murakami or Mario Vargas Llosa), recognized international English authors (like Ray Bradbury, Paul Auster or George Orwell), Spanish authors (Miguel Hernández, Arturo Pérez Reverte) and award winning or recognized (classic or contemporary) local authors (like Alejandra Pizarnik, Mario Benedetti or Manuel Puig). The 18 "foil" author names were selected from the editorial boards of several scientific journals, like IJPSY. A complete list of ART author names can be found in Appendix 1. ART scores were calculated as the number of author names identified correctly minus the number of foils marked as real authors. Internal consistency of our ART version was high for real (Cronbach's $\alpha = .880$) and false (Cronbach's $\alpha = .812$) authors, and similar to that reported in Mar et al. (2009).

3. Language assessment: Vocabulary and Reading speed

3.1. Vocabulary: WAIS IV vocabulary subtest

The WAIS IV intelligence scale vocabulary subtest (Wechsler, 2008) was used as an index of verbal IQ and vocabulary knowledge. The previous version of the WAIS (WAIS III) included vocabulary as one the verbal IQ subscales (Weschler, 1997), while in the most recent version, it has been added to the verbal comprehension factor. The adaptation study of WAIS IV to Chilean population (Rosas et al., 2014), has verified this factorial structure, and it has pointed out that Vocabulary has one of the highest factor loadings for verbal comprehension. While the reliability of the WAIS vocabulary subtest as an index of verbal intelligence has been highlighted since early versions of the scale (Feingold, 1982), it has also been widely applied to assess vocabulary performance (Verhaegen, 2003), and has been shown to correlate significantly with other specific language tests, such as the Peabody Picture Test (Dunn & Dunn, 1981), both in children and adolescents (Smith et al., 2005) and adults (Bell et al., 2001). In

this task, the subject is required to provide accurate definitions to increasingly difficult words. Task performance was operationalized as the total raw score, calculated according to WAIS IV instructions.

3.2. Reading speed

Reading speed (number of words correctly read aloud within a minute) is a widely used measure to evaluate reading fluency (Good & Kaminski, 2002; Wallot et al., 2014; Wiederholt & Bryant, 2001). In the current work, it was estimated by asking the subjects to read aloud a fragment from "The lottery in Babylon" from Jorge Luis Borges. The text reading difficult was considered "normal" (Flesch-Szigriszt index = 61,62) according to a scale designed to assess Spanish written texts readability (INFLESZ) (Barrio-Cantalejo et al., 2008). None of the subjects reported having read the text before the evaluation. Reading speed score was calculated as the total number of words of the fragment divided by total reading time, in minutes.

4. Executive functions

4.1. Cognitive flexibility: Trail making test B

Cognitive flexibility was assessed by Trail making test B (TMTB) (Arbuthnott & Frank, 2000; Tombaugh, 2004), a task that has been previously used in the study of executive functioning and reading comprehension (Nouwens et al., 2017). Trail making test A was also administered, in order to evaluate attention and processing speed. TMTA requires the subject to connect 25 randomly distribuited dots, as fast as possible and without mistakes. TMTB is similar, but the subjects have to alternate between the series of 1-11 numbers and the A-J alphabet letters (1, A, 2, B, 3, C…). Performance was operationalized as the total time to complete each task, in seconds.

4.2. Verbal working memory: Reading Span

Verbal working memory was evaluated using the Spanish version of reading span task (Elosúa et al., 1996; Gutiérrez et al., 1996), adapted to Argentina by Barreyro et al. (2009). In this task, subjects are required to read aloud increasingly larger series of sentences aloud and remember their last words, in order to repeat them at the end of each set. Similar to Barreyro et al. sentences were shown in a computer screen. A previous study showed that reading span scores were associated with reading comprehension performance among university students (Esquivel et al., 2016). Reading span score was calculated according to Barreyro et al. (2009). In addition, the total number of words recalled correctly during the task was considered.

4.3. Phonological and semantic verbal fluency

Phonological (Benton, 1968) and semantic (Newcombe, 1969) verbal fluency tasks have been extensively used to evaluated executive functioning (Lezak et al., 2012). It has been proposed that phonologic fluency tasks in particular involve cognitive flexibility subcomponent of executive functions (Abwender et al., 2001; Li et al., 2017), while others consider that the test recruits the whole set of executive functions (Piskunowicz et al., 2013). On the other hands, it has been pointed out that semantic fluency relies more heavily on automatic lexical access to semantic memory, while phonological fluency places greater demands on executive functions (Ardila et al., 2006). In addition, there is evidence that verbal fluency tasks are more closely related to language than other executive

functioning tests (Whiteside et al., 2015). In the current work, semantic fluency task consisted on naming as many animals as possible, while phonological fluency required naming words starting with the "p" letter, in both cases without repeating, mentioning word families and within a minute time limit (Butman et al., 2000). Performance was operationalized as total number of correct words within a minute, for each task.

5. Academic achievement: grade point average (GPA)

Participant's academic achievement was estimated through their grade point average (GPA). This measure has been previously included as an index of achievement in similar studies (Difabio de Anglat, 2008; Gutiérrez-Martínez et al., 2011; Oliveira & Santos, 2006), and is considered a sufficiently objective and representative measure of the student's typical performance, beyond the particular circumstances of evaluation contexts (Oliveira & Santos, 2006). In this study, GPA was calculated by adding up all accumulated final grades and dividing that figure by the number of grades awarded.

Procedure

The study was divided in two stages or sessions. The first one was conducted in a classroom setting, and it consisted on a presentation of informed consent and administration of reading habits survey, ART and cloze task. In the second session, conducted individually, subjects completed the language and executive function evaluation in a pencil and paper format (except for the computerized reading span task).

Statistical Analysis

Associations between reading comprehension scores, academic achievement, reading habits and print exposure were analyzed by Pearson correlations and hierarchical lineal regression models. Due to limited simple size (31 from the original 94 subjects), associations between executive functions, language measures, reading comprehension and academic performance were analyzed with Pearson correlations and partial correlations only. Non-parametric correlations were also calculated, in order to verify the observed effects. Data analysis was carried out on SPSS 25.0 software.

Results

1. Reading comprehension, print exposure, reading habits and academic achievement: descriptive statistics.

Table 1 describes the results of the cloze task, ART and reading habits survey in detail. Participant's mean percentage of correct responses in the cloze task was 64.8 (*SD* = 19.64). According to González Moreyra (1998) criteria, reading comprehension scores were classified as following: 37.89% of participants showed an *independent* reading level (*excellent: 6.32%, good: 31.57%*), while 40% exhibited a *dependent* level (*instructional: 29.47%*, *with difficulties*: 10.53%) and 22.11% belonged to the *deficit* level (*bad:* 17%, *worst:* 4.21%). On the other hand, ART performance was considerably low, with 89.5% of the subjects scoring below 9 (over a maximum of 18) (*Mdn* = 2, *IQR* = 5). Finally, participant's GPA was 7.08, *SD* = 1.35 (range: 2.79-9.50).

Table 1

Reading habits survey, ART scores and cloze task performance

Variable	Result (N = 95)
Begining of recreational reading	Infancy: 33.7% Primary School: 24,2% Secondary School: 27.4% University: 12.6% No recreational reading.: 2.1%
Personal library size	Med: 30 (65)
Books read in the last 6 moths	Med: 2 (3)
Typical weekly Reading average	
Academic texts	Med: 5 (3)
Magazines	Med: 1 (2)
Newspapers	Med: 2 (2)
E-mail	Med: 1 (1)
Web sites	Med: 4 (3)
Fiction	Med: 2 (2)
Non-fiction	1 (2)
ART score	2 (5)
Cloze task score	64,8 ± 19,64 %

Note. Medians and interquartile ranges are reported for ordinal variables (and non-normal distributions), means and standard deviations are reported for normally distributed continuous variables.

2. *Associations between reading comprehension, print exposure, reading habits and academic achievement.*

2.1. Bivariate correlations

Table 2 shows Pearson correlation coefficients between self-report reading measures, cloze task and ART scores. The following significant associations were observed:

- Cloze task scores were moderately associated with ART scores (r = 0.452, p < 0.001), and inversely correlated with beginning of recreational reading (r = -0.276; p = 0.007).
- Cloze task scores showed the highest association with academic achievement (r = 0.581, p < 0,001). Significant correlations were also observed between GPA and: ART scores (r = 0.413; p < 0.001), books read in the last 6 months r = 0.263, p = 0.010) and self-reported academic text reading times (r = 0.203; p = 0.049).
- ART scores showed weak, but significant correlations with other self-report reading measures, such as beginning of recreational reading (r = -0.241; p = 0.019), library size (r = 0.243, p = 0.018) and books read in the last 6 months (r = 0.287, p = 0.005). Surprisingly, self-reported fiction (or non-fiction) reading times were not correlated with ART.

Table 2

Bivariate correlations between self-report reading measures, ART, cloze task and GPA scores

	Age	Year	Begin	Lsize	B6m	Acad.	Mag.	News.	Email	Web	Fiction	Nfiction	TRA	Cloze	GPA
Age	1.000														
Year	0.115	1.000													
Begin	0.007	-0.075	1.000												
Lsize	0.087	0.045	-0.221	1.000											
B6m	-0.004	0.066	-0.250	0.275	1.000										
Acad.	0.033	-0.045	-0.078	0.069	0.206	1.000									
Mag.	-0.049	0.154	0.155	-0.108	-0.175	0.204	1.000								
News.	0.074	0.232	0.071	0.081	0.022	0.284	0.505	1.000							
email	0.129	0.237	-0.014	0.039	-0.028	0.356	0.316	0.345	1.000						
Web	-0.043	0.129	0.007	-0.090	-0.077	0.235	0.293	0.276	0.306	1.000					
Fiction	-0.113	0.067	-0.195	0.012	0.523	0.211	0.136	-0.020	0.066	0.098	1.000				
Nfiction	0.049	0.102	-0.212	0.179	0.254	0.269	0.299	0.293	0.173	0.089	0.140	1.000			
TRA	**0.287***	0.087	**-0.241***	**0.243***	**0.287***	0.099	-0.130	-0.082	-0.098	-0.030	0.129	0.024	1.000		
Cloze	0.037	**0.246***	**-0.276****	0.156	0.177	0.106	-0.154	0.021	-0.023	0.067	0.055	0.112	**0.452****	1.000	
GPA	0.168	**0.345***	-0.117	0.106	**0.263***	**0.203***	-0.089	-0.035	0.054	0.079	-0.090	0.060	**0.413****	**0.581****	1.000

Note. Pearson correlations are reported. Significant correlations appear in bold. *Begin:* benning of recreational reading in life. *Lsize*: personal library size. *B6m:* number of books read in the last 6 months. Acad: weekly average of academic text reading hours. Mag.: weekly average of magazine reading hours. *News.*: weekly average of newspaper reading hours. *Web*: weekly average of web site reading hours. *Fiction*: weekly average of fiction reading hours. *Nfiction*: weekly average of non-fiction reading hours. *ART*: author recognition test scores. *Cloze*: percentage of correct responses in the cloze task. *GPA*: grade point average. $p < 0.05$; **$p < 0.001$.

2.1.1. Associations with Sociodemographic variables

Pearson correlation analysis showed weak, but significant associations between age and ART ($r = 0.287$; $p = 0.005$) and career year and: GPA ($r = 0.345$, $p = 0.001$), cloze task score ($r = 0.246$, $p = 0.016$). Regarding sex, men exhibited higher reading comprehension scores ($T(93) = 2,191$, $p = 0,031$), while no significant differences were observed in ART scores.

2.2. Hierarchical linear regression models

2.2.1. Reading comprehension

In order to determine the best predictors of reading comprehension performance, associations between self-report measures, ART and cloze task scores were analyzed by a hierarchical linear regression model. In the first block, sociodemographic control variables were included (age, sex and career year). In the second block, ART scores and self-report measures were included.

The first block of the model reached statistical significance (see Table 3) and indicated significant effects of sex ($\beta = -0.219$, $p = 0.03$) and career year ($\beta = 0.241$, $p = 0.018$). Including ART and self-report reading measures in block 2 lead to a significant increase of explained variance ($R^2 = 0.340$, $p < 0.001$; $\Delta R^2 = 0.231$, $p = 0.001$). ART score was the best predictor of cloze task performance ($\beta = 0.388$, $p < 0.001$), while beginning of recreational reading was the only additional significant predictor ($\beta = -0.148$, $p = 0.046$). Results of the regression model are detailed in Table 3.

Table 3

Hierarchical linear regression model of cloze task scores

Block	Variable	*B*	*SE*	*B std*	T
1	Age	0,065	0,369	0.017	0,173
	Sex	**-9,576**	**4,342**	**-0,219**	**-2,206***
R^2 = 0.108	**Career year**	**3,544**	**1,465**	**0,241**	**2,418***
R^2 (corr.) = 0.079					
F (3,91) = 3.69*					
2	Age	-0,362	0,350	-0,098	-1.033
	Sex	**-9,913**	**4,148**	**-0,226**	**-2,390***
R^2 = 0,339	**Career year**	-3,154	**1,316**	**0,215**	**2,396***
R^2 (corr.) = 0.269	**Begin**	**-3,217**	**1,587**	**-0,193**	**-2,026***
ΔR^2 = 0.231**	Lsize	-0,009	0,030	-0,028	-0,288
F(9, 85) = 4.852**	B6m	0,152	0,933	0,018	0,163
	Fiction	-0,472	1,029	-0,50	-0,459
	Acad	1,178	0,893	0,123	1,319
	ART	**2,318**	**0,546**	**0,392**	**3,913****

Note. Begin: benning of recreational reading in life. Lsize: personal library size. B6m: number of books read in the last 6 months. Fiction: weekly average of fiction reading. Acad: weekly average of academic text reading hours. ART: author recognition test scores.
*p < 0.05. **p < 0.001.

2.2.2. Academic achievement

Associations between GPA, cloze task performance, ART scores and self-report reading measures were analyzed through a hierarchical linear regression model. The first block included cloze task performance and sociodemographic variables as predictors, and the second added ART, books read in the last 6 months, and weekly average reading of academic texts. The objective of this analysis was to identify any variables that might explain an additional portion of GPA variance besides the one associated with reading comprehension.

The first block of the model turned out significant and verified the expected correlation between GPA and reading comprehension (β = 0.528, p < 0.001). Career year was the only additional predictor (β = 0.200, p = 0.021). The second block led to a small, but significant increase of explained variance (R^2 = 0.450, p < 0.001; ΔR^2 = 0.054, p = 0.043). However, none of the individual predictors reached statistic significance. Results of this model are detailed in Table 4.

Table 4

Hierarchical linear regression model of GPA. Cloze: percentage of correct responses in cloze task

Block	Variable	*B*	*SE*	*B* std	*T*
1	Age	0.032	0.021	0.125	1.516
	Sex	0.010	0.254	0.003	0.040
R^2 = 0.396	**Career year**	**0.203**	**0.086**	**0.200**	**2.356***
R^2 (correg.) = 0.370	**Cloze**	**0.036**	**0.006**	**0.528**	**6.086****
F(4,90) = 14.778**					
2	Age	0.022	0.022	0.088	1.036
	Sex	-0.125	0.255	-0.041	-0.491
R^2 = 0.450	**Career year**	**0.220**	**0.084**	**0.218**	**2.2617***
R^2 (correg.) = 0.406	**Cloze**	**0.029**	**0.007**	**0.423**	**4.427****
ΔR^2 = 0.054*	B6M	0.063	0.049	0.110	1.298
F(7, 87) = 10.174**	Acad	0.091	0.056	0.138	1.640
	ART	0.048	0.036	0.128	1.325

Note. Cloze: Percentage of correct responses in the cloze task. B6m: number of books read in the last 6 months. Acad: weekly average of academic text reading hours. ART: author recognition test scores.
*p < 0.05. **p < 0.001.

3. *Associations between academic achievement, Reading comprehension, language and executive function measures*

Results of language and executive function evaluation are detailed in Table 5. Pearson correlations between academic achievement, reading comprehension and print exposure are detailed in Table 6. Significant associations were observed between cloze task performance and vocabulary scores (r = 0.506, p = 0.004) and phonologic fluency (r = 0.413, p = 0.021). On the other hand, the expected correlation between working memory and reading comprehension was not observed. Regarding academic achievement, significant associations were found with vocabulary (r = 0.470, p = 0.008) and verbal working memory (reading span: r = 0.375, p = 0.038; number of correctly remembered words showed a tendency: r = 0.344, p = 0.058). A non-parametric replication of these results, using spearman's rho coefficients, can be found in Appendix 2.

Partial correlation analysis showed that the association between vocabulary and GPA was completely mediated by the common association with cloze task scores (r = 0.188, p = 0.320; controlling for reading comprehension), while the GPA – cloze task correlation remained significant after controlling for vocabulary (r = 0.618, p < 0.001). Finally, ART scores were significantly correlated with vocabulary (r = 0.512, p = 0.003), and partial correlations controlling for vocabulary showed that the relation between ART and reading

comprehension was completely mediated by this variable (r = 0.291, p = 0.119).

Table 5

Language and executive functions scores

Variable	Result (N = 31)
WAIS Vocabulary	30.03 ± 7.66
Reading speed (words per minute)	148.48 ± 19.38
TMTA	24.93 ± 7.7
TMTB	52.03 ± 19.48
Reading span – score	3.04 ± 0.62
Reading span – words	24.03 ± 7.51
Verbal fluency – semantic	22.48 ± 4.58
Verbal fluency – phonological	17.8 ± 4.27

Note. TMTA: Trail making test A score. TMTB: Trail making test B score. Reading span - words: words recalled correctly during the task.

Table 6

Bivariate correlations between academic achievement, reading comprehension, language measures

	Age	Year	Rspeed	Vocab	TMTA	TMTB	RSrank	RSword	Semflu	Phoflu	ART	Cloze	GPA
Age	1.000												
Year	0.023	1.000											
Rspeed	-0.337	-0.154	1.000										
Vocab	**0.493****	0.366	0.092	1.000									
TMTA	0.287	-0.157	-0.229	0.040	1.000								
TMTB	0.198	-0.147	-0.302	-0.003	0.744	1.000							
RSrank	0.119	0.027	0.177	0.265	-0.037	-0.014	1.000						
RSword	0.180	**0.426***	0.097	0.480	0.056	-0.054	0.739	1.000					
Semflu	-0.145	0.154	0.057	-0.030	-0.231	-0.051	-0.055	-0.124	1.000				
Fonflu	0.089	**0.411***	0.032	0.166	0.173	0.072	-0.090	0.054	0.290	1.000			
ART	0.232	-0.012	-0.035	**0.512****	0.064	-0.029	0.015	-0.035	0.209	0.080	1.000		
Cloze	-0.038	0.422	0.157	**0.506****	-0.029	0.045	0.174	0.205	0.109	**0.413***	0.475	1.000	
GPA	0.128	0.152	0.093	**0.470****	-0.025	-0.073	**0.375***	0.344	-0.179	0.153	**0.455***	**0.676****	1.000

*Note***.** Reading scores, ART scores, GPA and executive function measures. Significant correlations are shown in bold. Rspeed: reading speed (words per minute), Vocab: WAIS vocabulary score. TMTA: Trail making test A score. TMTB: Trail making test B score. RSrank: reading span, maximum correctly recorded set size. RSword: reading span, number of correctly rememberd words throughout the task. Semflu: semantic fluency score. Phoflu: phonological fluency score. ART: author recognition test scores. Cloze: percentage of correct responses in the cloze task. GPA: grade point average.
*p < 0.05. **p < 0.001.

3.1. Associations with sociodemographic variables

Subject's age was significantly associated with WAIS vocabulary scores (r = 0.493; p =0.005), while career year correlated with: number of correctly remembered words in the reading span (r = 0.426, p = 0.017) and phonological fluency (r = 0.411, p = 0.022). No significant effects of sex were observed.

Discussion

The present work is the first to analyze and compare the effects of reading habits, print exposure and cognitive functioning over reading comprehension, and their associations with academic achievement, in adult Argentinean university students. Our findings verified the previously observed association between reading comprehension and GPAs. Furthermore, regression models indicated that the magnitude of print exposure, as indexed by ART, and an early beginning of recreational reading in life, were the strongest predictors of cloze task performance. Regarding language and cognitive abilities, reading comprehension was significantly associated with verbal intelligence and phonological fluency, and completely mediated the correlation between verbal intelligence and academic achievement. In addition, an independent association between verbal working memory and academic achievement was observed. These results are discussed in detail in the following sections.

1. Reading comprehension, print exposure and academic achievement

Correlation analysis and regression models suggested a significant link between lifelong fiction print exposure (indexed by ART) and comprehension of an informative text relevant to the Psychology curriculum (indexed by a locally validated cloze task - Difabio de Anglat, 2008). This result is congruent with several studies showing that the amount and type of reading exposure through life is associated with cognitive performance (and language ability, in particular), with these effects being observable both in children and adults (Landi, 2010, Mol & Bus, 2011). A meta-analysis that included 99 studies (Mol & Bus, 2011) of children and university students found strong to moderate correlations between print exposure and all their outcome measures of reading comprehension, technical reading and spelling. In addition, moderate associations between print exposure and academic performance indicated that more frequent readers were the most successful students. The authors interpreted this pattern of results in terms of a spiral of causality, where more proficient comprehenders and decoders read more, and the stimulation stemming from their print exposure leads to better comprehension and technical reading skills. It has been previously shown that early contact with reading material stimulates language and reading development (Fletcher & Reese, 2005). As a consequence, individual differences in reading abilities tend to increase over time, since more skilled readers choose to read more books, and more frequent readers exhibit better comprehension and technical reading and spelling performance (Bast & Reitsma, 1998; Cunningham et al., 1994). This interpretation can be applied to our results as well: print exposure (ART) was higher in those subjects with earlier

beginning of recreational reading in life, and this factor was the only additional predictor of reading comprehension scores (besides ART).

It should be noted that ART scores were the best predictors of reading comprehension, even though the cloze task presents an informative text, while ART was designed to assess exposure to narrative fiction texts. A possible explanation is that, contrary to textbooks, fiction print exposure is an indicator of independent leisure reading (particularly in early stages of development), since it represents a freely chosen behavior and distinguishes the frequent and motivated readers better (Mol & Bus, 2011). On the other hand, it has been proposed that narrative texts have greater potential than expositive texts to stimulate imagination, and readers find them more attractive and emotionally engaging. This would lead to a higher motivation in readers, and stronger consolidation and extension of word knowledge (Hakemulder, 2000; Harding, 1962; Mar, 2004). In order to verify this advantage of fiction texts, future studies should compare the association between objective measures of fiction and non-fiction exposure with university-level text comprehension.

The lack of correlations between self-report reading habits and reading comprehension is congruent with Stanovich and West (1989) claim that surveys are inaccurate and less reliable indicators of print exposure. Previous studies have found low or null associations between reading frequency surveys and text comprehension or verbal ability measures (Acheson et al., 2008; Marschark et al., 2012; Stanovich & Cunningham, 1992). Several factors might be responsible for this: dishonest responses regarding reading times due to social desirability, subject's inability to estimate the frequency and duration of their behavior or the fact that, in poor readers, reading times are more indicative of reading difficulties than of print exposure (Acheson et al., 2008). While we did not observe associations between ART and self-report reading frequencies, we did find weak correlations with other self-report variables like library size, books read in the last 6 months, and beginning of recreational reading in life. On the other hand, the regression model indicated that only ART and beginning of leisure reading were significant predictors of reading comprehension.

The fact that better comprehenders were also the most successful students in our study in congruent with previous findings at university (Royer et al., 1990), elementary (Meneghetti et al., 2006) and high school (Gutiérrez-Martínez et al., 2011) settings. This association makes sense, since every university career requires reading and learning from expositive texts. The correlation magnitude and explained variance we observed (r = 0.581 y r^2 = 0.338) were similar to the ones reported in other regional and local studies. A national study in Argentina found that reading comprehension explained 40% of the grade variance (Difabio de Anglat, 2005), while another study conducted in Brazil with a cloze task obtained correlations between 0.46 and 0.72 (depending on the subjects career and age-range). The same cloze task from our study obtained a correlation of r = 0.51 with student's grades in the "Research methodology" subject. Beyond the intrinsic importance of reading comprehension to learn from expository texts, it has been proposed that both academic tests and reading comprehension

tasks involve a common crystallized intelligence component, reflecting efficient long-term memory access and recall of complex semantic level representations (Gutiérrez-Martínez et al., 2011).

Our findings are consistent with previous studies that analyzed the link between print exposure and academic achievement. Mol and Bus (2011) meta-analysis found a moderate effect of ART scores and academic achievement (measured by standard tests like in university students *Scholastic Assessment Test* [SAT] o American College Testing [ACT]). A study that compared the association of self-report and objective measures of reading frequency with verbal ACT scores showed that ART was more correlated with academic performance than subjective measures (Acheson et al., 2008). Another work obtained similar results using a Title Recognition Test (similar to ART, but with book titles instead of authors) in university hypoacusis and normal hearing students (Marschark et al., 2012). In addition, the study found that print exposure tests were better predictors of academic performance in hypoacusis subjects. The authors concluded that hypoacusis students learn from reading than from personal interaction in classes. Our own results also indicated an association between ART and GPA, although it was completely mediated by the common correlation with reading comprehension. This was expected, since leisure fiction reading may contribute to academic learning by improving the subject's ability to comprehend texts in general. On the other hand, and in the same line of previously published findings, we did not observe strong associations between self-reported reading times and GPA. Even though we found significant correlations with the number of books finished in the last 6 months and the weekly average of study hours, the regression model indicated that these variables did not contribute significantly to explain the variance in academic performance.

1.1. Vocabulary, reading speed, reading comprehension and academic achievement

Within the subgroup of subjects that completed the language and cognitive evaluation, the WAIS IV vocabulary subtest was significantly correlated with reading comprehension (and through it, with academic performance), and completely mediated the association between ART and reading comprehension. These results suggest: 1) that the participant's vocabulary contributed to their reading comprehension, therefore improving their academic performance, 2) that fiction print exposure increased the subject's lexico-semantic knowledge (or facilitated lexical-semantic access / processing), therefore enhancing their reading comprehension.

The WAIS scale vocabulary subtest can be used as an indicator of participant's vocabulary performance (for instance, in children: Smith et al., 2005 and adults see: Bell et al., 2001). In this sense, the observed association between this subtest and cloze task scores is congruent with previous literature (Braze et al., 2007; Cunningham et al., 1990; Lundquist, 2004; Quinn et al., 2015; Ransby & Swanson, 2003). In addition, this association can be interpreted in terms of the lexical quality hypothesis (Perfetti & Hart, 2002), which states that the richness of orthographic, phonological, syntactic and semantic information of words, and their integration with lexical representations, facilitates lexical access and processing during

reading comprehension. Consequently, reading comprehension skill relies heavily on word knowledge and the ease and readiness of lexica-semantic retrieval, which is directly related to performance in vocabulary tests.

On their meta-analysis, Mol and Bus (2011) claim that reading skill is decreasingly influenced by technical reading skills and becomes increasingly dependent on vocabulary, world knowledge and intelligence, throughout development. Other studies showed progressive dissociations in high (reading comprehension, vocabulary) and low (spelling and decoding) linguistic skills through development. Comparisons of children and adults (Perfetti & Hart, 2001) indicate that the association between reading comprehension and low level skills depends on age and reading proficiency, being more prominent for children and less skilled adult readers. On the same line, a study that compared the contribution of high and low linguistic skills to reading comprehension in adults (Landi, 2010), found that high level skills (vocabulary and print exposure) were the best predictors of reading comprehension among the subjects. In addition, principal component analysis showed that reading comprehension, vocabulary and ART scores loaded to the same factor, which was independent of the one including spelling and decoding measures.

Regarding the association between vocabulary scores and academic achievement, the fact that this correlation was completely mediated by the common link with reading comprehension could be and indicator that the cloze task reflects the reading comprehension processes that are required for successful academic testing. In this sense, cloze tasks have been described as sensitive to text integration and inferences beyond word decoding, vocabulary and single sentence comprehension (Gellert and Ebro, 2012), measuring “language-related knowledge and abilities including syntactic or grammatical knowledge and both lower-level (e.g., clausal and sentential) and higher-level (e.g., intersentential and textual) reading comprehension” (Yamashita, 2003). Therefore, we may conclude that vocabulary contributes to academic achievement by enhancing reading comprehension. On the other hand, we should point out that our low sample size diminishes the generalizability of our results, and calls for a replication on a larger sample.

It should be noted that both vocabulary and cloze tasks involve, as Gutiérrez-Martínezz, Ramos and Vila (2011) suggest, a common “crystallized” intelligence component, reflecting the efficiency in semantic memory access and retrieval. Quite in fact, the very definition of crystallized and verbal intelligence (one of the two components of general intelligence or IQ, the other being fluid intelligence or performance IQ) comprises the abilities of vocabulary, reading comprehension (Carroll, 1993; McGrew, 2009) and in some cases, cloze ability (Carroll, 1993; Horn & Blackson, 2005; Scheider & McGrew, 2012; cited in Baghaei & Tabatabaee, 2015). Bearing this in mind, a correlation between a cloze task and a typical verbal intelligence measure such as WAIS vocabulary would be highly expected. Future studies might benefit from including non-verbal measures of intelligence (such as the Raven’s matrices test) in order to compare its contribution to reading comprehension performance.

We found the absence of significant correlations between reading speed, reading comprehension and cognitive functioning surprising. On the other hand, mixed results have been reported on this matter: some studies indicate a significant association between reading speed and comprehension (Fuchs et al., 2001; Perfetti et al., 2005; Stanovich, 2000) while others found low or null correlations nulas (Grabe, 2009; Kuhn & Stahl, 2003). A meta-analysis from the US National Reading Panel found moderate effects of reading fluency on comprehension (NICHD, 2000). Some authors argue that its influence on reading comprehension diminishes with age (Jenkins & Jewell 1993, Schwanenflugel et al., 2006), as is the case with other low level linguistic abilities. In addition, it has been proposed that the relation between reading speed and comprehension is modulated by multiple factors, including: age, motivation, reading proficiency and reading strategy, among others (Miyata et al., 2012). The lack of correlations we observed may be due to the fact that we focused on a "words per minute" measure of speed (an index that is widely used, but might be problematic according to Wallot et al. (2014), without considering processes like the comprehension-speed trade-off in reading aloud tasks, accuracy or prosody during reading. A considerations of *reading fluency*, defined as the ability to read in a "fast, accurate and expressively appropriate way" (National Institute of Child Health and Human Development [NICHD], 2000, p. 3-5) instead of pure *speed*, might shed more light on the link between this ability and text comprehension in university students, on future studies.

1.2. Executive function, reading comprehension and academic achievement

From all our executive function measures, only one was significantly associated with cloze task performance: phonological verbal fluency. This result is congruent with a series of studies showing that cognitive flexibility in the manipulation of verbal materials constitutes a significant predictor of reading comprehension, beyond verbal ability and decoding, in: early childhood (Cartwright et al., 2010), middle childhood (Cartwright, 2002) and adults (Cartwright, 2007). Other studies have found associations between reading comprehension in children and different cognitive flexibility tasks, such as Wisnconsin Card Sorting Test (Kieffer, et al., 2013) and Trail Making Test B (Nouwens et al., 2017). Furthermore, a study that compared cognitive flexibility in word and picture tasks found that verbal cognitive flexibility was a better predictor of children text comprehension, while controlling for decoding and word reading (Colé, et al., 2014). It has been proposed that cognitive flexibility is important to establish cross-modal connections between oral and written language, and to acquire and coordinate multiple text features (phonology, morphology, syntax and semantics) during reading acquisition (Berninger & Nagy, 2008). On the same line, Cartwright (2002, 2007) suggests that this ability is involved in the simultaneous processing of phonological code and semantic information during text comprehension. According to Nouwens et al. (2016), the link between cognitive flexibility and reading comprehension can be attributed to several factors: recall of multiple mental representations from the

lexicon and long-term memory (Cartwright, 2008), adaptation of active text representations to novel information (Diamond, 2013), or changes in reading strategy based on current goals and text difficulty (Ramsel & Grabe, 1983).

Verbal fluency tasks evaluate executive control of linguistic knowledge retrieval from long term memory, since they require coordination of verbal working memory, attention, cognitive flexibility, self-monitoring (to avoid repetitions) and processing speed Piskunowicz et al., 2013). On the other hand, since phonological fluency depends on the ability to switch between semantic categories more than semantic fluency, it constitutes a more accurate index of executive processing (Ardila et al., 2006). This might be the reason why we only found significant associations between reading comprehension and the phonological version of the task. In addition, there is evidence to suggest that verbal fluency tasks are more closely related with language that other executive function tests (Whiteside et al., 2015), which would explained why we failed to find associations with the other cognitive flexibility measure, TMTB in our adult sample. It should be noted, however, that this effect was actually observed in children (Nouwens et al., 2017).

A close consideration of the cloze task indicates that verbal cognitive flexibility seems to be directly involved in its resolution. Condemarín and Milicic (1988) claim that gap completion depends on the interaction between inferential top-down (predictions based on topic, language and text redundancy) and bottom-up (detection of specific text cues for confirming of rejecting hypothesis about possible target words) processes. In this sense, the tests capture and reflects the kind of prediction and hypothesis testing processes that take place during reading and language processing (Kuperberg, 2013). Cognitive flexibility is required for these predictive processes in order to switch between several sources of information (semantic, syntactic, topic and world knowledge) to infer potential target words, and in order to alternate between different word candidates as subjects move along the text and find evidence to confirm or disconfirm their hypothesis.

The lack of correlation between working memory and reading comprehension performance was surprising, since their link is widely documented in previous literature (for a meta-analysis, see Carretti et al., 2009; Daneman & Merikle, 1996). In particular, it has been proposed that the capacity to sustain active information in working memory is crucial to inference making (Barreyro et al., 2017; Kendeou et al., 2014), and to generate and update text representations during reading (Cain, 2006). Furthermore, significant associations between reading comprehension and the Spanish version of the reading span task have been reported (Elosúa et al., 1996; Gutiérrez et al., 1996), and specifically with cloze task performance (Esquivel et al., 2016). It should be noted that the authors of this work concluded that the link between cloze task and reading span performance should be considered with caution, since it varies considerably according to age, sex, and subject's proficiency in both tasks. In addition, they claim that the task of remembering unrelated final words from sentences might be more mnemonic than operative, and therefore it would be less representative of the kind of semantic processes involved in the cloze task. In this sense, they proposed a reasoning span

task, where subjects are required to make analogy-based inferences, as an alternative (Gutiérrez-Martínez et al., 2005). On the other hand, a study that analyzed reading and reasoning span tasks contribution to reading comprehension found no correlations between them, in adolescents (Gutiérrez-Martínez et al., 2011). The authors suggested that reading comprehension might be more dependent on crystallized intelligence, while both working memory tasks loaded heavily on fluid intelligence. Finally, a study with an oral version of the reading span failed to find effects on reading comprehension after controlling for vocabulary and decoding (Braze et al., 2007).

While we failed to observe associations between text comprehension and working memory, we did find a weak but significant effect of the latter on academic achievement. This result is congruent with several studies that identified working memory as a significant predictor of school performance in children and adolescents (García-Madruga & Fernández-Corte, 2008; Gathercole et al.; for a review, see Friso-van den Bos et al., 2013). A recent longitudinal study (Schneider & Niklas, 2017) followed 200 subjects from 6 to 23 years and found that general intelligence and working memory were significant predictors of academic achievement, although the effect of intelligence was stronger throughout development. Our results seem to fit into this pattern, since we observed a higher and more significant correlation between a verbal intelligence test (vocabulary) and student's GPAs. On the other hand, the presence of a link between verbal working memory and academic achievement that is independent of reading comprehension might be considered as consistent with Gutiérrez-Martínez et al. (2011) claims, since it indicates the specific contribution of an executive attention task dissociated from the kind of semantic representation and integration processes involved in reading comprehension. It should be noted, however, that our small sample size limits the reach and significance of these findings, and require replication in a larger sampler for verification.

2. Limitations of the present study

The main limitation of the current study is its limited sample, particularly in the case of executive function assessment. Expanding sample size would increase the robustness and representativity of our findings. In addition, it would allow for further testing and better understanding of potential mediation effects. In the same line, participant's sex was heavily biased towards females, since women represented 72.63% of the sample. Therefore, our results and conclusions on this matter should be regarded as preliminary. This analysis should be repeated on a larger and more evenly distributed sample of male and female students.

Another kind of limitation is that potentially relevant variables, like personality measures, were not considered in the individual assessment. Other executive functions, like planning (Georgiou & Das, 2016) or inhibitory control (Borella et al., 2010) might have shown associations with cloze task performance. In addition, personality measures, like "conscientousness" have been linked to academic achievement (Conrad & Patry, 2012). An objective measure of exposure to non-fiction tests, which might have allowed comparing its contribution to informative text

comprehension with fiction exposure, was also lacking. Finally, it may be argued that GPA does not constitute a sufficiently representative measure of academic achievement (Difabio de Anglat, 2008). Nevertheless, this variable has been previously chosen as an index of academic performance in several similar works (Difabio de Anglat, 2008; Gutiérrez-Martínez et al., 2011; Oliveira & Santos, 2006), and is considered a reliable estimator beyond particular circumstances of students testing (Oliveira & Santos, 2006).

In sum, future works would benefit from an increased sample size (and a more balanced proportion of male and female students), considering additional executive function components, relevant personality measures and objective measures of non-fiction print-exposure.

Conclusion

Our results suggest that comprehension of an informative text by university students: 1) is a good predictor of academic performance, 2) is significantly associated with lifelong print exposure and early beginning of recreational reading, 3) is strongly associated to vocabulary and flexible access to lexical-semantic memory systems. In addition, verbal working memory was the only independent additional predictor of academic performance. These results highlight the importance of reading comprehension for academic success in the university and the potential of leisure reading to increase this ability. In addition, our results constitute the first simultaneous replication of previous findings regarding the link between print exposure, executive functions and text comprehension in a Spanish speaking, adult, Latin American sample.

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Appendix 1

Author Recognition Test

Author names	Foil names
Albert Camus	Thomas J Carev
Alejandra Pizarnik	Nélida Cornejo
Arturo Pérez Reverte	Steve Graham
George Orwell	Guillermo Vallejo Seco
Haruki Murakami	Michael Dougher
Herman Hesse	Fernando Cuetos
José Saramago	Eduardo Fonseca
Manuel Puig	Perry Fuchs
Mario Benedetti	Leandro Almeida
Mario Vargas Llosa	Robert Flynn
Miguel Hernández	Milagros Gallo
Milan Kundera	Ana Delgado
Paul Auster	Amaia Bravo
Ray Bradbury	Stephen Higgins
Ricardo Piglia	Joaquín Fuster
Samuel Beckett	Ronald K. Hambleton
Umberto Eco	William Baum
Victoria Ocampo	Phillip Hineline

Appendix 2

Bivariate Spearman correlations between academic achievement, reading comprehension, language measures

	Age	Year	Rspeed	Vocab	TMTA	TMTB	RSrank	RSword	Semflu	Phoflu	ART	Cloze	GPA
Age	1,000												
Year	**0,437***	1,000											
Rspeed	**-0,444***	-0,005	1,000										
Vocab	**0,487***	**0,483****	0,142	1,000									
TMTA	0,244	-0,174	-0,254	0,082	1,000								
TMTB	0,159	-0,205	-0,252	0,098	**0,738****	1,000							
RSrank	0,021	-0,073	0,172	0,116	0,049	0,006	1,000						
RSword	0,294	**0,428***	0,236	0,470	0,096	-0,114	0,636	1,000					
Semflu	-0,143	0,147	0,040	0,061	-0,186	-0,082	-0,192	-0,306	1,000				
Fonflu	0,194	**0,415***	0,014	0,261	0,148	0,090	-0,133	0,001	0,359	1,000			
ART	0,206	0,044	-0,052	**0,561****	0,021	0,056	-0,045	-0,085	0,280	0,126	1,000		
Cloze	0,030	**0,415***	0,256	**0,541****	-0,078	0,006	0,157	0,272	0,061	0,328	**0,566****	1,000	
GPA	0,087	0,152	0,137	**0,456****	-0,058	-0,078	0,338	**0,409***	-0,164	0,102	**0,439***	**0,652****	1,000

*Note***.** Reading scores, ART scores, GPA and executive function measures. Spearman's Rho coefficients are reported. Significant correlations are shown in bold. Rspeed: reading speed (words per minute), Vocab: WAIS vocabulary score. TMTA: Trail making test A score. TMTB: Trail making test B score. RSrank: reading span, maximum correctly recorded set size. RSword: reading span, number of correctly remembered words throughout the task. Semflu: semantic fluency score. Phoflu: phonological fluency score. *ART*: author recognition test scores. Cloze: percentage of correct responses in the cloze task. GPA: grade point average.
*$p < 0.05$. **$p < 0.001$.