

HOW DO READING FLUENCY AND EXECUTIVE FUNCTIONS RELATE IN READING COMPREHENSION? A SYSTEMATIC REVIEW

¿CÓMO SE RELACIONAN LA FLUIDEZ LECTORA Y LAS FUNCIONES EJECUTIVAS EN LA COMPRESIÓN LECTORA? UNA REVISIÓN SISTEMÁTICA

COMO SE RELACIONAM A FLUÊNCIA DE LEITURA E AS FUNÇÕES EXECUTIVAS NA COMPREENSÃO DE LEITURA? UMA REVISÃO SISTEMÁTICA

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Palavras-chave: fluência de leitura; funções executivas; compreensão da leitura; revisão sistemática

ABSTRACT

Multiple cognitive processes are required to understand what is read—the goal of reading. The objective of this study is to analyse and synthesize the evidence presented in literature regarding the relationships between reading fluency and executive functions in reading comprehension. To this end, a systematic review of studies published between 2019 and 2023 was conducted using a metasearch engine. Six articles that met the inclusion criteria were found. The results indicate that there is no consensus on the definition of reading fluency or the instruments used to measure it. The findings on how reading fluency and executive functions are related to reading comprehension are inconclusive. Nevertheless, the evidence analysed suggests that both reading fluency and executive functions are relevant variables in reading comprehension, making it essential to continue investigating these relationships. The study proposes future research lines aimed at clarifying the processes involved in reading comprehension and their interconnections.

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RESUMEN

Múltiples procesos cognitivos son requeridos para comprender lo que se lee -fin de la lectura-. El objetivo de este estudio es analizar y sintetizar las evidencias arrojadas por la literatura acerca de las relaciones entre la fluidez lectora y las funciones ejecutivas en la comprensión lectora. Con este propósito, se realizó una revisión sistemática de estudios publicados entre 2019 y 2023 a través de un metabuscador. Se encontraron seis artículos que cumplieron con los criterios de inclusión. Los resultados indican que la definición de fluidez lectora y los instrumentos utilizados para medirla no cuentan con consenso. Los hallazgos sobre el modo en que la fluidez lectora y las funciones ejecutivas se relacionan en la comprensión lectora no son concluyentes. Aun así, las evidencias analizadas sugieren que tanto la fluidez lectora como las funciones ejecutivas resultan variables relevantes en la comprensión lectora, por lo que es fundamental continuar indagando estas relaciones. El estudio propone líneas futuras de investigación que permitan aclarar los procesos involucrados en la comprensión lectora y sus interconexiones.

RESUMO

São necessários múltiplos processos cognitivos para compreender o que é lido - o objetivo da leitura. O objetivo deste estudo é analisar e sintetizar as evidências apresentadas na literatura a respeito das relações entre fluência de leitura e funções executivas na compreensão leitora. Para tal, foi realizada uma revisão sistemática de estudos publicados entre 2019 e 2023, utilizando um motor de meta-busca. Foram encontrados seis artigos que atenderam aos critérios de inclusão. Os resultados indicam que não há consenso sobre a definição de fluência de leitura ou sobre os instrumentos utilizados para medi-la. As conclusões sobre a forma como a fluência de leitura e as funções executivas estão relacionadas com a compreensão da leitura são inconclusivas. No entanto, a evidência analisada sugere que tanto a fluência de leitura como as funções executivas são variáveis relevantes na compreensão da leitura, tornando essencial continuar a investigar estas relações. O estudo propõe linhas de investigação futuras que visam clarificar os processos envolvidos na compreensão da leitura e as suas interligações.

The purpose of reading is comprehension (Nation, 2005; Snowling & Hulme, 2005). Accessing the meaning of the written code is essential in everyday life (Abusamra et al., 2010; Carretti et al., 2009; Helder et al., 2013; Van Den Broek & Espin, 2012) and is a fundamental tool for learning and the development of thinking (García Madruga, 2006). According to the RAND report, reading comprehension (henceforth RC) is “the process of simultaneously extracting and constructing meaning through interaction and involvement with written language” (Snow, 2002, p. 11). It constitutes an extremely complex cognitive activity in which multiple skills are involved (Kintsch & Rawson, 2005; Perfetti, 1999; Sánchez Miguel et al., 2011).

According to the Simple View of Reading (henceforth SVR), RC is the product of decoding and linguistic comprehension (Gough & Tunmer, 1986; Hoover & Gough, 1990). However, the literature has been indicating the need of expand the approach and add other cognitive processes for its study (Cartwright, 2002, 2007, 2012; Cartwright et al., 2010; Connors, 2009; Cutting et al., 2009; Kieffer et al., 2013; Sesma et al., 2009). In this regard, in recent years evidence has been reported regarding the impact of two relevant cognitive factors on reading comprehension: executive functions (henceforth EFs) (Escobar et al., 2024; Nouwens et al., 2021; Spencer et al., 2020; Taboada Barber et al., 2021) on one hand, and reading fluency (henceforth RF) (Álvarez Cañizo et al, 2015; Baker et al., 2008; Groen et al, 2018; Gutiérrez & Jiménez, 2019; Roldán et al., 2021), on the other. Furthermore, an emerging line of research has investigated the relationships between both cognitive factors in explaining RC performance, thereby adding complexity to classical models (Chang, 2020; Cirino et al., 2019; Kieffer & Christodoulou, 2020; Kim, 2017; Weaver & Kieffer, 2022).

RF is a multidimensional construct that encompasses the dimensions of accuracy, speed, and prosody (Kuhn & Stahl, 2002; Rasinski, 2004). While automaticity in reading implies reading with minimal cognitive effort, in an accurate and fast manner (Kuhn et al., 2010), fluency in reading involves transcending these aspects and endowing reading with “the characteristic expressiveness of speech” (Gómez Zapata et al., 2011, p. 21). Such a skill has been proposed as a bridge between decoding and comprehension (Rasinski, 2004) and can therefore either facilitate or interfere with access to the meaning of written language (Kuhn et al., 2010).

EFs are defined as those capacities that enable the regulation of goal-directed behaviour (Lezak, 1982) and respond adaptively to novel situations (Blair & Diamond, 2008; Lezak et al., 2012). They form the foundation of numerous cognitive, emotional, and social skills (Lezak et al., 2012) and are essential for the comprehensive development of individuals and their functioning in various vital domains, including the educational context (Diamond, 2013). Working memory -or *updating*-, inhibition and cognitive flexibility -or *shifting*- constitute the core EFs (Miyake et al., 2000), and underlie higher-order EFs, such as reasoning, problem-solving, and planning (Diamond, 2013).

Although the way RF and EFs interact to explain RC remains unclear, research on this topic has prompted a debate regarding the inclusion of these skills in explanatory models of reading (Burns et al., 2023; Guo et al., 2023; Kim, 2017). Systematically gathering research that links RF and EFs to RC will allow for a thorough analysis of both conceptual and methodological aspects, in order to contribute to this discussion.

ANTECEDENTS

Various systematic reviews and meta-analyses have presented arguments supporting the contributions of EFs and RF, respectively, to RC.

In relation to EFs, Butterfuss & Kendeou (2018) proposed to investigate the extent to which and under what conditions EFs play a role in RC. They examined 45 articles, organizing them according to the three components of EFs: updating, inhibition, and shifting (Miyake et al., 2000), and found that the latter component is the least studied. They concluded that, beyond the reports documenting the direct impact of each executive function on RC, it is still necessary to expand the evidence and clarify how the relationships and interdependencies among the different EFs contribute to this ability. Furthermore, they emphasized the importance of considering the type of task used to assess each measure when interpreting the results. They concluded their review by positing the significance of including the role of EFs in theoretical models of RC, which would allow for a more appropriate approach to the processes involved in its learning.

Additionally, Follmer (2018) published a meta-analysis in which he examined the association between EFs and RC and assessed the potential moderating effects of the type of executive function, age range, type of executive function measure, and type of RC measure. He found a moderate positive association between EFs and RC. The age range, type of executive function measures, and RC measures were not significant moderators of the relationship. Consistent with the report by Butterfuss & Kendeou (2018), Follmer's (2018) review identifies similar mechanisms whereby working memory, inhibition, and cognitive flexibility contribute to RC. Moreover, his study also highlights that among these three functions, cognitive flexibility is the least studied. The report emphasizes that EFs can account for variability in RC beyond decoding processes, word reading, fluency, and vocabulary. Following this review, Follmer (2018) notes that while the causal effect of EFs on RC does not yet have sufficient empirical support, it is reasonable to assert that they constitute a key component in RC throughout development and across a variety of readers. Finally, he cautions about the inherent difficulty in measuring EFs (Friedman et al., 2008; Miyake et al., 2000; Miyake & Friedman, 2012), as the tasks used for their evaluation necessarily require non-executive processes. This leads to subsequent complications in understanding their contribution to various academic learnings.

Regarding RF, the systematic review conducted by the National Reading Panel (2000) is inescapable. The report identifies RF as a fundamental skill for RC and one of the key components in successful reading programs, although its instruction is often overlooked in classrooms.

Two studies focused on the relationship between prosody, as a component of RF, and RC. Wolters et al. (2022) conducted a systematic review in which, after examining 35 articles, they found a moderate relationship between prosody and RC. They also discovered that the strength of the relationship varies depending on the prosodic feature in question and the assessment instrument used. Both the degree and depth of orthography were not significant moderators. In conclusion, Wolters and colleagues posit that reading prosody is multidimensional, and therefore its relationship with RC should not be considered unitary. Subsequently, Roldán et al. (2022) conducted a study aimed at synthesizing research on the contribution of prosody

to RC in Spanish-speaking populations. The results revealed a significant relationship between prosody and RC with a moderate effect. Furthermore, they found that neither the students' grade level nor the level of comprehension assessed—sentence or text—moderated this relationship. The authors conclude that prosodic skills contribute to semantic processing at both the sentence and text levels in Spanish, regardless of the educational level involved.

Finally, Rodríguez Brito et al. (2023) conducted a systematic review aimed at studying the relationships between word recognition skills and RF with RC in students from 4th to 9th grade. They reported that RF tends to maintain a significant relationship with RC during the second cycle of primary school; however, this is not the case for word recognition.

Although these reviews and meta-analyses provide substantial contributions to the study of RC, they do not jointly address the three variables. Analysing the relationships between RF and EFs and their contribution to RC is important not only for the study of teaching these processes but also for planning interventions that address populations with reading learning difficulties (Cain & Oakhill, 2006; Cuetos, 2013; Gómez-Veiga et al., 2013; Sánchez Miguel et al., 2011). However, no literature reviews have been found that have addressed this issue. In this way, the present research has the goal of systematically reviewing studies aimed at examining the interaction between the three variables. The research questions that motivate this study are: what scientific evidence exists regarding the relationship between RF and EFs in RC, in school-readers? Particularly, how do the three components that constitute RF—accuracy, speed, and prosody—relate to working memory, inhibition and cognition flexibility, in terms of the capacity to comprehend written language?

METHOD

Inclusion criteria

This study decided to include empirical research that:

1. Aim to evaluate the contribution of EFs and RF to RC.
2. Include, among the EFs, at least one of the following functions: working memory, inhibition or cognition flexibility.
3. The evaluated participants should consist of students who:
 - a. are in primary or secondary school;
 - b. do not have developmental disorders or learning difficulties;
 - c. are assessed in their native language.
4. Have been conducted during the period 2019-2023.
5. Have been published in English or Spanish.

Articles that did not aim to evaluate the contribution of EFs and RF to RC were excluded. Additionally, publications were disregarded if, when evaluating EFs, they did not consider working memory, inhibition or cognition flexibility. Articles were also excluded if their participants were students in early childhood education, higher education, or adults; if participants had a diagnosis of neurodevelopmental disorders or specific learning difficulties; and/or if they were assessed in a language other than their native tongue. Lastly, articles published before 2019, as well as those published in languages other than English or Spanish, were excluded.

Search procedure

The systematic literature review was conducted following the guidelines of the PRISMA statement (Page et al., 2021). The literature search took place in May 2023 using the EBSCO metasearch engine. This tool streamlines the search process while providing access to a broad and robust source of information through well-known databases (see Table 1).

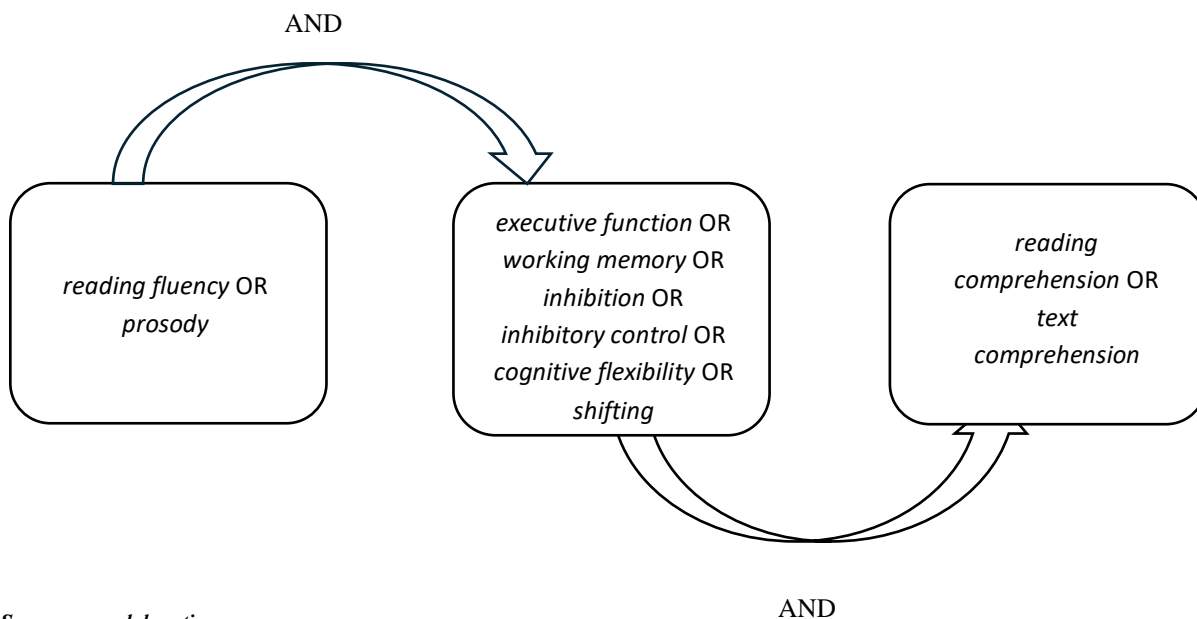
Table 1
List of databases and number of articles extracted from each one of them

Database	Number of articles extracted
Academic Search Complete	58
Academic Search Ultimate	58
APA PsycArticles	1
Business Source Complete	2
Communication Source	9
ERIC	34
MEDLINE	39
Professional Development Collection	26
Psychology and Behavioral Sciences Collection	21

Source: own elaboration.

The search was conducted based on combinations of search terms, organized into three axes: the first related to RF, the second related to EFs, and the third related to RC (see Figure 1).

Figure 1
Search terms

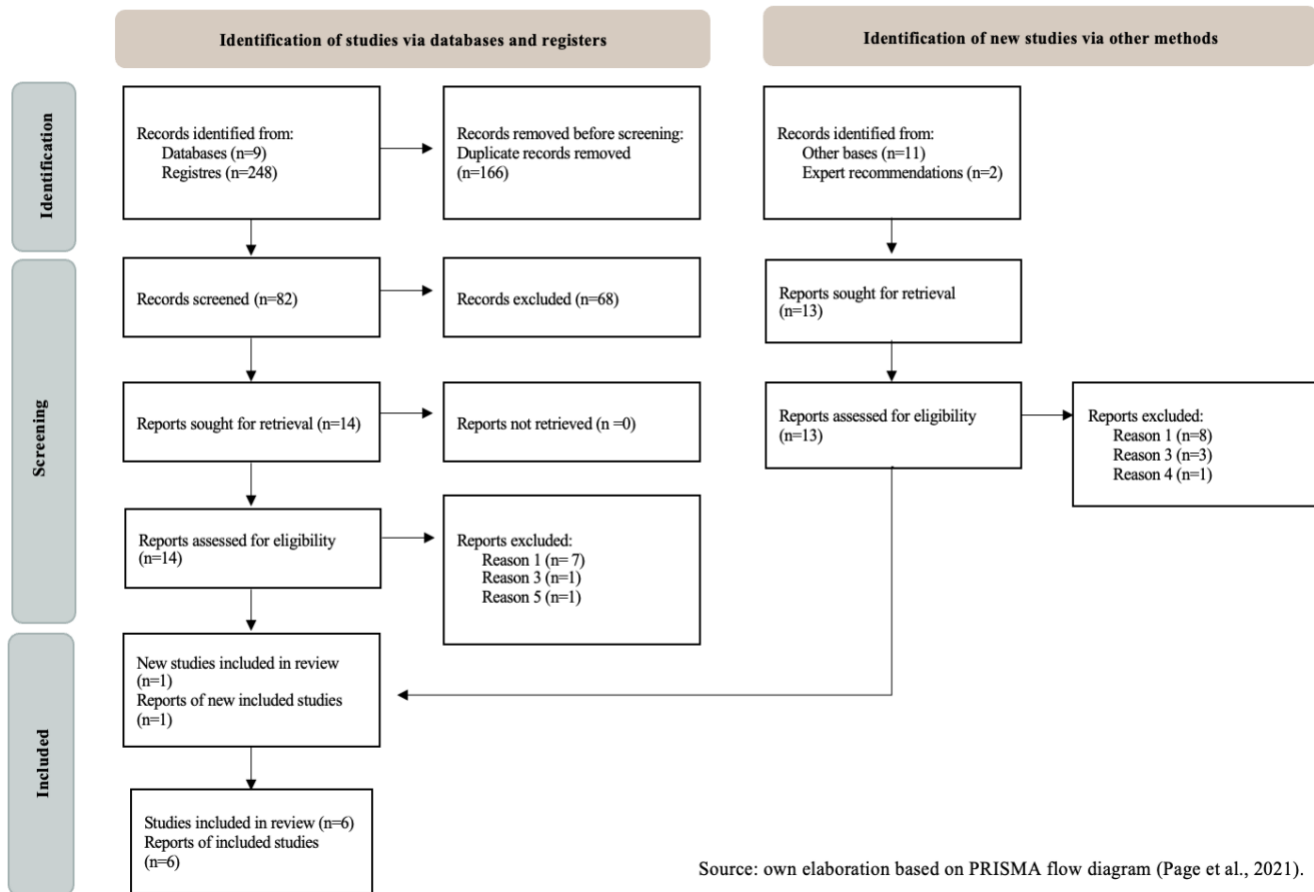


Source: own elaboration.

In the first axis, the term *prosody* was used in isolation to capture articles that specifically evaluate reading prosody as a component of RF. This decision was made due to the particular interest in its study today and the limited knowledge about its impact on RC compared to other dimensions of fluent reading. The terms chosen for the construct of RC aimed to cover the different levels of written language comprehension: word, sentence and text. Finally, with regard to EFs, it was decided to include both the general term and the three components that, according to the literature, are considered most relevant to RC. Once the search was completed, the records found were imported into the Rayyan software (Ouzzani et al., 2016), where an initial selection based on title and abstract was independently conducted by two of the three authors. The agreement level,

calculated using Cohen's Kappa index, was moderate ($\kappa = 0.538$). In cases of disagreement, discrepancies were resolved through discussion. Subsequently, a full-text review was carried out. To complement the results, a secondary search was conducted, tracking relevant citations, consulting experts in the field, and including other studies previously found in different databases (see Figure 2).

Figure 2
 PRISMA flow diagram for article selection



Data analysis

For the analysis of the identified articles, a data matrix was constructed in Excel, including both bibliometric variables and categories to capture content information (study objective, definition of the variables under study, population, methodological approach, instruments, results, among others). Based on the research question and in accordance with the methodology employed by the analysed studies, the results were organized into three dimensions. The first dimension referred to the definitions of the studied variables, the second to the measurement instruments used by the studies, and the third dimension referred to the main findings reported in each research.

RESULTS

The database search resulted in a total of 248 records, with an additional 13 added through the supplementary search. The identification and selection process led to the inclusion of six studies (see Figure 2).

Main features

The general characteristics of the studies are presented in Table 2. All the research was conducted in primary schools, specifically with students in its first three years. Despite the linguistic differences, given the diversity of countries where the studies were carried out, all the languages studied are transparent. In only one case was a language that is considered relatively transparent studied (Kim, 2020).

Table 2
General characteristics of the studies included in the revision

Study	Country	Language/ orthographic depth	n	School grade	Methodological design
Bizama Muñoz; Saldaño Silva & Rodríguez Rodríguez. (2019).	Chile	Spanish (transparent)	98	3°	Cross-sectional
Dolean; Lervåg; Visu-Petra & Melby-Lervåg (2021).	Rumania	Rumanian (transparent)	184	2° (T1: beginning. T2: end)	Longitudinal
Escobar & Rosas Díaz (2023).	Chile	Spanish (transparent)	148	T1:1°. T2: 3°	Longitudinal
Kim (2020).	Corea	Hangul (relatively transparent)	201	1°	Cross-sectional
Kirschmann, Lenhard & Suggate (2021). †	Alemania	German (transparent)	114	2° a 4°	Cross-sectional
Kocaarslan (2022)	Turquía	Turkish (transparent)	140	3°	Cross-sectional

Source: own elaboration.

This article consists of two studies. According to the inclusion criteria, Study 2 was examined.

**CONCEPTUAL FRAMEWORKS:
 VARIOUS DEFINITIONS OF THE VARIABLES UNDER EXAMINATION**

RC definitions

In general, the studies under analysis agree on conceptualizing RC as a complex and multi-component activity. Likewise, several of the articles explicitly state that comprehension is the purpose of reading (Bizama Muñoz et al., 2019; [Dolean et al., 2021](#); Escobar & Rosas Díaz, 2023; Kirschmann et al., 2021) and indicate that RC is essential for academic success (Bizama Muñoz et al., 2019; [Escobar & Rosas Díaz, 2023](#); [Kocaarslan, 2022](#)). In addition, frequent reference is made to the SVR as a relevant theoretical antecedent. While some studies regard it as the fundamental construct for understanding RC (Dolean et al., 2021; Kirschmann et al., [2021](#)) or integrate it with other models to formulate their own, expanded, and enriched proposal (Kim, 2020), Kocaarslan (2022) challenges it by including other variables for analysing performance in RC. On the basis of the study by Kocaarslan (2022) is the understanding that the SVR has significant limitations, as it does not include RF or other relevant cognitive components, such as EFs.

RF definitions

Most studies define RF as a three-dimensional construct, consisting of the variables of accuracy, speed, and prosody¹ (Bizama Muñoz et al., 2019; Escobar & Rosas Díaz, 2023; Kim, 2020; Kocaarslan, 2022). However, two of the studies do not mention prosody as a component of RF: while defining RF Kirschmann et al. (2021) specifically refer to the speed of word decoding in order to access semantics, in the study by Dolean et al. (2021), it is possible to distinguish the notions of accuracy and speed—although these terms are not literally mentioned in their proposal. All the studies present the notion that fluent reading serves to RC.

A recurring concept in the definitions of RF is that of reading automaticity. Kocaarslan (2022) considers it equivalent to fast reading, whereas Bizama Muñoz et al. (2019) include the concept when describing the variable of accuracy. In relation to word-level RF, Kirschmann et al. (2021) state, following the dual-route model, that automated reading is linked to word direct recognition. They also mention that fluency in sentence reading would be a higher-order process that reflects automaticity. For their part, Dolean et al. (2021) use the notion of automaticity as a feature of effective decoding, from this perspective, the concept of RF is associated with reading ease and automaticity.

When defining what is meant by prosodic reading, some authors equate it with the idea of expressiveness or reading expression (Bizama Muñoz et al., 2019; Kim, 2020). For his part, Kocaarslan (2022) considers that prosodic reading is one that conveys the characteristics of orality to the written code. Besides, he links working memory by stating that “prosodic reading contributes to comprehension particularly by supporting the retention of an auditory sequence in the working memory” (Frazier et al., 2006, as cited in Kocaarslan, 2022, p. 3). Although Escobar & Rosas Díaz (2023) note that prosody is one of the attributes of oral RF and emphasize its role in RC, their manuscript does not include a specific definition of prosodic reading.

Finally, it is worth noting that the studies record various possible levels of processing in RF: lexical, sentential, and textual. Besides, the oral and silent reading modes appear. At this point, it is important to note that these dimensions are explicitly present in the definitions of RF in certain articles, although not in others. For example, some authors refer to RF in terms of word reading, without making direct mention of fluent text reading (Escobar & Rosas Díaz, 2023; Dolean et al., 2021.) Kim (2020) addresses both the word level and the text level when explaining the concept of RF, and Kirschmann et al. (2021) add the notion of sentence reading fluency. In the same way, it is possible to analyse how the authors refer to the matter of the audibility of reading: while some refer directly to these two possible forms of fluent reading (Escobar & Rosas Díaz, 2023; Kim, 2020; Kirschmann et al., 2021) and describe the correlates in the cognitive processing of each modality (Escobar & Rosas Díaz, 2023; Kim, 2020), others do not make mention of them (Bizama Muñoz et al., 2019; Dolean et al., 2021). In turn, the study by Kocaarslan (2022) directly defines RF as reading aloud.

EFs definitions

When considering EFs, some authors characterize them as high-level processes and recognize working memory, cognitive flexibility, and inhibitory control as central EFs (Escobar & Rosas Díaz, 2023, Kocaarslan, 2022). They are defined as *top-down* (Dolean et al., 2021) general domain skills (Bizama Muñoz et al., 2019; Kim, 2020). It is understood that their primary purpose is to execute and control complex goal-oriented behaviours (Dolean et al., 2021; Escobar & Rosas Díaz, 2023).

Regarding working memory, several authors (Bizama Muñoz et al., 2019; Kim, 2020; Kocaarslan, 2022) conceive it in accordance with Baddeley's model at its different stages (Baddeley, 1986, 1996, 2000, 2012; Baddeley & Hitch, 1974) and define it as a system for temporarily storing and manipulating information relevant to an ongoing task. Kim (2020) explains that working memory allows for the simultaneous holding and processing of incoming linguistic information, which is necessary for constructing the surface structure. For their part, Kirschmann et al. (2021) indicate that working memory in its auditory modality contributes to the development of integrated mental representations, which in turn facilitates the construction of

¹ It is important to clarify that Kim (2020), instead of using the term *prosody* in her conception of RF, uses the term *expression*.

the situation model and the making of inferences. Both Kirschmann et al. (2021) and Escobar & Rosas Díaz (2023) emphasise the impact of working memory on RC, beyond other fundamental skills, such as decoding, vocabulary and inferences. At the same time, several articles highlight the connection between working memory and word reading (Escobar & Rosas Díaz, 2023; Kim, 2020; Kirschmann et al., 2021; Kocaarslan, 2022), and even with RF (Kim, 2020; Kirschmann et al., 2021; Kocaarslan, 2022). In this way, when framing their studies, the authors underline that working memory is not only directly related to RC, but also indirectly linked to it through the skills above mentioned. In summary, most of the articles under review agree in highlighting that the role of working memory in RC is well-documented (Escobar & Rosas Díaz, 2023; Kim, 2020; Kirschmann et al., 2021; Kocaarslan, 2022) and that this skill exerts a significant weight on performance in comprehension (Bizama Muñoz et al., 2019; Escobar & Rosas Díaz, 2023; Kim, 2020; Kirschmann et al., 2021; Kocaarslan, 2022).

The role of inhibition and cognitive flexibility in RC is less known (Escobar & Rosas Díaz, 2023) and, in accordance with this, they are the less studied EFs (see Table 3). Concerning inhibition, Escobar & Rosas Díaz (2023) explicitly define it as the ability to actively suppress dominant responses. These responses would be automatic cognitive representations that were previously activated; suppression would prevent or halt these responses. In terms of reading, it is noted that inhibition impacts the rapid decoding of words, and since the appropriate access to the written code is a fundamental step in constructing the meaning of the text, inhibition makes a key initial contribution to RC (Escobar & Rosas Díaz, 2023). Besides, inhibition plays a fundamental role in regulating the contents of working memory during the process of constructing the meaning of the text; in this sense, it has been documented that children with difficulties at this level tend to fail in suppressing irrelevant information for RC (Dolean, et al., 2021; Escobar & Rosas Díaz, 2023).

With respect to cognitive flexibility, Escobar & Rosas Díaz (2023) agree with previous studies that of the three core EFs, this one has received the least academic attention regarding its contribution to RC. Cognitive flexibility has been defined as the ability to simultaneously manage various aspects of a task and to be able to switch between them (Diamond, 2013; Miyake et al., 2000). Dolean et al. (2021) and Escobar & Rosas Díaz (2023) agree in suggesting that this function contributes to RC in multiple ways, enabling the reader to consider various perspectives presented in a text, connect new and old pieces of information to make sense of what they read, use different reading strategies flexibly, and shift attention between decoding and constructing the meaning of the text.

In sum, all the articles coincide that EFs play a relevant role in RC. Nevertheless, its relative impact in relation to other skills involved in reading is a matter of discussion among the articles.

Measurement instruments for the variables under study

The instruments used to measure the variables of interest for this research are described in Table 3. It should be noted that while some of the reviewed articles describe their instruments by referencing the variables (Escobar & Rosas Díaz, 2023; Kocaarslan, 2022; Kim, 2021), others do so by referring to the techniques themselves (Kirschmann et al. 2021; Bizama Muñoz et al., 2019, Dolean et al., 2021) and, in the description of each one, indicate the cognitive process they intend to measure through it.

Synthesis of the main findings

Regarding the relationships among the three variables under study, Kirschman et al. (2021) found that auditory working memory predicts RC and that its influence is maintained once word and sentence RF are controlled. In this way, they concluded that both auditory working memory and RF are predictors of RC.

Table 3.
Measures of reading fluency, executive functions and reading comprehension used in the studies.

Study	Fluency			Executive functions		Reading comprehension		
	Dimension	Level	Silent/oral	Test	Function	Test	Level	Test
Bizama Muñoz et al. (2019).	Accuracy	Word	Oral	EVALEC-3 (García et al. 2013). Subtest: Reading automatization	Auditory working memory	Wisc III. (Ramírez & Rosas, 2010). Subtest: Digit Span †	Text	CL-PT (Medina et al., 2009). Subtest: Reading comprehension
	Speed	Word	Oral	EVALEC-3 (García, et al. 2013). Subtest: Fluency and expressiveness				
Dolean et al. (2021).	Accuracy and speed	Word and pseudoword	Oral	Word and pseudoword correct per minute (Dolean, et al., 2019) †	Visuospatial working memory	Corsi blocks test (Corsi, 1972). †	Text	NARA II (Lervag et al., 2019). Form: A †
					Auditory working memory	Backward digit recall test		
					Inhibition	NEPSY-II (Korkman et al., 1998) Subtest: Inhibition †		
					Cognitive flexibility	NEPSY-II (Korkman et al., 1998). Subtest: Switching †		
Escobar & Rosas Díaz (2023).	Accuracy and speed	Word	Oral	Battery III (Muñoz et al., 2005). Words correct per minute	Inhibition	Hearts & Flowers (Davidson et al., 2006; Diamond & Wright, 2014). †	Text	Battery III (Muñoz et al., 2005). Subtest: Reading comprehension
	Accuracy and speed	Word	Silent	Test of Silent Word Reading Fluency (López-Escribano et al., 2013) †	Cognitive flexibility	Tríos (Rosas et al., 2019).		
Kim (2020).	Accuracy and speed	Text	Oral	Words (Kim, 2015a; Kim et al., 2014). ‡	Auditory working memory	Listening Span test (Daneman & Merikle, 1996; Kim, 2015b, 2016).	Text	Reading comprehension tasks (Kim, 2015b; Kim et al., 2014). †‡
Kirschmann et al. (2021).	Accuracy and speed	Word	Oral	SLRT-II (Moll & Landerl, 2014). Words correct per minute	Auditory working memory	Wisc-IV (Wechsler, 2011). Subtest: Digit Span †	Word, sentence and text	ELFE-II (Lenhard, et al., 2017)
	Accuracy and speed	Sentence	Silent	SLS 2-9 (Mayringer & Wimmer, 2014)				
Kocaarslan (2021).	Accuracy	Text	Oral	Words correct	Auditory working memory	Digit-Span Backward Task (Gogan, 2011).	Text	Text comprehension task (Kocaarslan, 2017)
	Speed	Text	Oral	Words correct per minute	Sustained attention	Bourdon's Attention Test (1955). Form: Letter †		
	Prosody	Text	Oral	Multidimensional Fluency Rubric (Zutell & Rasinski, 1991) †				

Source: own elaboration. - † These are tests adapted in language or in the mode of application, compared to the originals. - ‡ Three tasks were applied in each cas

Bizama Muñoz et al. (2019) found a positive and significant relationship between fluid intelligence, working memory, RF, and RC, although not all variables were related to the same extent. While fluid intelligence and reading speed were moderately related to RC, working memory and reading accuracy were more weakly related. Furthermore, their results indicate a significant contribution from some of these variables to RC: while general domain skills (working memory and fluid intelligence) accounted for half of the variance, reading speed accounted for the other half. Reading accuracy, as a component of RF, did not make a significant contribution.

Kocaarslan (2022) investigated the relations between sustained attention, working memory, reading accuracy and speed, prosody and RC. To determine the contribution of the components of reading fluency -accuracy, speed and prosody- to RC, he conducted a hierarchical regression analysis. Once working memory and sustained attention were controlled, only prosody made a unique contribution to RC, while working memory ceased to contribute significantly to RC once the measures of RF were added. Furthermore, mediation analysis revealed that working memory is a significant predictor of RC directly and indirectly, through prosody. This accounts for the mediation role that prosody plays between working memory and RC.

In a longitudinal study, Escobar & Rosas Díaz (2023) found that both cognitive flexibility and inhibition at time 1 were associated with RC at time 2. They also found that cognitive flexibility was positively associated with silent RF but not with oral RF, while inhibition correlated with both measures of RF. They evaluated the mediating role of oral RF between cognitive flexibility and inhibition with RC; they found that inhibition made an indirect contribution to RC through oral RF. Additionally, cognitive flexibility made a direct contribution. The authors noted that the indirect contribution of inhibition to RC via oral RF is linked to the fact that the latter is more demanding than silent RF in terms of the cognitive resources required. Thus, inhibition would allow the suppression of similar word pronunciations during fluent word reading, which in turn would free up cognitive resources that can be devoted to comprehension. They also studied the mediating role of silent RF between cognitive flexibility and inhibition with RC, observing that cognitive flexibility had both a direct and indirect role, while inhibition only made a direct contribution to RC. The authors noted that while silent RF is faster than oral RF, the former reduces monitoring opportunities. This was reflected in their results: cognitive flexibility would allow for the deployment of shifting strategies during silent reading, thereby indirectly supporting RC.

In another longitudinal study, Dolean et al. (2021) found that EFs indirectly impacted early RC (time 1) through decoding and language skills—listening comprehension and vocabulary. As children progressed in learning to read, decoding skills no longer had a significant effect on RC at time 2, although language skills continued to contribute. Consequently, EFs contributed to RC at time 2 only through language skills. Based on these results, Dolean et al. (2021) suggest that language skills are more important than EFs in predicting the development of RC once children have already developed decoding fluency skills. In other words, the effect of EFs on RC decreases as RF mastery increases, according to the results of this study. The authors argue that the findings provide further evidence in support of the SVR, as both language skills and decoding explain performance in RC.

According to the structural equation model tested by Kim (2020), EFs—specifically working memory—indirectly influenced RC through their impact on vocabulary, word reading, and text RF. These relationships follow a hierarchy: working memory affected vocabulary and word reading; in turn, vocabulary influenced word reading; word reading impacted text RF; and, finally, text RF contributed to RC. The author emphasizes that text RF is shaped by word reading and listening comprehension, and it mediates their relationships with RC by integrating both word reading and post-lexical semantic processes.

DISCUSSION

The aim of this study was to systematically review the evidence presented in the literature regarding the contribution of EFs and RF to RC. The analysis of the findings initiates a discussion across various dimensions while also posing questions for future research.

Firstly, the fact that a very limited number of studies were identified in this search highlights the scarcity of research on the subject. While numerous publications address the relationships between EFs and RC, as well as between RF and RC, this study reveals that knowledge about the interactive role these two variables play in the ability to understand written text is significantly missing.

Regarding the definition of RF, the discrepancies found in the studies reviewed reveal a lack of consensus about its components. In particular, with respect to prosody, only one study assesses it (Kocaarslan, 2022), while a second study acknowledges the omission of this measure as a limitation and suggests its inclusion in future research (Escobar & Rosas Díaz, 2023). Based on Kocaarslan's (2022) findings, which demonstrate that prosody plays a key role in RC, it is evident that its incorporation as a dimension of RF is essential in reading research. This may enable a deeper understanding of the indirect role that EFs play in written language processing.

The studies under review also highlight the lack of consensus regarding whether RF should be assessed in oral and/or silent modalities. However, as Kim (2020) and Escobar & Rosas Díaz (2023) explain, it is important to weigh the cognitive processes

involved in each reading mode to better understand how each modality is associated with RC. Additionally, a comparison of the studies reveals other disparities in the instruments used to measure RF, such as the level being assessed, the involvement of semantic processing, or the inclusion of pseudoword reading as part of the variable (see Table 3). The absence of common methodological criteria once again reflects certain conceptual ambiguities, which in turn have implications when evaluating theoretical models of RC. Thus, the findings of this study align with the argument put forth by Frankel et al. (2016) that there is no universally accepted definition of RF.

Regarding the skills assessed within the construct of EFs, the prominence of working memory is emphasized. The literature analysed consistently selects complex span tasks for its evaluation, making the verbal component the most frequently considered dimension. When examining the interaction between working memory and RF in explaining RC, Kirshmann et al. (2021) found that auditory working memory significantly contributes to the variance explained in RC, even when word and sentence RF are controlled for. Similarly, Bizama Muñoz et al. (2019) observed that once RF is controlled, working memory provides a unique contribution to RC. Moreover, studies conducting mediation analyses (Kim, 2020; Kocaarslan, 2022) agree that working memory plays a key role in RC indirectly through various skills: prosody (Kocaarslan, 2022), vocabulary, and word reading, and through these, it influences text RF (Kim, 2020). Additionally, Dolean et al. (2021) found that their construct of EFs, which included working memory, also contributes indirectly to RC through initial language skills.

The studies that included inhibition and cognitive flexibility as variables used visual paradigms for their evaluation (Dolean et al., 2021; Escobar & Rosas Díaz, 2023). This contrasts with the linguistic modality used to assess working memory in all cases. The results of Escobar & Rosas Díaz (2023) show that inhibition and cognitive flexibility predicted performance in RC, and that the mediating role of RF between EFs and RC varies depending on the reading modality considered. In their part, Dolean et al. (2021) reported that EFs do not explain any additional significant variability in RC after controlling for initial reading comprehension skills, decoding fluency, and oral language skills.

The disparities in the results obtained by the examined articles (Dolean et al., 2021; Escobar & Rosas Díaz, 2023) may stem from conceptual differences that, in turn, influence methodological decisions. Dolean et al. (2021) combine accuracy and speed in oral reading of words and pseudowords to measure decoding fluency. It is worth noting that this assessment of RF places significant emphasis on mastering grapheme-phoneme conversion rules. In contrast, the study by Escobar & Rosas Díaz (2023) employs two measures of RF, encompassing both oral and silent modalities, while not including the reading of pseudowords. Moreover, the instruments used to evaluate RC in the studies by Dolean et al. (2021) and Escobar & Rosas Díaz (2023) differ. While the former employs a test that requires written expression skills to answer open-ended questions based on the texts, the latter uses a cloze-type paradigm that requires completing missing words in the texts. It is possible that performance in the RC task utilized in Dolean et al.'s (2021) study is particularly influenced by linguistic domain skills, meaning that the executive variable would have less impact than in the task of the study by Escobar & Rosas Díaz (2023). In this case, EFs such as inhibition for the suppression of inappropriate words in accordance with the syntactic and semantic requirements of the text, as well as cognitive flexibility for word retrieval from the mental lexicon, would be particularly relevant.

Furthermore, it is important to examine the different considerations made by the authors regarding the skills that would be involved within the SVR. Both Dolean et al. (2021) and Kirschmann et al. (2021) interpret their results from this perspective, but the components differ in each case. While Dolean et al. (2021) and Kocaarslan (2022) refer to working memory as a skill external to the SVR, Kirschmann et al. (2021) suggest that this executive function is part of it. Furthermore, whereas Kocaarslan (2022) understands RF—as a skill that transcends word recognition—as not being encompassed by the SVR, the articles by Dolean et al. (2021) and Kirschmann et al. (2021) imply that fluent reading does indeed form part of this model. These discrepancies highlight that even the most studied theoretical models for explaining RC still present areas of debate.

In summary, the review conducted reveals differences at various levels among the examined articles. While the authors tend to agree on their conception of what it means to read comprehensively, the definitions of RF and the instruments used to measure it are not homogeneous. Furthermore, this review provides evidence supporting the role of working memory in RC. However, the methodological differences among the studies highlight discrepancies in the theoretical assumptions: Do EFs—among them, working memory—affect RC directly, or do they do so indirectly through RF? Attention to the mediating role of

RF between EFs and RC is still a novelty among researchers (Escobar & Rosas Díaz, 2023; Georgiou & Das, 2018; Kieffer & Christodoulou, 2020), but it should be considered to address the issue more deeply and accurately.

SUMMARY AND RECOMMENDATIONS

Limitations y future considerations

The results of this review should be taken with caution for several reasons. First, the number of studies found may be influenced by the methodological decisions related to the selection of search terms. Although these decisions were based on a careful analysis of the existing literature, it is possible to consider that the involved concepts present aspects that are difficult to delineate. This is particularly evident in the case of RF. Consequently, some studies that evaluate skills such as accuracy and reading speed were excluded from this review, even though they do not consider the construct of RF as a variable in itself (Johann et al., 2020; Nouwens et al., 2021; Spencer et al., 2020). The decision to include articles that specifically employed the term "reading fluency" was made with the intention of investigating what the literature presents under this nomenclature and what it does not. The fact that some researchers call *decoding* (Bizama Muñoz et al., 2019) what others refer to as *fluency* (Dolean et al., 2021) illustrates the need for ongoing refinement of the definition of the concept of fluent reading.

The criteria related to population characteristics also pose restrictions. Although the decision was made to include articles whose participants are situated within the academic cycles that formally aim to teach reading, the results of this study could be complemented by findings from research conducted in the preschool stage (Chang, 2020; Ergül et al., 2023). RC can be affected by weaknesses in multiple cognitive processes (Beck et al., 1982; Cain et al., 2001, 2004; Nation et al., 2010; Nation & Snowling, 1997, 2000; Oakhill et al., 2005), and it is especially challenging for children learning in a second language (Mancilla-Martinez & Lesaux, 2010; Proctor et al., 2005). Therefore, it would be advisable to expand the results of this study with research addressing the relationships between RF and EFs in RC among children with difficulties in acquiring reading skills and learners whose native language differs from the curriculum language (Kieffer & Christodoulou, 2020; Weaver & Kieffer, 2022).

To enhance understanding of what processes are involved in written language comprehension and how they interact, it is necessary to increase research in this area. Such studies should be as comprehensive as possible in several respects. First, it would be essential to assess RF integrally, incorporating the prosodic aspects of reading. Similarly, it would be pertinent to have a wide range of measures to evaluate EFs, requiring the processing of audio-verbal and visual stimuli. As Follmer (2018) and Butterfuss and Kendeou (2018) suggest, it is fundamental to consider the cognitive processes required by each executive task when examining its relationship with RC. Additionally, increasing the number of longitudinal studies would deepen knowledge about how the relationships between RF and EFs vary and influence RC as children mature in their neuropsychological development and progress through their school life. Translinguistic studies would help expand existing knowledge regarding the impact of language characteristics on reading acquisition, as the orthographic depth affects the learning of reading skills (Seymour et al., 2003). Finally, it is considered relevant to increase research dedicated to evaluating the role of RF and various EFs in the comprehension of different text genres. The limited evidence reported from this perspective suggests that the interaction of these variables in texts of different types is particular in each case (Escobar et al., 2024; Escobar & Espinoza, 2024; Wu et al., 2020).

CONCLUSIONS

Becoming a competent reader entail mastering a wide range of cognitive processes. The limited number of articles examining the relationships between RF and EFs in explaining RC not only highlights the need for increased research on the topic but also calls for caution when generalizing the identified trends. Nonetheless, the analysed evidence allows us to assert that both RF and EFs are relevant variables in the RC of typically developing children. Regarding RF, the results prompt us to consider that the type of task selected for its measurement influences how this variable relates to RC, particularly regarding its mediating role with EFs. Ultimately, paying attention to the cognitive demands of the instruments used to assess the skills under consideration becomes essential when supporting, reviewing, and expanding theoretical models of RC. This study aimed to contribute in this regard, offering insights toward a more comprehensive understanding of the cognitive processes involved in RC.

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