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Impact of the Central Executive on Reading Comprehension for the Pupils Enrolled in the Grades from the Second to the Fourth of the Primary Cycle

تأثير المنفذ المركزي على الفهم القرائي عند التلاميذ المسجلين من الصف الثاني إلى الرابع من المدرسة الابتدائية

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Abstract:

Learning to read in children is a complex operation which involves high-level cognitive functions, for decoding writing and then understanding it. The reader searches for meaning at the level of morphological units as well as their global coherence, which involves active processing at the level of the central executive that is one of the components of the working memory.

The purpose of this study is to evaluate the impact of the central executive on reading comprehension in eighty-three pupils enrolled in the grades from 2 to 4 in primary school. Simple linear regression analysis showed that there is a significant impact, and these results are supported by previous studies that have demonstrated the impact of the central executive on the comprehension of written and spoken language. These results will help us better understand the involvement of the working memory in text comprehension, and anticipate difficulties of reading comprehension.

Keywords: *Central executive; working memory; Executive functions; Text comprehension; Schooled pupils.*

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ملخص :

تعلم القراءة عند الأطفال هي عملية معقدة تستدعي وظائف معرفية عالية المستوى، لفك ترميز الكتابة ومن ثم فهمها. يبحث القارئ عن المعنى على مستوى الوحدات المرفولوجية وإنسجامها العام، وهو مايستدعي معالجة نشطة على مستوى المنفذ المركزي، أحد مكونات الذاكرة العاملة،

الغرض من هذه الدراسة هو تقييم تأثير المنفذ المركزي على الفهم القرائي لثلاثة وثمانين تلميذا مسجلين من الصف الثاني إلى الصف الرابع في المدرسة الابتدائية. أظهر تحليل الانحدار الخطي البسيط أن هناك تأثير دال، وقد تم تأكيد هذه النتائج من خلال الدراسات السابقة التي سلطت الضوء على تأثير عمل الذاكرة، بما في ذلك مكونها التنفيذي، على فهم اللغة المكتوبة والمنطوقة. ستسمح لنا هذه النتائج بفهم أفضل لمشاركة الذاكرة العاملة في فهم النص والتنبؤ بصعوبات فهم المقروء.

الكلمات المفتاحية: *المنفذ المركزي؛ الذاكرة العاملة؛ الوظائف التنفيذية؛ فهم النص؛ التلاميذ المتمدرسين.*

Introduction

For nearly three millennia, human society has undergone a major evolution with the emergence of reading and writing. According to Dehaene (2007), the invention of reading is the result of the evolution and complexification of social relationships, in which oral dialogue alone could no longer ensure the transfer of ideas from one generation to the next one, or between a large number of interlocutors. In fact, as Giasson (2005) explains, through reading, the speaker and the listener are not limited by time or space. This importance of reading in social relationships and socio-professional emancipation could explain society's interest in its learning.

Reading, according to Springer Charolles (2013), is a cognitive operation that aims to transmit an idea, a concept, or a feeling (mental representation) from one person to another through graphic signs (graphemes). This involves two levels of processing:

- A low or passive level (from bottom to top), in which the reader tries to decode the graphic form to transform it into a phonological form (Mann & Liberman, 1984).
- A high or active level (from top to bottom), in which the reader seeks to find meaning in the text, based on his previous experiences and knowledge.

Several authors emphasize the metacognitive aspect of reading (Kintsh & Van Djik, 1978; Zwaan & Radvansky, 1999; Trabasso & Wiley, 2005; MacDonald & Christiansen, 2002; Perfetti et al., 2005). In this sense, active processing involves several operations:

- Conscious processing.
- Construction of propositions regarding the smallest syntactic units of the read text.
- Temporary storage of propositions in order to evaluate them.
- Adaptation to changes in the ideas implied by the progression in the text reading.

It should be noted here that the comprehension of a text requires the focus of attention which involves a state of consciousness, a capacity for temporary data storage (Miles & Ellis, 1981; Haarmann et al., 2003; Cain, 2004), an inhibitory capacity in the sense that the reader must, according to the information available, choose between the different possible explanations (activation and inhibition). Comprehension requires a capacity for quick and flexible adaptation; for example, the reader will adopt an idea at the beginning of the text that he or she will eventually reject after progressing in reading. These different capacities are defined by Diamond (2013) as the executive functions which can be limited here to: planning, inhibition, flexibility, and working memory.

In this schema, working memory (WM) plays an important role (Baddeley, 1993; Savage et al., 2007; Carretti et al., 2009; Bader, 2016; Taylor, 2017), as it constitutes the conscious platform in which various executive functions operate. This can be explained within the framework of Baddeley's (2000) four-component model, which includes:

- Two slave modules responsible for visual and phonological inputs.
- A conscious control and processing module.
- A buffer module that serves as the interface between working memory and long-term memory.

According to Elosúa et al. (2013), in this pyramid model, the central executive is responsible for a set of executive functions such as inhibition and activation, flexibility (shifting & switching), and attention maintenance. A similar pattern is found in Norman and Shallice's (1986) Supervisory Attentional System (SAS). In these models, the idea of a conscious platform, a sort of

cognitive container, is quite prevalent, although some authors like Diamond (2013) explicitly distinguish the WM as an executive component. However, this functional and anatomical distinction seems difficult to establish, as Gazzaley and Nobre's (2012) observations show that the anatomical structures which are responsible for working memory are also responsible for inhibitory centers. Jurado and Rosselli (2007), Marvel and Desmond (2010), Van den Heuvel et al. and Fassbender et al. (2011) distinguish the dorsolateral prefrontal cortex and anterior cingulate cortex as the neural centers of the executive functions and working memory.

The involvement of the central executive and its executive functions has been raised by several authors (Butterfuss & Kendeou, 2018; Bouayad & El-Mir, 2022; Nouwens et al., 2021; Tarchi et al., 2021). The study by Savage et al. (2006) demonstrated a significant correlation between the increase of inhibition and attention with the comprehension of the read text. The regression analysis performed by Holsgrove et al. (2006) to assess the impact of the central executive on written comprehension in 60 schooled children showed that there was indeed a significant weight. The comparative study by Dawes et al. (2015) between two groups of pupils; good readers and bad readers, demonstrated a significant impact of the central executive on the recorded results, which means that a deterioration in the central executive could explain the poor scores recorded in reading (decoding and comprehension). The various studies converge towards a significant and positive impact of the central executive on reading comprehension. The aim of this study is to review this correlation in the Algerian school context in order to better understand the involvement of executive functions related to the central executive in reading comprehension. This leads us to formulate the following question:

- Does the central executive affect reading comprehension through the executive functions?

Our working hypothesis is as follows: The central executive affects reading comprehension through executive functions.

We assume that the more efficient the central executive is, the higher the level of reading comprehension. The academic and clinical implications of our research seem important to us:

- A better understanding of the cognitive operations involved in reading.

- The use of working memory evaluation, including its executive component, as a predictor of reading comprehension level.
- Understanding pupils with difficulties and integrating the stimulation of the central executive into therapeutic care.

1.- Method

1.1. - Participants

The group in this study consisted of 83 primary school pupils from the 2nd to the 4th grade, as indicated in Table 1.

Table 1.- Number of pupils for each level

	Class	Number (N)
	2nd PY	25
	3rd PY	25
	4th PY	33
Total		83

1.2. - Work Tools

The objective of our research is to quantify the positive impact that the central executive might have (independent variable) on the understanding of the read text (dependent variable). To this end, we used the following tests:

- Reading comprehension: Test of comprehension of the read text (Zwobada, 1978).
- Central executive: Test of working memory proposed by El Khatib (الخطيب، 2012).

For the evaluation of reading comprehension, we used the test suggested by Zwobada. In this test, we asked the pupils to read a short first text and then answer a series of questions related to the identification of characters and their related actions. Then, we asked them to read a second, more complex text, in terms of syntax and morphology, which includes notions of space and time in

addition to characters and actions. This reading is followed by a set of questions related to the identification of characters, actions, and spatiotemporal relationships between them.

As for the evaluation of the central executive's executive functions, we opted for the test suggested by El Khatib for several reasons:

- The tools are in Arabic language.
- The test allows the evaluation of the executive functions in their interaction, not in their isolated form.
- The test consists of 9 items that target various executive functions, such as maintaining attention and inhibition, flexibility (shifting), and planning.

The subject has to perform the following tasks:

- Complete incomplete words with orally given letters.

- Extract even numbers from a series of numbers, presented orally and then visually.

- Matching shapes of the same colour.

Each task is scored out of 3 points, with a total score of 9/9.

2. - Presentation and analysis of the results

In order to evaluate the impact of the variable: the central executive (executive functions), on the variable: comprehension of text 1 and 2, we conducted two linear regression analyses.

2.1. - Linear regression analysis for text1

After inputting the raw scores of the central executive and those of text 1 into the SPSS program, we obtained the results indicated in tables 2 and 3.

Table 2.- The values R, R2 and their significance

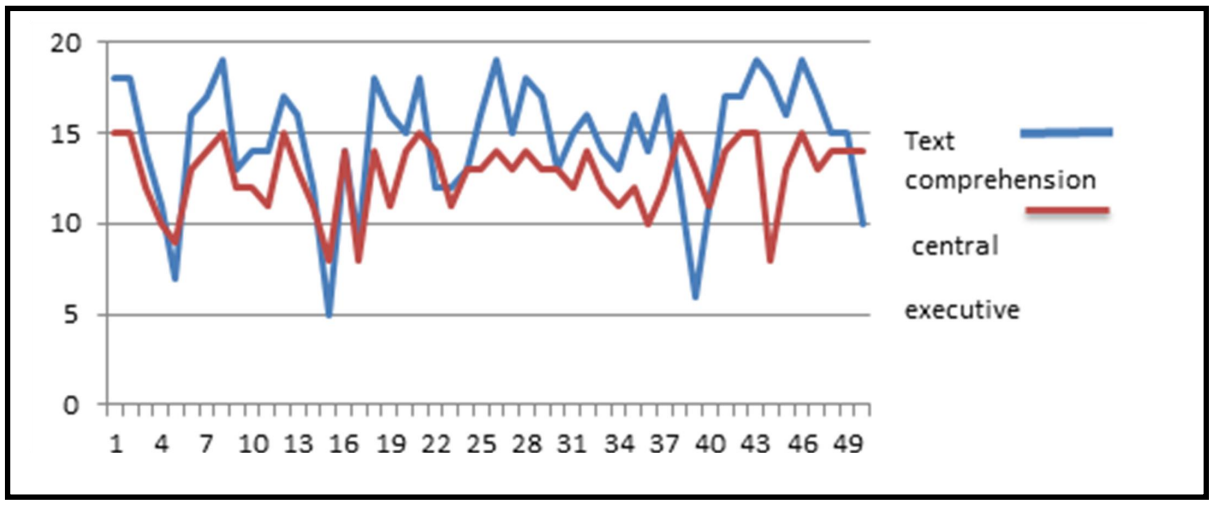
Model	R	R-2	R-2 adjusted	Standard error of estimation	Sig ANOVA
1	,579	,336	,322	2,74172	,000

Table 3.- The value of beta and its significance

Model		Non-standardized coefficients		Standardized coefficients	t	Sig.
		A	Standard error	Bêta		
1	(Constant)	1,998	2,600		,769	,446
	Central executive	,995	,202	,579	4,926	,000

Tables 2 and 3 show a value of R=β=0.58, with an adjusted R2 of 0.32, which means that 58% of the results of text 1 comprehension are related to the scores recorded in the central executive. The more proficient a pupil is in the central executive, the more their comprehension of text 1 improves. This positive correlation can be represented by the graph in Figure 1.

Figure N° 1: Positive correlation between executive functioning and comprehension of text 1



The graph in Figure 1 shows a strong correlation between the scores. If the scores of the central executive increase (upper peaks), so do the scores of comprehension of text 1, and vice versa (lower peaks).

2.2. - Linear regression analysis for text 2

After inputting the raw scores of the central executive and those of text 2 into the SPSS program, we obtained the results indicated in tables 4 and 5.

Table 4.- The values of R, R2, and their significance

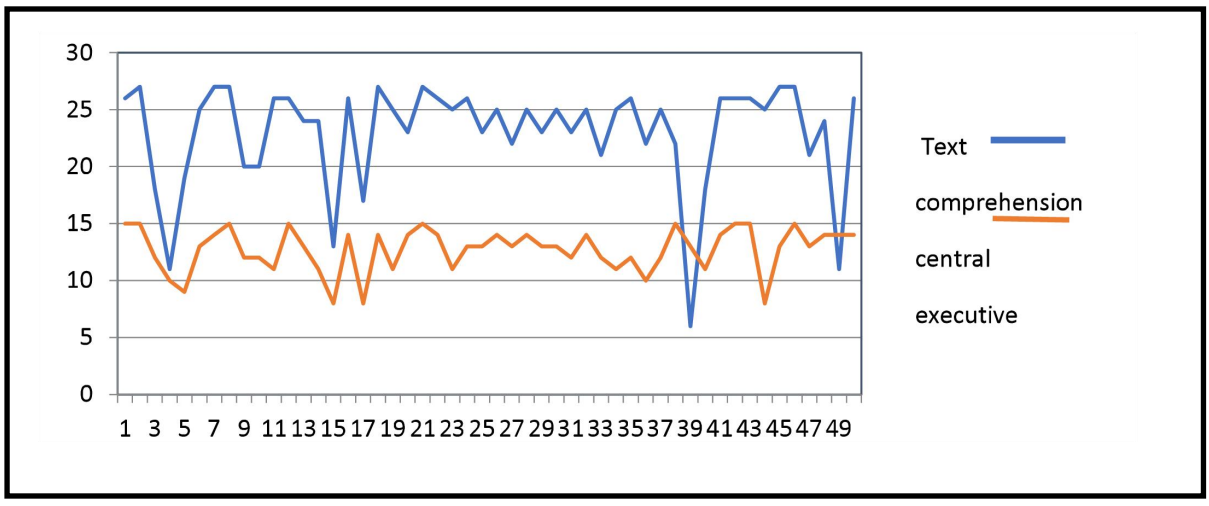
Model	R	R-2	Adjusted R-square	Standard error of the estimate	Sig ANOVA
1	,434	,189	,172	4,23709	,002

Table 5.- The value of beta and its significance

Model		Non-standardized coefficients		Standardized coefficients	Mode l	Sig.
		A	Standard error			
1	(Constante)	9,733	4,017		2,423	,019
	Central executive	1,043	,312	,434	3,340	,002

Tables 4 and 5 indicate an R=β=0.43 value, with an adjusted R2 of 0.17 which means that 43% of the results for Text 2 comprehension are related to the scores recorded in the central executive. The more proficient the pupil is in the central executive, the more his comprehension of Text 2 improves. This positive correlation can be represented by the graph in Figure 2.

Figure N° 2: The positive correlation between executive functioning and Text 2 comprehension



Graph 2 shows a strong correlation between the scores. If the scores of the central executive increase (higher peaks), those of Text 2 comprehension also increase, and vice versa (lower peaks). However, we notice that the R2 value has dropped by 15% between Text 1 and Text2, which can be explained by the complex nature of Text 2 on both a morphological and syntactical levels compared to Text 1. Additionally, Text 2 integrates the notions of space and time that are not found in Text 1.

3. - Discussion and analysis of the results

The results in Tables 2 and 3 show that there is a significant impact of the central executive through its executive functions on text1 comprehension. The pupil is evaluated based on his ability to identify the characters, the different actions related to them, as well as the relationship between these characters in view of these actions. The text1 has a very simple syntactic composition, the words used are semantically and morphosyntactically very close to those used in the everyday dialectal Arabic used in Algiers, which allows young readers to access basic syntactic compositions: subject-verb (character-action).

The implication of the central executive is highly relevant with a weight of 58%, which is supported by all studies that have evaluated this correlation (Savage et al., 2006; Holsgrove & Garton, 2006; Chrysochoou et al., 2011; Dawes et al., 2015). This very strong implication of the central executive can be related to the different executive functions that are involved in text comprehension at the level of syntactic and grammatical consciousness (Hung, 2021). Indeed, this implies maintaining focused attention on the most important elements: characters and actions (Zwan & Radvansky, 1999). Also, it requires the ability to transfer attentional fixation points (inhibition-disinhibition) in order to develop a coherence plan at the micro and macro structures level (Kintsh & Van Dijk, 1978), as well as the activation of mental representations stored in long-term memory in the form of verbal or mental images (Rossi, 2008). On the other hand, it is necessary to inhibit any automatic response in order to develop a set of propositions based on the projection of previous information onto incoming data (top down). The reader also tries to establish connection points between the elements that would present a form of logical coherence (activation), but also eliminates the elements that would not fit into this coherence (Van den broeck et al., 2005). This processing capacity is based on mental flexibility, which allows the renewal of propositions at the sentence or

text level as it integrates new data during its progression in reading (Trabasso & Wiley, 2005).

For Text 2, we recorded in Table 5 a positive impact estimated at 43%. We note that the weight decreases by 15% compared to Text 1, which can be explained by the complex nature of the second text on the morphosyntactic and semantic level. The syntactic composition integrates space and time, and a comparison of the average scores of Text1 vs Text 2, showed that children had more difficulty with the second text ($\bar{X}1 > \bar{X}2$ with $p<0.05$). The increase in the amount of difficulty and the nature of the data to be processed causes cognitive overload in working memory, specifically in the central executive, which, according to Just and Carpenter (1992), is limited by the processing capacity

Conclusion

Reading is a cognitive operation that is acquired within the framework of learning and dictated by a social obligation, which aims at socio-professional and spiritual emancipation. This could explain the growing interest of researchers in studying this operation as well as the different cognitive operations attributed to it, in order to adapt pedagogical methods to the real needs of the schooled children. These studies have distinguished between a lower level of grapho-phonological decoding and a higher level in which the reader's interest is focused on the search for meaning at the level of sentences and then the text as a whole. They have also emphasized the significant weight of the central executive in comprehension. In our study, which is in the same line, we tried to evaluate the weight of this variable among 83 pupils enrolled in the grades from the 2nd to the 4th year of primary school. The results suggest that there is indeed a significant influence of executive functioning on text comprehension, the more progress there is in the first, the more progress there is in the second. However, this variable alone cannot explain the level of comprehension, as other explanatory factors may interact, such as:

- Acquisition of the notion of space and time.
- The morphosyntactic nature of words and their distance from dialectal Arabic in its formal or semantic aspect.
- The child's ability to adopt his own strategy to understand the text.

The aforementioned results have pedagogical implications, in the sense that it would be wise to take into consideration the simulation of working memory and

its executive component, through exercises which are integrated into the school curriculum since preschool. On a therapeutic level, our results suggest that some of the difficulties in text comprehension may be related to executive dysfunction, which should lead us to a systematic evaluation of working memory in these pupils, with an adapted care.

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