

Research paper

Title: The impact of cognitive functions (cognitive inhibition and mental flexibility) on reading comprehension: A Comparative Study between Primary School Students with High and Low Reading Levels in Morocco

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ABSTRACT

Oliver Hoody (2004) says "cognitive evolution should not only be seen as a gradual acquisition of knowledge, but also as an ability to curb reactions that hinder the expression of existing knowledge." (Brague Sarah ;2013).In this regard, braking mechanics are very important in school learning in general and in reading understanding in particular, It works on curbing distracting ideas from the main idea relevant to the topic. What allows students to better understand the texts they study, and also braking is essential in our daily lives, so that we can make decisions and choose their attribution and curb negative ideas confused with appropriate ideas. In order to reach a sound understanding, executive functions must be sound as braking and cognitive flexibility To reach an integrated readership understanding, a child must have good cognitive flexibility. We mean cognitive flexibility is the ease of navigation between two or two ideas flexibly, and to reach for good flexibility it must be a strong work memory and control braking ordinarily and flexibly . Cognitive flexibility refers to the ability to alternate between two works, or two ideas, that allow us to change our view of a situation or a person, in fact to change our view, we must restrain (or disrupt) our previous perspective and activate a different perspective in our thinking, through working memory. Another aspect of cognitive flexibility is to change the way we think about something as a result. Many studies have linked creativity to cognitive flexibility. In this context, lack of flexibility will lead to stiffness of thought, difficulties of emerging from the intellectual environment and persistent mistakes. On the social level, this will lead to stubborn attitudes towards others and difficulties in understanding social skills. (S. Henrard; 2021 [1])

INTRODUCTION:

Executive functions are a term that encompasses a set of processes such as attention, planning, and the strategies used. These can be summarized into three main components: working memory, inhibition, and cognitive flexibility (C. O.-Y. Hung, 2020[2]).

function of the supervisory attentional system (A. Seron et al., 2000, p.281[3]).

Numerous studies have distinguished between the components of cognitive flexibility, emphasizing that it should be assessed as a general ability rather than being reduced to a single process, such as its contribution alongside inhibition and working memory in children, particularly in simulation, execution, and transformation (V. A. Filippetti and G. Krumm., 2020[4]).

It is also noteworthy that some researchers have divided cognitive flexibility into three types (reactive, spontaneous, and representational), while others have categorized it into two types that emerge before schooling and are influenced by inhibition and working memory. Ebersbach and Hagedorn 2011; found different correlations in their study of the contribution of types of cognitive flexibility (reactive, spontaneous, and representational) to the spatial representation in children's drawings. They found that only spontaneous and representational flexibility predicted spatial drawing (V. A. Filippetti and G. Krumm., 2020[4]).

Inhibition control involves the ability to pause to take actions, control one's attention, behavior, thoughts, and emotions to stay focused on the desired goal without interference from the environment or personal thoughts. At the attentional level, inhibition is characterized by the ability to suppress mental representations, meaning the capacity to resist unwanted thoughts or memories, including intentional forgetting . (S. Henrard; 2021 [1]) Another aspect of inhibition leads to self-regulation, which is the ability to resist temptation and not act impulsively. This allows, for example, maintaining the discipline needed to stay focused despite peripheral stimuli and completing a task despite temptations to switch to a more interesting activity or have fun. It involves delaying gratification by foregoing immediate pleasure to obtain a greater reward later, as illustrated in the famous marshmallow test . (S. Henrard; 2021 [1])

In this context, inhibition is characterized by impulsivity and repetitive actions (automatic) in the task that needs to be completed or by being distracted by elements in the environment. This leads to speaking before thinking and difficulty directing attention to the required task . (S. Henrard; 2021 [1])

Hasher et al. (1999) identified three inhibitory functions in working memory: preventing access to irrelevant information, suppressing dominant responses, and avoiding access to information that has become irrelevant. Altemeier, Abbott, and Berninger, in 2008, emphasized the impact of this executive function on spelling and writing skills. Consequently, poor inhibitory control, which results in difficulties in prioritization, leads to challenges in selecting ideas to include in a text and identifying less important ideas (C. Vachon, 2020[5]).

Inhibitory monitoring can also help detect spelling errors and avoid certain behaviors, such as repeatedly using incorrect spellings. It enables the writer to ignore incorrect forms that they might regularly produce by reinforcing the correct spelling knowledge of the word.(Laurie 2019) and Kaufman (2010) both noted that thanks to inhibitory monitoring, an individual can follow instructions and the intent of the writing, as well as maintain focus to persevere throughout the task (Catherine Vachon, 2020). Additionally, a deficit in this cognitive function can cause the writer to repeatedly misspell a word. Kaufman (2010) also adds that a student struggling with inhibitory monitoring may find it difficult to explain why they wrote a word a certain way or why they chose that specific form (C. Vachon, 2020[5]).

According to A. Miyake, N. P. Friedman, M. J. Alexander, H. Witzki, and A. Howerter . (2000) [6]), the central executive system of Baddeley's model is associated with three main executive functions: inhibition, updating, and shifting. Inhibition involves the ability to suppress dominant or quick responses, shifting is the skill of changing strategies while attending to multiple tasks or mental processes, and updating involves the ability to replace old, irrelevant information, retaining only a limited set of items in working memory relevant to the current situation (M. C. Passolunghi et al 2021 [7]).

METHODOLOGY:

If many studies in cognitive linguistics and cognitive neuroscience in Morocco have not yet settled the issue of the effect of inhibition and cognitive flexibility on the process of reading comprehension, then our research seeks to uncover the impact of inhibition and cognitive flexibility on the learning process, especially reading comprehension. This leads us to pose the following problem, which we will strive to answer in this study: What is the relationship between reading comprehension, inhibition, and cognitive flexibility? This problem has led us to the following hypothesis: We assume in this study that there is a difference between learners with poor reading comprehension and those with good reading comprehension in terms of inhibition and cognitive flexibility.

RESEARCH INSTRUMENTS, SAMPLE, AND VARIABLES (FIELD STUDY):

TESTS:

To test the validity of the hypotheses we formulated, we relied on some tests targeting specific processes to evaluate their performance. The measurements we will use, whether to measure inhibition, cognitive flexibility, or reading comprehension, have been prepared based on their syllabi. Taking age into account, it should be noted that these tests share the commonality of targeting aspects of linguistic and cognitive ability in children. They are as follows:

- Stroop test to measure inhibition tasks.
- Card Sorting Test to measure cognitive flexibility.
- Reading comprehension test formulated based on Moroccan curriculum guidelines.

Sample:

The sample of this research consists of two groups of primary school students, specifically fifth and sixth graders. These students were selected based on their performance in the classroom according to the information provided by their teachers, in addition to observations recorded during reading comprehension sessions. We had to ensure that the sample includes two categories of participants: those with poor and good reading comprehension, while excluding students with language disorders, mental disabilities, or learning difficulties.

Note: The age of the research participants ranges between 11 and 13 years.

Table 1. Distribution of sample members according to gender and educational level.

	Male	Female	Total
Fifth	14	16	30
Sixth	15	15	30
Total	29	31	60

Research Location: Moulay Yaacoub, Ben Talha Al-Alam Rural School Group, Sebt El Guerdane Municipality.

STEPS FOR ANALYZING RESULTS:

In our analysis of the results of this research, we relied on descriptive statistics, which involved calculating the means, minimum and maximum values, and standard deviations for each individual in the sample. Then, for each category separately (good and poor readers), we placed them in statistical tables. Afterward, we examined the correlations between the research variables and documented them in a table. Finally, we will discuss the results in light of the hypotheses formulated at the beginning of the research.

ANALYSIS OF THE PERFORMANCE OF FIFTH AND SIXTH-GRADE LEARNERS IN VARIOUS TESTS:

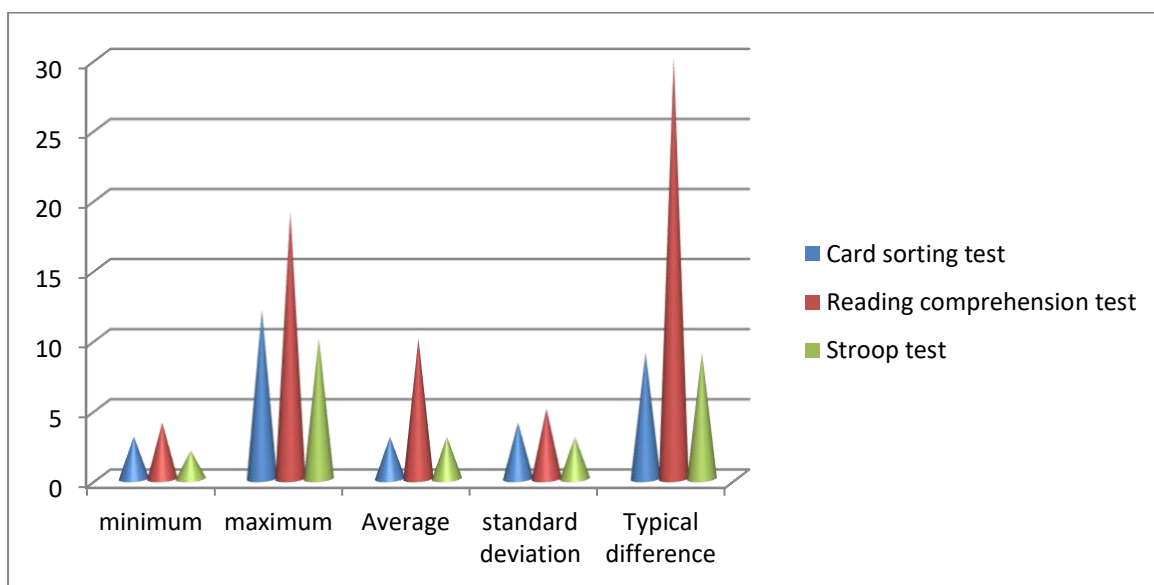


Fig . 1. A graph showing average performance, minimum and maximum values, and general typical differences

Based on the results obtained in the table and the statement, it is clear that there is a significant difference in the performance between good comprehension learners and poor comprehension learners at the same level in the Stroop test and the Card Sorting test.

For learners with good comprehension, the minimum performance level in the Stroop test was 2 and in the Card Sorting test was 3, reaching a maximum of 10 in Stroop and 12 in Card Sorting. The average performance was 3.93 in Stroop and 3.60 in Card Sorting, with a standard deviation of 0.255 in Stroop and 0.266 in Card Sorting.

For poor comprehension learners, the minimum performance level in the Stroop test was 1, reaching a maximum of 4, with an average performance of 2.22 and a standard deviation of approximately 0.782. The same pattern was observed for the Card Sorting test, with a minimum of 0.99, a maximum of 4, an average performance of 2.22, and a standard deviation of approximately 0.700.

This indicates that there are statistically significant differences indicating the engagement of inhibitory control and cognitive flexibility in learners who excel in reading comprehension compared to those with weak reading comprehension, confirming the hypothesis we previously assumed.

Through the above data and by comparing the average performance between learners with good comprehension and those with poor comprehension in inhibition and flexibility tests, it is evident that learners with poor comprehension also have weaknesses in tasks requiring inhibitory control. This confirms the general hypothesis of the research, which states that there are statistically significant differences indicating the engagement of inhibitory control and flexibility in learners who excel in reading comprehension compared to those with poor reading comprehension.

THE INTERRELATIONSHIP BETWEEN READING COMPREHENSION, INHIBITION FUNCTION, AND COGNITIVE FLEXIBILITY:

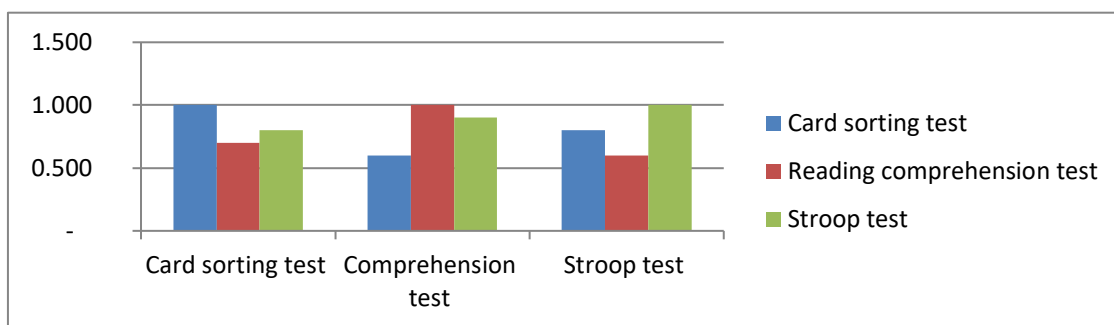


Fig . 2. Factor analysis of the correlations between the various types of tests and their various variables for the fifth and sixth levels of primary school:

The graph shows the correlations between the performance of level 5 and 6 learners on various tests.

The reading comprehension is associated with measures of cognitive flexibility and inhibition, as evident from the previous table, showing a strong correlation between them. The correlation coefficient between reading comprehension and the Card Sorting test reaches 0.600, and with the Stroop test, it reaches 0.900.

The statistical data we have obtained confirms the strength of the correlation between reading comprehension, considered the most important cognitive process, and the ability of inhibitory control. The correlation coefficients range between 0.750 and 0.800, and are statistically significant.

Additionally, we noticed during the test exercises and corrections that while some learners are equal in word comprehension, there are differences in other aspects such as sentence comprehension and inferential comprehension. Learners who succeeded in all levels of sentence comprehension demonstrated greater inhibitory control than others and had a high level of cognitive flexibility. This confirms that comprehension is generally the result of internal cognitive programming, where goals or final situations are determined. These processes are fundamentally linked to the level of cognitive activity and the learner's ability to process, activate, and coordinate information, as well as the effectiveness of cognitive flexibility in quickly grasping meaning and inhibiting distracting thoughts.

DISCUSSION AND ANALYSIS OF RESULTS:

Based on the current study's results regarding the impact of executive functions, particularly inhibition and cognitive flexibility, on reading comprehension, through tests of these functions and relying on statistical analysis and results, it can be said that all the hypotheses we started with at the beginning of the research are initially confirmed.

We observed a clear difference between good and poor reading comprehension learners due to variations in cognitive resources available to them, as well as differences in how these inhibitory control and flexibility capacities are utilized to activate appropriate information, organize mental space, and select relevant information during reading and comprehension activities. Problems hindering successful performance in comprehension may be associated with difficulty in selecting the appropriate meaning of words due to a variety of distracting stimuli interfering with comprehension.

Our study confirms that learners with poor comprehension have a deficit in the essential executive function of cognitive flexibility, as evidenced by the Stroop color-naming test, which focuses on naming the color rather than reading the word itself. The challenge for these learners was to overcome written distractors and focus solely on perceiving the color, where weakness was observed among poor comprehension learners.

As mentioned earlier in this article, one-third of fourth graders in the United States cannot understand texts, leading to scientific contributions emphasizing the significant role of executive functions. Thus, our study contributes to this field by confirming that teacher interventions at the level of cognitive stimuli deficiency and assistance in inhibiting distracting stimuli help learners reach accurate meaning.

Most studies investigating whether cognitive flexibility makes a significant contribution to reading have been linked to intelligence focusing on reading-specific cognitive flexibility (K. B. Cartwright, et al., 2017[8] ; Sondergaard Knudsen et al, 2018 cited in Kelly B et al 2017). There is a study that investigated whether cognitive flexibility provides a unique contribution to reading beyond intelligence (S.D Mayse et al., 2009) [9]. However, this study found that cognitive flexibility only affects mathematics and not reading abilities (measured by the Winsconsin Card Sorting test). (K. B. Cartwright, et al., 2017[8]).

Furthermore, the application of tests in our study was influenced by age, as older children obtained higher scores than younger ones. Similarly, a study conducted by Cantin, Gnaedinger, Gallaway, Hesson-McInnis, and Hund (2016) found that working memory, inhibition, and cognitive flexibility are affected by age, especially in children aged 7 to 10 years, as well as in young people in reading comprehension. This indicates that the contribution of executive functions to literacy skills may be influenced by age. (K. B. Cartwright, et al., 2017[8]).

As observed in our study, learners with good comprehension demonstrate active cognitive flexibility compared to learners with poor comprehension, which aligns with findings by Kelly B and others (2019) that executive functions, especially cognitive flexibility, play a significant role in reading comprehension, specifically in reading fluency. The study was conducted on 50 students from the second and third levels, evaluating reading fluency, decoding, reading comprehension, and their relationship with executive functions, with results showing that cognitive flexibility significantly contributes to improving reading fluency and comprehension. (K. B. Cartwright, T. R. Marshall, C. M. Huemer, and J. B. Payne) [10] .

Regarding inhibition, the results were consistent, as inhibitory control is one of the three main components of executive functions and, in reading, enables the organization of retained information according to the initial goal for message comprehension. Considering the goal during the task is essential to identify distractions that prevent it. Controlling internal and environmental distractions is necessary to maintain focus on the goal related to working memory (Laurie, 2019), as the primary function of inhibition is to suppress irrelevant interpretations that have no connection to the text. Similarly, inhibition is also affected by age, as older learners with good comprehension have stronger inhibitory control than younger ones, and older learners with poor comprehension inhibit variables to a greater extent than younger learners. Additionally, response times varied between good and poor comprehension learners in the inhibition test, with good comprehension learners taking less time than poor comprehension learners, who took longer and sometimes made numerous errors. The daily cognitive processes and learning do not only require knowledge accumulation but also selection and selection processes, hence inhibiting all irrelevant ones. In fact, various tasks occurring in oral or written language (speaking, dialogue, post-conversation, etc.) require automatic activations (for words and concepts), including all components close to the auditory network, requiring inhibiting semantics or morphology to occur for a specific outcome to be relevant (S. Bague; 2013) [11] .

In conclusion, reading comprehension and the development of inhibitory control are subject to long-term development. In early childhood, inhibitory control plays.(L.-A. Garneau-Gaudreault)[12] .

SUMMARY:

Based on our discussion of the statistical data and comparison with previous studies, there is a consensus and harmony between the results of our research and the findings of most studies, which also emphasized the deficiency in inhibitory control and cognitive flexibility among learners with poor comprehension. This indicates a statistically significant correlation between the poor performance of inhibitory control and cognitive flexibility and weak comprehension. There were clear differences in the performance of learners with poor comprehension in inhibition and flexibility tests compared to learners with good comprehension, who showed high performance. This confirms that the hypotheses regarding the impact of inhibition and flexibility on reading comprehension, which we previously assumed, are now confirmed.

The results also indicate that the deficiency in planning flexibility leads to weakness in adapting correctly to the situation. We observed that weakness affects inhibition when flexibility is low, and vice versa, indicating a deficiency in cognitive flexibility. Cognitive flexibility and inhibition are considered the basis of executive functions that intervene in reading comprehension, especially when performing two tasks simultaneously or managing attentional resources, or distributing appropriate cognitive resources to accomplish the required task, starting with the outputs, i.e., attention and selecting suitable stimuli, inhibiting distracting stimuli for processing, and reaching the goal of proper understanding.

Reference :

1. S. Henrard, "De l'importance des fonctions exécutives dans la vie de tous les jours," Revue francophone d'orthoptie, Elsevier Masson, 2021.
2. C. O.-Y. Hung, "The role of executive function in reading comprehension among beginning readers," Yew Chung College of Early Childhood Education, Hong Kong, 2020.
3. . A. Seron et al., *Traité de neuropsychologie clinique*, vol. 1 et 2, Solal, France, 2000.
4. . V. A. Filippetti and G. Krumm, "A hierarchical model of cognitive flexibility in children: Extending the relationship between flexibility, creativity and academic achievement," *Journal of Clinical and Experimental Neuropsychology*, 2020, DOI: 10.1080/09297049.2019.1711034.
5. C. Vachon, "Le transfert des fonctions exécutives développées en jouant aux jeux vidéo d'action de type FPS et RTS vers les situations d'écriture," 2020.
6. A. Miyake, N. P. Friedman, M. J. Alexander, H. Witzki, and A. Howerter, "The unity and diversity of executive functions and their contributions to complex 'Frontal Lobe' tasks: A latent variable analysis," *Cognitive Psychology*, vol. 41, pp. 49–100, 2000.
7. M. C. Passolunghi *et al.*, "Psychological well-being in childhood: The role of emotional intelligence, regulatory emotional self-efficacy, coping and general intelligence," *Clinical Child Psychology and Psychiatry*, vol. 26, no. 4, pp. ..., Oct. Ca.
8. K. B. Cartwright, E. A. Coppage, A. B. Lane, T. Singleton, T. R. Marshall, and C. Bentivegna, "Cognitive flexibility deficits in children with specific reading comprehension difficulties," Christopher Newport University, Newport News, Virginia, USA, 2017.
9. S. D. Mayes, S. L. Calhoun, E. O. Bixler, and D. N. Zimmerman, "IQ and neuropsychological predictors of academic achievement," *Learning and Individual Differences*, vol. 19, no. 2, pp. 238–241, 2009.
10. K. B. Cartwright, T. R. Marshall, C. M. Huemer, and J. B. Payne, "Executive function in the classroom: Cognitive flexibility supports reading fluency for typical readers and teacher-identified low achieving readers," Christopher Newport University, Newport News, VA, 2019.
11. . S. Brague, *Étude des répercussions d'un entraînement des fonctions exécutives sur les mécanismes de la lecture chez des enfants dyslexiques de CM2, mémoire*, Université Bordeaux Victor Segalen, Département d'Orthophonie, 2013.
12. . L.-A. Garneau-Gaudreault, "Les processus de compréhension en lecture, le contrôle inhibiteur et les habitudes d'utilisation des médias: étude exploratoire chez les élèves de 4e à 6e année du primaire," Québec, 2019.