



Working Memory Disorders and Attention Deficit as Cognitive Indicators of Dyscalculia in Students According to the Theoretical Framework

Ibtissam Ben Youssef*

University of Algiers 2, (Algeria)

benyoussef.ibtissem@univ-alger2.dz

Laboratory of Anthropology and Psychoanalysis

Loubna zarour

University of Algiers 2, (Algeria)

Loubna.zarour@univ-alger2.dz

Laboratory of Education and Mental

Abstract ;

This paper presents a comprehensive theoretical review of the role of working memory and attention as primary cognitive indicators in explaining dyscalculia among primary school children. The central research question addresses how deficits in working memory and attention contribute to the emergence and cognitive profiling of dyscalculia. The paper reviews foundational concepts, theoretical frameworks, and explanatory models in this field, while examining findings from recent Arabic and international studies linking these two cognitive variables to arithmetic disorders. The review concludes that deficits in the phonological loop and central executive components of working memory, combined with impaired selective and sustained attention, represent key indicators that can inform early diagnosis and the design of intervention programs.

Article info

Received

July 31;2026

Accepted

September 08;2026

Keyword:

- ✓ Working Memory
- ✓ Attention
- ✓ Dyscalculia
- ✓ Learning Disabilities;
- ✓ Cognitive Processes

* Corresponding author

1. Introduction

The field of learning disabilities is one of the most complex domains due to the ambiguity surrounding it. It encompasses varying levels of severity and requires specialized skills in diagnosis through diverse methods, as this group demonstrates a discrepancy between their mental abilities and academic achievement, particularly in core subjects like mathematics, which demand specific skills from learners. Across all educational stages, mathematics is considered one of the most vital subjects relied upon to cultivate logical and mathematical thinking skills. It holds a significant position among the sciences, though individuals' perceptions of mathematics vary depending on their interests, needs, attitudes, and the extent to which they apply and utilize it in their daily and professional lives.

Learning disabilities represent one of the most prominent challenges facing educational systems globally and regionally, as they profoundly impact learners' academic trajectories and their psychological and social adjustment. In this context, dyscalculia occupies a prominent place among these difficulties due to its wide prevalence and its substantial impact on children's achievement in mathematics in particular, and their cognitive development in general.

1. Problem Statement:

Students with learning disabilities experience specific challenges in acquiring reading, spelling, and arithmetic skills, despite receiving appropriate instruction and being free from intellectual disabilities. Studies indicate that approximately 6–7% of school children suffer from a cognitive or neuropsychological deficit that negatively affects their numerical competence and word-problem solving abilities (Badian, 1983; Gross-Tsur, Manor, & Shalev, 1996). Recent studies on mathematics difficulties attribute these impairments to at least three primary sources: first, difficulty retrieving basic arithmetic concepts from long-term memory; second, the reliance on counting strategies in the absence of sustained attention and focus (Barrouillet, Fayol, & Lathuliere, 1997; Geary, Brown, & Samaranayake, 1991; Jordan & Geary, 1993); and third, deficits in the visuospatial representation of numbers (Montani, 1997).

This idea can be further expanded while maintaining a scientific tone and consistent style, specifically by detailing the relationship between dyscalculia on one hand, and working memory and attention on the other, while linking this to modern explanatory models. Here is the expanded text:

Recent decades have witnessed a fundamental shift in the approach to understanding dyscalculia, as researchers moved from traditional educational explanations—which attributed mathematical difficulties to external factors related to instruction, curricula, or the school and social environment—toward adopting more precise and in-depth cognitive and neuropsychological models. These models posit that the roots of dyscalculia are not confined to external factors, but rather reside primarily in deficits affecting internal core cognitive processes, foremost among which are working memory and attention.

Working memory, as a limited-capacity cognitive system responsible for temporarily storing and processing information during complex cognitive tasks, plays a decisive role in mathematical learning. It enables the learner to retain intermediate numbers and operations while solving arithmetic problems, organize sequential steps, and update information in accordance with task demands. Research has demonstrated that children with dyscalculia suffer from clear deficits in working memory components—particularly the phonological loop (responsible for the verbal processing of numbers), the visuospatial sketchpad (responsible for the spatial representations of numbers and operations), and the central executive, which controls attentional allocation and coordinates cognitive operations.

Attention, particularly selective attention, represents an equally vital cognitive mechanism, as it allows the child to focus cognitive resources on relevant numerical information while filtering out irrelevant or distracting information during problem-solving. Individuals with dyscalculia experience difficulty in selectively directing their attention to the mathematical dimensions of a task, leading to fragmented processing and an increased rate of errors, especially in word problems that require distinguishing essential from non-essential data.

The significance of this neurocognitive approach stems from its ability to explain why certain children with average intelligence and good linguistic achievement fail in learning mathematics despite the availability of appropriate educational conditions. Furthermore, this understanding opens new horizons for early diagnosis and therapeutic intervention based on training these core cognitive processes, rather than relying solely on re-teaching mathematical content through traditional methods. This also explains why dyscalculia frequently co-occurs with other developmental disorders, such as dyslexia and Attention Deficit Hyperactivity Disorder (ADHD), given their shared deficits in central cognitive systems such as working memory and attention.

This expansion maintains scientific terms (working memory, selective attention,

phonological loop, visuospatial sketchpad, central executive, dyslexia, ADHD) and adds explanatory details without altering the original meaning.

Recent decades have witnessed a fundamental shift in the approach to understanding dyscalculia, as researchers moved from traditional educational explanations based on instruction and environmental factors toward adopting more precise and in-depth cognitive and neuropsychological models. These models posit that the roots of these difficulties reside primarily in deficits affecting core cognitive processes such as working memory and attention. The significance of this approach stems from the fact that working memory and attention represent two central and indispensable cognitive structures for processing numerical information and executing mathematical operations.

From this perspective, this article aims to present a systematic theoretical review of the scientific literature concerning the role of working memory and attention in explaining dyscalculia. This objective seeks to outline an integrated and comprehensive theoretical framework that contributes to enriching the cognitive field and establishing solid foundations from which effective therapeutic interventions can be developed.

2. Definition of Concepts

1.2 Dyscalculia:

It is a developmental disorder that affects numerical and mathematical abilities in children with average intelligence, independent of any clear sensory or educational deficits. Estimates indicate that its prevalence ranges between 3% and 7% among primary school children (Shalev et al., 2001; Butterworth, 2005). Researchers distinguish it from mere "mathematical weakness," as it refers to a core cognitive deficit in processing quantities and numbers.

2.2 Working Memory:

Working memory is defined as a capacity-limited processing component responsible for holding information simultaneously with the processing of the retained information or other information (Swanson & Zheng, 2013, p. 215).

3.2 Attention Deficit (Distractibility):

The term "attention deficit" is a recently emerged concept that reflects attentional difficulties that are prominently and commonly observed in children with learning disabilities. Attention deficit is often comorbid with Attention Deficit Hyperactivity Disorder (ADHD), appearing clinically starting from the age of three.

John Carroll affirmed that given normal living conditions for the student, their learning of the required subject or skill is

directly proportional to the amount of focused time spent during the learning process (Mohamed Laamaira, 2002, p. 222).

3. Working Memory Models

Working memory has received widespread attention in cognitive, educational, and neuropsychological psychology, leading to the development of numerous models and theories aiming to explain its structure and functions. Below is a concise review of the most prominent models:

First: Engle's Inhibitory Control Theory:

Engle and colleagues argue that working memory is primarily related to an individual's ability to control and regulate attention, rather than merely to short-term storage capacity. Its function lies in maintaining task-relevant information in an active state while inhibiting irrelevant stimuli and information. According to this theory, individual differences in working memory efficiency reflect a person's capacity to resist distraction and maintain attentional focus, making inhibitory control the primary factor in working memory efficiency.

Second: Long-Term Working Memory Model:

Ericsson and Kintsch proposed that long-term memory plays an important role in supporting working memory by contributing to temporary storage and

retrieval. This model relies on the observation of expert performance across various domains, where experts utilize their prior experience and knowledge stored in long-term memory to process and retrieve information with higher efficiency. This effective deployment of prior knowledge and experience expands the functional capabilities of working memory and enhances its performance in complex cognitive tasks.

Third: Cowan's Embedded-Processes Model:

Cowan defines working memory as the activated portion of long-term memory that remains available for processing through attentional mechanisms. He asserts that information remains active as long as attention is directed toward it or through rehearsal, whereas it decays in the absence of attention. He also emphasizes that working memory consists of an interaction between short-term memory and attention, and that its capacity is relatively limited, as an individual can hold approximately four information units within the focus of attention simultaneously. This model highlights the central role of attention in maintaining and organizing information during cognitive processing.

Thus, these models differ in their explanations of the nature of working memory: while Engle focuses on inhibitory control and executive attention, Ericsson and Kintsch stress the role of long-term

memory and expertise, whereas Cowan views working memory as an activated subset of long-term memory governed by attentional processes.

Fourth: Baddeley and Hitch's Multi-Component Model (1974):

Baddeley and Hitch developed their multi-component model of working memory in response to certain limitations of the Atkinson–Shiffrin model, which assumed that the transfer of information to long-term memory depends primarily on its duration of stay in short-term memory. The researchers relied on empirical and neuropsychological evidence showing that some individuals with short-term memory deficits can efficiently perform complex cognitive tasks requiring the use of long-term memory.

Based on this, Baddeley and Hitch conceptualized working memory as an active system for processing information rather than a mere temporary store. They hypothesized that working memory consists of several specialized components working integratively, wherein the central executive directs attention and coordinates cognitive operations, while other sub-systems handle the temporary retention and processing of verbal and visual information. This model remains one of the most influential and widely adopted frameworks for working memory, serving as a foundation for numerous subsequent theoretical and empirical developments in

the study of cognitive processes and learning.

4. Working Memory and Dyscalculia

Children with learning disabilities exhibit specific difficulties in mastering reading, spelling, and counting skills despite receiving adequate instruction and in the absence of intellectual disability. Approximately 6% to 8% of school-aged children suffer from a cognitive or neuropsychological/psychological deficit, which impairs their counting competence and word-problem solving procedures (Badian, 1983; Gross-Tsur, Manor, & Shalev, 1996). Theoretical models in the domain of counting and arithmetic have identified at least three sources of mathematical difficulty: difficulty retrieving basic arithmetic facts from long-term memory, the use of developmentally immature counting procedures, and common failures involving working memory deficits for words and numbers along with an increased frequency of various errors (Passolunghi & Siegel, 2001). Similar to reading impairments, mathematical abilities do not show significant improvement throughout schooling, and these manifestations of deficit persist over time.

Visuospatial memory is also linked to mathematical abilities. In this context, visuospatial memory functions can be viewed as a mental blackboard upon which numbers, place values, and the alignment

of values and columns in counting and arithmetic are represented. Children with impaired visuospatial memory skills lack sufficient space on this mental "blackboard" to retain relevant numerical information in their minds (McLean & Hitch, 1999).

Specific associations have been found between visuospatial memory and the recoding process in visual problems (Logie, Gilhooly, & Wynn, 1994), as well as in multi-digit arithmetic operations (Heathcote, 1994). Furthermore, visuospatial memory skills uniquely predict performance variability in non-verbal problems (such as quantities represented by blocks) among preschool children (Rasmussen & Bisanz, 2005). Conversely, the role of verbal short-term memory is limited to the temporary storage of a few numbers during mental calculation (Hecht, 2002), as well as contributing to general mathematical skills (McLean & Hitch, 1999; Ryan, 1989; Swanson, 1993).

The study by Passolunghi and Siegel (2004) investigated the relationship between working memory, mathematical ability, and cognitive impairment in children with dyscalculia. A group of children with dyscalculia was selected and compared with a group of typically achieving peers matched for vocabulary, age, and gender ($N = 49$). The children were asked to perform a series of tasks related to working memory and short-term memory, which were administered a year

earlier. Additionally, tasks designed to provide information on verbal speed were administered. The results indicated a general deficit in working memory among children with dyscalculia, particularly in the central executive component of Baddeley's model, which pertains to the capacity to suppress and inhibit irrelevant information. However, children with dyscalculia did not show deficits in speech rate or counting speed tasks, which involve a major contribution from the phonological loop.

5. Cognitive Mechanisms Underlying Working Memory Deficits in Children with Dyscalculia

Some studies have concluded that certain children with dyscalculia may exhibit a selective impairment in working memory tasks where retaining arithmetic information is essential. Siegel and Ryan found that the performance of children with mathematics learning disabilities was similar to that of their typically developing peers on working memory tasks involving sentence processing; however, impairment emerged in working memory tasks that required processing numerical information. In a related study, McAuley and Hitch (1991) found that children with specific difficulties in mathematics exhibited deficits in working memory tasks involving the processing of numerical information, but not in other complex verbal tasks. Conversely, other researchers have found that children with dyscalculia possess a

general deficit in working memory. For example, Passolunghi and Siegel (2001) demonstrated that children with learning disabilities performed poorly across both numerical and verbal working memory tasks.

Some researchers have noted that performance on digit span tasks was lower among children with dyscalculia, whereas other studies found no statistically significant differences in digit span and verbal span, particularly when controlling for reading ability (Hitch, 1999).

It is possible to formulate a hypothesis to distinguish between short-term memory and working memory tasks. Short-term memory operations rely on a "passive storage" system, which involves retaining information without manipulating or processing it in any manner. In contrast, working memory requires more active operations wherein information is temporarily maintained while being manipulated, utilized, and updated. Factor analysis has indicated that short-term memory measures and procedures (e.g., simple forward digit span and verbal span tasks) and working memory procedures (e.g., complex span tasks, such as Daneman and Carpenter's listening span task) load on two distinct factors. Nevertheless, passive and active memory tasks can be conceptualized along a continuum (Cornoldi & Vecchi, 2000). For instance, tasks such as forward digit span and forward verbal span lie closer to the passive

end of the continuum, whereas backward span tasks are closer to the active end and can be considered working memory tasks because they involve manipulating and updating information for processing. A key implication of these assumptions is that children or adults with learning disabilities may experience working memory impairments that are independent of short-term memory deficits.

Furthermore, research examining the cognitive mechanisms that may lead to working memory deficits in children with poor mathematical abilities has placed particular emphasis on inhibition, which plays a vital role in reading comprehension and mathematical problem-solving. Specifically, children with reading disabilities or learning disabilities in mathematics exhibit poor performance on working memory tasks that require the inhibition and suppression of irrelevant information.

Furthermore, previous researchers concluded that children with learning disabilities experience difficulty in inhibiting, suppressing, or retrieving irrelevant associations in simple multiplication problems. Taken together, these findings indicate the presence of a working memory impairment in children with learning disabilities, which may be tied to a deficit in the inhibitory mechanism responsible for purging task-irrelevant information from the system. This hypothesis posits that impairments in

inhibitory processes are linked to a breakdown in the central executive component (Miyake & Shah, 1999).

On the other hand, it is possible for children with learning disabilities not to exhibit a reduction in the number of items they can retain in memory. Engle (2002) hypothesized that individual differences in working memory capacity are not tied to the number of items stored in working memory, but rather to the ability to control attention, maintain information in an active state, and retrieve it rapidly. Moreover, Engle contends that this attentional control is linked to inhibitory deficits, rendering individuals who struggle to sustain focus on task-relevant information more susceptible to intrusion errors.

The phonological loop also plays a role in the ability to solve arithmetic word problems, as resolving these verbal tasks requires encoding as well as comprehension; consequently, deficits in phonological processing may cause difficulties at higher-level cognitive operations, such as word-problem solving (Bowey, Cain, & Ryan, 1992).

Bull and Johnston (1997) found significant differences between high-ability and low-ability mathematical groups of children on measures of speech rate/articulation speed. Swanson and Sachse-Lee (2001) found that impairments in arithmetic word-problem solving were attributable to phonological aspects as well as to executive components,

as outlined in Baddeley's model (1982, 1986). However, results reported by McLean and Hitch (1999) indicate that children with low mathematical abilities scored normally on phonological working memory tasks, but exhibited poor performance on working memory tasks involving executive processing; thus, further empirical evidence is required to reach a conclusive resolution on this issue.

In general, cognitive mechanisms may lead to working memory deficits in children with dyscalculia (Passolunghi & Siegel, 2001), where a general working memory deficit necessitates the processing of both numerical and verbal information. Furthermore, working memory deficits reflect a failure in the inhibitory mechanisms of the central executive component, manifested as difficulty among children in manipulating relevant items within working memory. Additionally, it can be predicted that children with dyscalculia will demonstrate typical performance patterns on short-term memory tasks (e.g., simple span tasks for digits or words) as well as tasks associated with the role of the phonological loop.

6. Theories of Attention

Attention is a fundamental cognitive process that overlaps with various mental activities, contributing to the reception, processing, and organization of information. Theoretical explanations of attention have varied according to differing

conceptualizations regarding its capacity and its role in information processing. Among the most prominent of these theories are the following:

. Attention as a Selective Filter (Broadbent's Filter Theory) Broadbent proposed the filter model to explain selective attention, hypothesizing that sensory information enters the cognitive system through multiple input channels operating simultaneously. Because the volume of incoming information exceeds the processing capacity of the cognitive system, a selective mechanism becomes necessary to regulate the flow and processing of information.

According to this model, information first passes through a "filter" that selects a limited portion based on its physical, sensory characteristics before it proceeds through a capacity-limited channel for perceptual processing. Information that is not selected is briefly held in short-term sensory storage, allowing for potential retrieval if attention is directed toward it within a short timeframe. Subsequently, this unselected information undergoes gradual decay if it is neither processed nor retrieved.

Furthermore, Broadbent posited that the selection process precedes semantic analysis—meaning that the choice of information initially depends on its sensory properties rather than its semantic content. However, this assertion faced criticism

from Treisman, who pointed out the existence of more complex analytical mechanisms that allow for the processing of certain informational features prior to the completion of the selection process, while concurrently acknowledging the existence of a filtering or attenuating mechanism for information.

. Flexible Capacity Allocation Theory of Attention This theory conceptualizes attention as a capacity-limited cognitive resource that can be allocated among different tasks according to their demands. Kahneman (1973) hypothesized that attentional capacity is not fixed, but rather possesses flexibility and undergoes fluctuations tied to task difficulty and cognitive load.

When an individual performs multiple tasks simultaneously, attentional resources are dynamically distributed among these tasks; the share allocated to the more complex or primary task increases, whereas resources dedicated to secondary tasks decrease without being entirely omitted. Kahneman argued that attention operates in parallel across various processing stages, and that heightened task demands necessitate a greater allocation of attentional resources.

This theory indicates the feasibility of dividing attention across several tasks at once, with the volume of resources allocated to each task varying according to factors such as task difficulty, situational

characteristics, and individual differences. This approach was further supported by several subsequent models, including those of Norman and Bobrow, Posner and Snyder, and Navon and Gopher, all of which affirmed the limited nature of available cognitive and attentional resources.

In this context, Norman and Bobrow clarified that cognitive performance is influenced by the nature of the task: if a task is data-limited, resources can be distributed across multiple activities without a noticeable impact on performance; conversely, if a task is resource-limited, it consumes most of the available attentional energy, leading to a decline in performance level, particularly during multi-tasking or increased cognitive load.

7. Attention Deficit (Distractibility) and Dyscalculia from a Cognitive Perspective

Neurocognitive studies have contributed to revealing the brain mechanisms that link attention to numerical processing. Functional magnetic resonance imaging (fMRI) studies have demonstrated concurrent activation in both the superior parietal lobule—associated with processing quantities and numerical relationships—and the prefrontal regions, which are responsible for executive control and attention during the performance of simple arithmetic tasks (Dehaene et al.,

2003). These findings support the hypothesis that attentional deficits do not merely represent a comorbid symptom of dyscalculia, but rather constitute a core component of the underlying neural mechanism of the disorder.

In this context, Dehaene (1997) presented the "Triple-Code Model," which posits that number processing occurs across three representational systems: the visual Arabic code, the auditory verbal code, and the analog magnitude code. Attention plays a pivotal role in regulating the transitions between these systems and directing cognitive resources toward the representation most suitable for the demands of the arithmetic task.

8. Theoretical Explanations of the Relationship Between Attention Deficit (Distractibility) and Dyscalculia

A. Attentional Depletion Hypothesis:

This hypothesis posits that individuals with dyscalculia consume a greater share of attentional resources during numerical processing due to poor automaticity in basic arithmetic operations, which in turn limits the resources available for more complex mathematical operations. Empirical evidence indicates that these individuals exhibit broader brain activation and greater cognitive effort when performing simple arithmetic operations compared to their typically developing peers (Rubinsten & Henik, 2009; Kucian et al., 2006).

B. Functional Interference Hypothesis:

This hypothesis stems from a neurocognitive perspective, assuming the existence of shared neural networks involved in both spatial attention and numerical processing, particularly within the temporoparietal junction (TPJ) and the angular gyrus. Consequently, any functional impairment in these neural structures may simultaneously lead to deficits in spatial attention and disruptions in number representation along the mental number line (Hubbard et al., 2005).

C. Deficit in Automatic Attentional Selection Hypothesis:

Rubinsten & Henik (2005) proposed a distinction between deficits in automatic selective attention and deficits in voluntary selective attention. Findings from Numerical Stroop Tasks have demonstrated that individuals with dyscalculia experience difficulty in suppressing the automatic processing of task-irrelevant numerical information, suggesting that the impairment resides primarily in automatic attentional orientation mechanisms rather than stemming from a weakness in voluntary attentional control (Rubinsten & Henik, 2005).

9. Empirical Evidence on the Relationship Between Attention and Dyscalculia

The scientific literature indicates a close relationship between attentional efficiency

and mathematical performance. A longitudinal study conducted by Shalev et al. (2005) demonstrated that early childhood deficits in selective attention serve as a significant predictor of subsequent mathematical difficulties. Similarly, Passolunghi & Siegel (2004) showed that the ability to suppress irrelevant information within working memory is one of the strongest predictors of mathematical competence.

At the Arab regional level, Al-Waqfi & Al-Natour (2014) concluded that impairments in selective and sustained attention are strongly associated with low mathematical performance among pupils with learning disabilities. Furthermore, a study by Al-Alwani (2016) revealed that children with dyscalculia score statistically significantly lower on measures of sustained attention and attentional inhibition compared to their typically achieving peers.

10. Attention and Working Memory: The Interaction Mechanism in Dyscalculia

Recent literature indicates that the relationship between attention and dyscalculia is not entirely direct, but rather mediated by working memory as the connecting link between mathematical task demands and attentional processes. The central executive component in Baddeley's working memory model fundamentally represents a system responsible for directing attention and allocating cognitive

resources between verbal and visuospatial subsystems (Baddeley, 2000).

Consequently, deficits in central executive functions manifest as impairments in both attention and working memory, which explains the substantial overlap between the symptoms of attention disorders and dyscalculia.

Geary (2011) formulated this relationship within his developmental model of mathematical learning, hypothesizing that the acquisition of mathematical skills progresses through two main phases: an attention-driven learning phase, which demands a substantial investment of attentional resources, followed by an automatization phase, in which arithmetic operations become more automatic and less dependent on attentional control. Part of the difficulty in dyscalculia is attributed to a failure in transitioning from the first phase to the second, resulting in a persistent, heavy reliance on attentional resources even during simple arithmetic tasks (Geary, 2011).

11. Conclusion

It is evident from this theoretical review that dyscalculia is not merely a deficit in acquiring mathematical skills, but rather represents a complex cognitive developmental disorder linked to a set of core mental processes, chief among which are working memory and attention. Research has demonstrated that children with dyscalculia suffer from deficits in

working memory components—particularly the central executive and visuospatial sketchpad—which negatively impacts their ability to process numerical information and solve mathematical problems. Furthermore, theoretical and empirical evidence has shown that attention, across its various components, plays a pivotal role in directing numerical processing and organizing the cognitive resources required for mathematical performance. Modern cognitive and neuropsychological models have contributed to clarifying the nature of the interaction among working memory, attention, and dyscalculia, affirming that mathematical difficulties stem from impairments in the cognitive systems responsible for storage, processing, and executive control of information. Accordingly, understanding this relationship constitutes an essential foundation for early diagnosis and the design of effective intervention programs aimed at enhancing working memory and improving attentional efficiency, thereby contributing to mitigating the impact of dyscalculia and fostering the academic performance of affected children.

References

First: Arabic References

1. Al-Alwani, H. (2016). Attention and indicators of dyscalculia among primary school children [Unpublished doctoral dissertation]. King Saud University, Riyadh.

2. Al-Waqfi, R., & Al-Natour, M. (2014). The relationship of attention to mathematical learning disabilities among primary stage students in Jordan. *Journal of Educational and Psychological Sciences*, 15(3), 185–210.

3. Moawad, M. L. (2002). Classroom learning and teaching. Dar Al-Fikr for Publishing and Distribution, Amman.

Second: Foreign References

1. Baddeley, A. D. (2000). The episodic buffer: A new component of working memory? *Trends in Cognitive Sciences*, 4(11), 417–423.

2. Baddeley, A. D., & Hitch, G. J. (1974). Working memory. In G. H. Bower (Ed.), *The psychology of learning and motivation* (Vol. 8, pp. 47–89). Academic Press.

3. Badian, N. A. (1983). Dyscalculia and nonverbal disorders of learning. In H. R. Myklebust (Ed.), *Progress in learning disabilities* (Vol. 5, pp. 235–264). Grune & Stratton.

4. Barrouillet, P., Fayol, M., & Lathuliere, E. (1997). Selecting between competitors in multiplication tasks: An explanation of the errors produced by adolescents with learning disabilities. *International Journal of Behavioral Development*, 21(2), 253–275.

5. Bowey, J., Cain, M., & Ryan, S. (1992). A reading-level design study of phonological skills underlying fourth-grade children's word reading difficulties. *Child Development*, 63(4), 999–1011.

6. Bull, R., & Johnston, R. S. (1997). Children's arithmetical difficulties: Contributions from processing speed, item identification, and

short-term memory. *Journal of Experimental Child Psychology*, 65(1), 1–24.

7. Butterworth, B. (2005). The development of arithmetical abilities. *Journal of Child Psychology and Psychiatry*, 46(1), 3–18.

8. Cornoldi, C., & Vecchi, T. (2000). Mental imagery in blind people: The role of completely-blind and late-blind individuals. In M. Heller (Ed.), *Touch, representation, and blindness* (pp. 173–194). Oxford University Press.

9. Dehaene, S. (1997). *The number sense: How the mind creates mathematics*. Oxford University Press.

10. Dehaene, S., Piazza, M., Pinel, P., & Cohen, L. (2003). Three parietal circuits for number processing. *Cognitive Neuropsychology*, 20(3–6), 487–506.

11. Engle, R. W. (2002). Working memory capacity as executive attention. *Current Directions in Psychological Science*, 11(1), 19–23.

12. Geary, D. C. (2011). Consequences, characteristics, and causes of mathematical learning disabilities and persistent low achievement in mathematics. *Journal of Developmental & Behavioral Pediatrics*, 32(3), 250–263.