The relation between memory and other cognitive skills and their impact on children's school performance

Emilia Saralegui

Titu Maiorescu University, Bucharest, Romania

Abstract

A complete theory of cognitive development should not be limited only to describing and explaining how memory capacity improves with age, but also to show how these changes interact with other cognitive aspects. Working memory represents the capacity to hold and manipulate information mentally over brief periods of time and plays an important role in supporting a wide range of everyday activities. Actual research emphasizes, on one hand, the impact of cognitive processing on memory, and on the other hand, the impact of working memory on learning skills and school performance. Thus, it was suggested that children with weak memory skills present difficulties in key areas like learning, language, reasoning and problem solving, but also behavioral issues, that should be properly identified and anticipated in order to improve their academic performance by establishing specific educational intervention programs.

Keywords: *working memory, cognitive skills, school performance, intervention*

Corresponding author: Saralegui Emilia

Phone number: -

E-mail address: emiliamoga@yahoo.de

I. INTRODUCTION

Memory improves with age throughout childhood. Various studies have followed children over time to ascertain why this happens, and four possible reasons were explored: working memory capacity (improvement in childhood results from increased capacity rather than increased efficiency, important differences being linked to performance in reading and mathematics - Swanson, 1999), strategies (a variety of decisional processes as rehearsal, categorization and recalling are more evident in older than in younger children – Chi, 1978; Benga, 2006), metamemory (evidence less clear - the knowledge that children have about their own memory skills improves with age, but may not always lead to improved performance –Schneider & Pressley, 1989), content (in areas where children have equal knowledge to adults –chess-, their memory performance is similar – Schneider et al., 1993).

All these aspects suggest that there are certain differences between the amount and type of memory in children and adults and their limitations in capacity may be influenced by use of strategies, content and, possibly, metamemory, but overcoming them is important in assisting general cognitive development. However, a complete theory of cognitive development should not be limited only to describing and explaining how memory capacity improves with age, but also to show how these changes interact with other cognitive aspects. Actual research emphasizes, on one hand, the impact of cognitive processing on memory, and on the other hand, the impact of working memory on learning skills and school performance.

II. THE IMPACT OF COGNITIVE PROCESSING ON MEMORY

Some researchers argue that the changes that appear in memory development should be understood in a wider context, which takes into consideration other cognitive areas, like language development, attention, resistance to interference and strategic planning, as these skills are involved in solving memory tasks.

For example, learning a list of words during several stages of a memory task involves the use of encoding strategies and the effort of focusing attention (Korkman, Kirk, & Kemp, 1998); the attempt of recalling the words after presenting a new list highlights children's ability to resist to interference. The process of listening and retelling a story requires attention and planning, organizing and sequencing, as well as understanding all of the aspects that are narrated in parallel to remembering specific details, the use of semantic and syntactic language and, last but not least, the ability to encode, store and update the contents of information (Norris & Bruning, apud Korkman, Kirk, & Kemp, 1998). The process of face and name recollection implies the

development of certain associations between visual and semantic information. With age, new strategies of identifying these associations also seem to appear.

From this perspective, it is considered that specific memory problems are quite rare in children with learning disabilities and that it is more likely that their memory limitations appear as side effects of deficits in attention, verbal processing or visual perception or due to the presence of brain injuries, the lesion's location being strongly related to certain types of memory deficits (Korkman, Kirk, & Kemp, 1998). In fact, one argues the importance of identifying those primary deficits that underlie memory and learning problems, in order to be able to intervene accordingly.

From our point of view, the relation between memory and other cognitive aspects should not be limited at a causal perspective, emphasizing only which kind of deficits were primary and which appeared afterwards. When we speak about the influence of different variables on memory development, we should not forget the importance of external conditions. These can influence the development „only to the extent that they influence children's mental and physical activity at the time of the original event" (Siegler, 2004), taking into consideration that actual events in the external world cannot be remembered, what children remember is their processing of the events. Ornstein et al.'s research (2004) on the effects of mother-child conversations on children's memory shows that maternal elaborations however uniquely accounted for 5% of the variance in children's recall of the events out of a total of 49% accounted for children's language skills and elaborative talk. These findings suggest that children's remembering is highly related to their processing activity, as reflected both in their speech and in their nonverbal mental activities. In order to understand how external circumstances affect memory development we should see that children are „self-modifying systems" (Siegler, 2004) who process in an active manner what they go through, and that changes appeared in processing activity with age and experience shape the development of memory.

III. WORKING MEMORY AND COGNITIVE TASK PERFORMANCE

Based on the idea that working memory represents the capacity to hold and manipulate information mentally over brief periods of time, some researchers consider that the more limited this capacity of an individual, the more reduced his ability to process information. Therefore, it is suggested that differences in intellectual abilities are actually correlated with differences in the capacity of working memory.

For instance, people with mental deficiency have lower performance on memory tasks, compared to average intelligence people (Hulme & Mackenzie, 1992). Furthermore, individuals with average-intelligence level have poorer results than those with above average intelligence level, especially when the assessment tasks involve memorizing concepts that belong to their area

of expertise (Dark & Benbow, 1991). However, it is difficult to clarify whether these differences are due to structural or to processing aspects. Thus, it is known that the processing speed decreases from the individuals who have outstanding abilities to those with an average intelligence, and further to the persons with mental retardation, these three groups presenting differences also at the level of strategies and conceptual knowledge (Pressley & McCormick, 1995).

Regarding the connection between working memory and IQ, following a detailed analysis of Raven's Progressive Matrices (an analytical reasoning test intended to measure fluid intelligence) Carpenter, Just and Shell (1990) concluded that a mediator for success in solving the task was the discovery and maintenance of rules that regulate the variation among different factors in the problem. Thus, the ability to maintain goal-relevant information in conditions of a concurrent processing and distraction becomes essential for successful performance on Ravens Progressive Matrices.

The capacity of working memory, specifically the ability to maintain the information available for immediate access, plays an important role in supporting a wide range of everyday activities that are based on complex cognitive tasks such as reasoning and problem solving or language comprehension and learning (Baddley, 1996). Complex memory span measures of working memory are closely associated with children's learning abilities in the key scholastic areas of literacy (Gathercole & Pickering, 2000; Swanson & al., 1996) and mathematics (Geary, 2004). The explanation of the central role of working memory in different cognitive tasks could be that working memory is involved in the regulation of activity in certain (more posterior) regions in the brain (Petrides et al., 1995).

A large number of studies have focused on the connection between memory and language, considering that many aspects of language learning involve working memory activity. Thus, positive correlations have been found between verbal working memory and vocabulary comprehension (Gathercole & Baddeley, 1989), on one hand, and the acquisition and understanding of grammatical forms among typical and atypical population, on the other hand (Robinson & al., 2003). Working memory may serve to maintain incoming contextual information while retrieving the necessary lexical and syntactic information from long-term memory. However, a smaller number of studies have investigated the effect of working memory on language production, proving that unlike adults, children show positive correlations between the variables mentioned above. The connection between memory and language production might be mediated by the receptive language of children, by the child's existing lexical and grammatical representations.

Following a similar direction, Pickering and Gathercole (1993, apud Gathercole & Alloway, 2006) have highlighted the correlation between working memory and learning skills in school domains such as arithmetic calculations and reading. Learning difficulties that extend to

the areas of reading and mathematics or those that are related to language seem to characterise children who perform poorly on complex memory measures of working memory, the authors suggesting that the reason for this is that working memory acts as a bottleneck for learning (Gathercole, 2004). The acquisition of knowledge and skills in complex fields such as mathematics and literacy requires the gradual accumulation of knowledge over several learning episodes, many of which take place in the structured school setting.

IV. IMPLICATIONS FOR CLASSROOM LEARNING

Many activities in the school context require the children's ability to maintain certain information activated whilst engaging in other cognitive activity. Children with a poor working memory capacity face serious difficulties with such tasks, and as a result of a working memory overload, they fail in the academic activities. Therefore, the impact of the working memory also extends to various behaviors and activities related to the school context. Gathercole and Alloway (2006) suggested that working memory deficits affect the following aspects of classroom activity:

- Following instructions – reflected in forgetting the content of the instruction especially when the instruction is longer;
- Representing the position of an element in a complex task – in the process of writing sentences from dictation it seems to appear some sort of partial forgetting of the sentences' contents, as omissions, repetitions and intrusions of words and even task abandonment;
- Adjusting to simultaneous requirements of storage and processing – refers to children's failure in complex tasks such as counting the sentences of a text while reading it aloud, or tasks of identifying certain items from a written or oral text;
- Recalling after a long period of time - refers to the forgetting of information from previous activities, which suggests that working memory deficits may limit the flow of information and also the functioning of long-term memory systems.

Working memory represents an important predictor for children's academic performance and the results of longitudinal studies confirm this (Alloway et al., 2005): low scores on working memory tests in early educational training period can actually be useful in order to identify those children who are at risk of experiencing learning difficulties in the coming years. From this perspective, one needs to emphasize the importance of an early memory assessment, as a crucial part in the process of developing a prompt and effective educational program for children with learning difficulties.

The way to minimize different types of working memory problems in children and to improve their learning outcomes is by training. Although significant improvements in working memory performance have been found following extensive programs of training in children, the

effects have been small in magnitude and showed little generalization to other tasks implying working memory (Turley-Ames & Whitfield, apud Gathercole & Alloway, 2006). Out of this necessity, Gathercole & Alloway, (2006) developed an educational intervention program, which aims not only to recognize the warning signs of working memory failures and to evaluate working memory loads, but also to reduce working memory loads by diminishing the overall amount of material to be remembered, the degree of unfamiliarity, by increasing the meaningfulness of the material, by simplifying the structure of verbal material, by re-structuring complex tasks into separate independent steps, by encouraging the use of memory aids, etc. "What is unique about the intervention is that it draws together these elements in a way that will reduce working memory failures in the classroom and so improve the ease and rate of learning of children with low working memory capacities. A further strength of the intervention is that it does not require the adoption of a new approach to curriculum delivery, but represents an approach that can be seamlessly applied in the context of the particular teaching methods in use in a classroom" (Gathercole & Alloway, 2006).

V. CONCLUSIONS

A whole body of research shows that there is a strong connection between working memory, cognitive skills and children's learning ability in main school areas, children with low working memory capacities facing substantial learning difficulties. Many activities in the school context require the children's ability to maintain certain information activated whilst engaging in other cognitive activity.

Children with a poor working memory capacity face serious difficulties with such tasks, and as a result of a working memory overload, they fail in the learning activities. The reason for this is that working memory acts as a bottleneck for learning. This theoretical analysis has direct implications in practice, emphasizing the importance of an early memory assessment in order to recognize the warning signs of working memory problems, but also the crucial role of educational intervention programs with children, aiming to minimize failures of memory and learning resulting from excessive working memory loads.

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