



Working Memory and Processing Speed among Low Achievers in Mathematics

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Abstract

The present study focuses on two major cognitive components, working memory and processing speed, that are considered to be the important predictors of Mathematical performance. It has examined the differences in working memory and processing speed among low achievers in mathematics with learning disability features and without learning disability features. In order to screen the sample, tests used were CPM (coloured progressive matrices, Ravens, 1965) to measure the intellectual ability, Maths achievement test to obtain their mathematical performance and Brigance Diagnostic system of basic Skills (Brigance, 1977) to find their learning disability features. These tests were conducted among 182 lower primary school children at the age group of 8 to 10 years. Out of which 21 were low achievers in mathematics with learning disability features and 21 were low achievers in mathematics without learning disability features. Wechsler's Intelligence Scale for children (Wechsler, 2003) was used to assess the working memory and processing speed of these low achievers in Mathematics. The data obtained was analyzed through t test to find out the significant mean difference. The result shows that there is significant difference in working memory but there is no significant difference in processing speed among low achievers in mathematics based on their learning disability features.

Key words: Working Memory, Processing Speed, Low achievers in Mathematics

Introduction

Specific Learning Disability means a disorder in one or more of the basic psychological processes involved in understanding or in using language, spoken or

written, which may manifest itself in an imperfect ability to listen, think, speak, read, write, spell, or to do mathematical calculations. The term includes such conditions as perceptual handicaps, brain injury, minimal brain dysfunction, dyslexia, and developmental aphasia. The term does not include children who have learning problems which are primarily the result of visual, hearing, or motor handicaps, of mental retardation, of emotional disturbance, or of environmental, cultural, or economic disadvantage (National joint committee for learning disability, 1981). Mathematics has a very important role in our lives; Children who show signs of mathematical difficulties in early years of schooling are having more chances to encounter future career problems and even more problems with their day to day living. Compared to research on other areas of learning disorders such as language difficulties and writing difficulties, field of mathematical difficulty is in its formative years, but now there is a great deal of relevant information available, that can inform us as to how can we adapt and address the difficulties and problems in learning mathematics. Thus Mathematical learning Disabilities (MLD) refers to a specific learning disability affecting the acquisition of arithmetic skills and numerical competences, despite normal intelligence and in the absence of neurological injuries (Temple, 1992). The diagnosis criteria include persistent difficulties in arithmetic facts or arithmetic procedures, in number sense, or in mathematics reasoning (American Psychiatric Association, 2013).

Mathematics revolves upon several cognitive processes of these; Working Memory and processing speed are considered to be the most prominent ones. Working memory is defined as “a brain system that provides temporary storage and manipulation of the information necessary for such complex cognitive tasks as language comprehension, learning and reasoning” (Baddeley, 1992). Many models of working memory have been proposed by different researchers but the multiple component working memory model, Baddeley and Hitch (1974) model still remains the most influential framework in this area (Landeira–Fernandez, Zylbergberg-Landeira, Charchat-Fichman & Cardenas, 2012). It comprises of three components- phonological loop, visuo-spatial sketch pad and central executive. Working memory has a significant role in mathematical performance, for instance, for adding two numbers mentally, requires initially storing the problem in the working memory before a solution can be found. Raghubar, Barnes and Hecht (2010) is of the view that while solving mathematical problem, working memory is required to hold partial information, process new information, and ignore irrelevant information. Studies like Swanson and Beeb Frankenberger (2004) have shown strong relationship (correlation of 0.54) between working memory and mathematical problem solving. Alloway, Gathercole, Kirkwood and Elliot (2009) have suggested the children with low working memory experience difficulties in school related to learning like distractibility, problems generating new solutions, and monitoring the quality of work and in particular subjects including mathematics.

Processing speed, important cognitive function that describes how much time does an individual takes to complete an activity. Processing speed thus predicts an individual's academic performance especially in subjects like Mathematics. Slow processing speed implies poor functioning on activities such as reading, writing, listening or responding. Intelligence cannot be considered as a predictor of processing speed. Processing speed is the ability to process information quickly and automatically, without conscious effort. The higher processing speed, better the higher order functions like thinking, reasoning, decision making and learning. Processing speed is the period between you receive information and time you takes to interpret it and respond. Processing speed is not a good predictor of how quickly someone is likely to learn a new skill. However, once a person has learnt a task, it becomes a very good predictor of how skilled they can become. This basically means that two people may be equally good at learning a new skill, but they may differ greatly in how quickly and accurately they can perform the skill (Lichtenberger & Kaufman, 2012).

Need and significance of the study

This study is an attempt to find whether there is any difference in working memory and processing speed among low achieving children in Mathematics based on their learning disability features. The cognitive mechanisms such as working memory and processing speed have a significant role in development of mathematical skills and performance; these factors also have a significant effect on child's overall academic performance. Literature reviews support that children with Mathematical Learning Disability (MLD) have significantly poor working memory than low achievers and typical achievers in mathematics. There are very few reviews about processing speed and MLD, however some studies indicates that children with MLD have problems with controlled retrieval of information from long-term memory and are slower with respect to general processing speed but few other studies indicate that children with MLD do not display any processing speed delay.

This study attempts to overcome some of the margins in the field of Mathematical learning difficulties in Indian population. It is also expected to be beneficial to teachers, special educators, school authorities and professionals to realize the importance of early identification of mathematical difficulty among lower primary class and to recognize the role of underlying cognitive factors such as working memory and processing speed associated with this difficulty.

Objectives

To find out whether there is significant difference in working memory and processing speed among low achievers in Mathematics based on their learning disability features.

Hypothesis

Hypothesis 1: There is no significant difference between low achievers in mathematics with Learning disability features and without Learning disability features in working memory.

Hypothesis 2: There is no significant difference between low achievers in mathematics with learning disability features and without learning disability features in processing speed.

Method

Sample

The sample for the present study consists of lower primary school children aged between 8 to 10 years, third standard and fourth standard students. Sample was selected after conducting screening test in 182 lower primary school children and thus there are 21 low achievers in mathematics with learning disability features and 21 low achievers in mathematics without Learning disability features.

Tools

1. Coloured Progressive Matrices (Ravens, 1965).
2. Ganitha Vigyan (Screening test by SSA, Kerala)
3. Brigance Diagnostic system of basic skills (Brigance,1977)
4. Weschler's Intelligence Scale for Children-Fourth, Indian edition (Weschler,2003)

Procedure

The population for the study consisted of third and fourth standard students at the age group of 8-10 years, selected from Government and aided lower primary schools in the Ernakulum district, Kerala state. In the initial phase of sample selection, student's performance in Maths achievement test prepared by SSA, Kerala was collected from their concerned maths teachers and their percentage was calculated such that students who fall below the 40 percentage were considered as low achievers in Mathematics. Low achievers were then assessed on different screening tests such as Coloured Progressive Matrices (CPM) and those with average performance on CPM were only included in the study. Further Brigance Diagnostic system of basic skills was employed to find their learning disability features. Thus the present study includes two groups' low achievers in mathematics with learning disability features and low achievers in mathematics without learning disability features. The participants of both groups were

tested on working memory and processing speed subtests such as digit span, letter number sequence test, symbol search, coding from Wechsler's Intelligence Scale for Children.

Statistical Analysis

For comparing the working memory and processing speed between low achievers in mathematics with Learning disability features and without learning disability features, students' t test was employed manually.

Result and Discussion

The present study was conducted to compare the low achievers in mathematics with and without learning disability features on their working memory and processing speed. In order to find out whether there is any significant difference in working memory between the groups, t-test was done and the results are given in table 1.

Table 1: Comparison of working memory scores of low achievers in Mathematics with and without Learning Disability features

GROUP	MEAN	SD	n	t value
Low achievers in mathematics with Learning Disability features	11.23	2.06	21	6.05**
Low achievers in mathematics with without Learning Disability features	16.85	3.04	21	

**p<0.01

From the above table it can be seen that there is significant difference in working memory scores between low achievers in mathematics with and without learning disability features ($t=6.05$, $p<0.01$).

Mean scores indicates that working memory is higher for those without learning disability features compared to those with learning disability features. There are several studies conducted to measure the role of working memory and its components in children with Mathematical learning disability (MLD). Murphy et al. (2007) identified subtle differences in the working memory deficits of their MLD and Low achieving (LA) groups, but there was no specific cognitive or mathematics variable

that differentiated the groups. Rather, the groups differed in terms of more or less severe deficits in the same cognitive and mathematical domains. Geary et al. (2007), in contrast, identified a group of average-IQ children with MLD that had substantial working memory deficits and a group of average-IQ LA children with no such working memory deficits.

Research studies conducted by Swanson and Beeb Frankenberger (2004) have shown strong relationship (correlation of 0.54) between working memory and mathematical problem solving. Alloway, Gathercole, Kirkwood and Elliot (2009) have suggested the children with low working memory experience learning difficulties in school like distractibility, problems involving generating new solutions, monitoring the quality of work and in particular subjects including mathematics.

Studies were also conducted to find the role of working memory and its subcomponents in children with MLD. Recent research was conducted using a broad spectrum of working memory tasks (verbal and visual-spatial) to demonstrate that children with Mathematical Learning Difficulty have deficits with both verbal and visual-spatial working memory functions (Andersson & Lyxell, 2007; Kytälä, Aunio, & Hautamäki, 2010; Passolunghi & Cornoldi, 2008; Wilson & Swanson, 2001), whereas a few studies have found that MLD children only have a deficiency with visual-spatial working memory but not with verbal working memory (Andersson, 2010; Schuchardt, Maehler, & Hasselhorn, 2008).

A recent meta-analysis by Fuchs et al. (2005), has provided evidence that children with Dyscalculia demonstrate numerically specific working memory impairment in comparison to typically developing controls. These deficits are pronounced in working memory tasks that require numerical manipulations, such as backward digit recall; rather than general working memory impairment. Therefore, these findings reflect the specific nature of working memory deficits in children with MLD.

A Contrasting finding to the above study is that there is no evidence of working memory's contribution in MLD children. Bull, Johnston, and Roy (1999) found that 7-year-old children of high and low mathematics ability did not differ on a spatial Working Memory task, when assessed using the forward Corsi block task.

Discrepancy in these results could be in part the result of developmental changes related to the participants' ages but also the different manners of selecting groups.

In order to find out whether there is any significant difference in processing speed between low achievers in mathematics with and without Learning disability features, t-test was done and the results are given in table 2.

Table 2: Comparison of processing speed scores among low achievers in Mathematics with Learning Disability features and without Learning Disability features.

GROUP	MEAN	SD	n	t value
Low achievers in mathematics with Learning Disability features	11.95	2.31	21	1.29
Low achievers in mathematics without Learning Disability features	15.38	4.64	21	

$p > 0.05$

From the above table it can be seen that there is no significant difference in processing speed scores between low achievers in mathematics with and without learning disability features ($t=1.29$, $p > 0.05$).

Processing speed implies how quickly an individual can respond to a given task. Faster processing speed is connected with higher achievement scores, correlation studies showing this relationship is limited than found between intelligence, working memory, and achievement. Low achievers in Mathematics have comparatively poor processing speed than their typically achieving age group. Slow speed in maths related tasks is due to the retrieval problems faced by many low achievers, which causes dependence on poor procedures for problem solving.

Above results indicate that low achievers with learning disability features and without learning disability features do not have significant difference in their processing speed. Few studies found that children with MLD do not display a processing speed deficiency (Chan & Ho, 2010; van der Sluis et al., 2004; Willburger, Fussenegger, Moll, Wood, & Landerl, 2008), whereas other studies report normal inhibition control (Andersson & Lyxell, 2007), shifting ability (Andersson, 2008b; 2010) and visual-spatial working memory (Andersson, 2008b).

There are contrasting studies showing that there is processing speed deficiency in children with MLD. There are some indications that children with MLD have problems with controlled retrieval of semantic information from long-term memory and are slower with respect to general processing speed (Andersson, 2008; Andersson & Lyxell, 2007; Bull & Johnston, 1997; Swanson & Beebe-Frankenberger, 2004).

Conclusion

In summarizing the result obtained in the present investigation, it is found that there exists a significant difference in working memory of low achievers in mathematics with learning disability features and without learning disability features, but there is no significant group difference in processing speed.

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