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THE INTERACTION BETWEEN VISUAL AND SPATIAL WORKING MEMORY IN INDIVIDUALS WITH SPECIFIC LEARNING DISABILITY

Medical Science

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Specific Learning Disorder (SLD) is a generic term used to describe a heterogeneous condition, as it is a single overall diagnosis, incorporating deficits that impact academic achievement. Rather than limiting learning disorders to diagnoses particular to reading, mathematics and written expression, the DSM criteria describes the shortcomings in general academic skills and provide detailed specification for the areas of reading, mathematics, and written expression (Diagnostic and Statistical Manual of Mental Disorders, DSM-5 2015). Several researchers have investigated that the individual with SLD encounter severe learning problems and have difficulty in scholastic achievements due to working memory deficits specifically in visual and spatial memory (Mammarella, Daniela Lucangeli, and Cesare Cornoldi, 2010).

Working memory (WM) refers to the ability of an individual to perform complex tasks to retain the task related information and to access it overtime. WM can be categorized as auditory working memory (AWM) and visuo spatial working memory (VSWM). AWM underpins the capacity to retrieve information and manipulate them as required. The VSWM is a temporary visual store including dimensions such as color and shape (Logie, 1995)

The Evidences of previous studies have shown that VSWM is associated for retaining location information (pattern recognition) and object information (i.e., colors, shapes). The visual working memory (VWM) and spatial working memory (SWM) have distinct information processing as visual memory is responsible for retaining information regarding shapes and colors, whereas spatial memory is responsible for retaining information about locations and movement. This distinction is not always distinguished as visual memory involves spatial information and vice versa. In practice the two systems work together in some capacity but different tasks have been developed to highlight the unique abilities involved in either visual or spatial memory. Carlesimo et al., 2001studied a brain-damaged person and reported that brain damage can impair object memory or spatial memory without impairing the type of memory. Petit et al., 1998 suggested that memory tasks activate different neural substrates than spatial memory task. Klauer & Zhao, 2004 reported that there is less interference between object memory task and or spatial memory task. These studies suggest regarding dissociation between VMW and SWM.

Children with SLD exhibit deficits in working memory and researchers have suggested that as visual working memory plays an important role in storing information during complex and demanding activities, which is required for a child's daily routine, difficulty in performing multi step instructions, failing to complete common classroom activities that require to store multistep commands and manipulate the information and complex activities such as writing, and high level of inattentive and distractible behavior (Alloway , Gather Cole and Pickering 2008). Children with SLD find it difficult to cope up with the demands of the classroom teaching due to various reasons including poor visuo spatial working memory skills etc as it enables to store information for short period of time and retrieve the information. Improving the Visuo spatial working memory can have a direct influence on performance in academics.

Researchers have identified few models to explain the process of storing the information. The object - based model predicts that SWM does not play a necessary role in retaining information about how individual features were organized as objects in VWM. In contrast, other researchers argue that VWM stores feature values from different feature dimensions in separate feature-specific memory stores, and requires SWM and attention to keep those features organized as integrated object representations in memory (Wheeler & Treisman, 2002).

Jiang, Olson, & Chun, 2002 suggested that VWM and SWM can function independently from one another in any context. Specifically, when observers retain objects in VWM they also store information about the spatial relations between those objects. Thus, objects can be stored as part of a larger spatial configuration. But the does VWM stores all visual information as parts of a larger spatial configuration is a subject to be explored.

The individual with SLD have difficulty in coordinating with visual, auditory and sensory inputs and decode instructions by analyzing these repeatedly. Though a number of studies have proved the influence of VWM deficits in academic performance among children with SLD, the interaction between Visuo-spatial working memory has not been evaluated so far in Indian scenario. The present study is a preliminary attempt to shed light on these issues by characterizing the conditions in which VWM and SWM interact and to assess their effect on academic performance.

Aim

The current study aimed to determine the (a) visuospatial working memory deficits in individuals with SLD and (b) to asses the interaction between VWM and SWM and its influence on academic performance in children with specific learning disorder.

Method

Participants: The study involved 40 participants and they were in the age range of 9years – 12 years. The participants were categorized into 2 groups. Group 1 consisted of 20 participants (9 Female and 11 Male) who were diagnosed as individuals with specific leaning disorder (SLD) by qualified speech language pathologist. The test battery administered were Early Reading Skills (ERS), Linguistic Profile Test - K (LPT - K), Test for Pragmatics Skills (TPS), Test for Auditory Comprehension of Language (TACL) and Test for Examining Expressive Morphology (TEEM) and SLD assessment protocol. Group 2 consisted of 20 typically developing children (9 Female and 11 Male) who were in the age rage of 9 years -12 years. All the participants were screened for the presence of neurological, audiological, visual and psychological deficits. Only the participants who passed the screening tests were included in the study.

Design: A dual-task paradigm was used to measure the visual and spatial working memory. This method was previously been adapted by researchers to measure the storage capacity of working memory for objects, locations, and observed movements, (Jiang et al., 2000; Luck & Vogel, 1997; Wood, 2007). The study consisted of 4 tasks, Task 1 (T1) is pattern recognition task in which the individuals had to view the stimulus and mark the location array consisting of varying numbers of locations along the spatial grid within the time lock presentation. Task 2 (T2) is color recognition task, here the participants were instructed to view the color and mark corresponding color. Task 3 (T3) is shape pattern recognition task, here the individual had to plot across the spatial grid within time lock. Task 4 (T4) is color shape recognition task; here the individuals remembered shape and color within given time. The stimulus consisted of 4 tasks and 26 stimuli, which was prepared with increasing complexity using DmDx software with a time lapse of

1500msec between each picture. The study involved 4 experiments to assess the interaction between visual and spatial task and to associate with the academic performance.

Procedure: Each trial began with a 500 ms presentation; Task 1 was pattern recognition task, which had eight different matrices with varying complexity that was presented to the participants. Each matrix was composed of blue dots with different patterns. Each participant was presented with one matrix at a time for duration of less than 500msec. The participants were instructed to remember the pattern and shade the color to the given empty matrix. Initially, the participants were presented with a 2 x 2 matrix pattern followed by which 3x3, 4x4 and 5x5 respectively.

Task 2 is shape pattern recognition task, in this task the participants were presented with a series of 5 images. One image has 1 shape and one blank and the complexity of the task was same for the 1st and 5th image. Each subject was presented with a blank sheet without geometric shape. The participants were instructed to remember the position and shape of geometric pattern that was shown and draw the shape to the given sheet in the same pattern, which was shown.

The Task 3 was color recognition task. In this task the children were presented with a series of 9 images, in different matrices with varying complexity. One matrix with minimum 2-4 colored squares was presented at a time. Where the complexity increased from 1st to 6th image, which had one square blank following to, those next 3 images had all the 4 colored blocks. Each subject was presented with a sheet of the squares without color. The participants were instructed to remember the position and color of squares presented and colors the shape to the given sheet in the same pattern. Initially, the participants were presented with 2 squares in which one was colored and another empty, pattern followed by which 3 squares with 2 squares colored and 1 uncolored and 4 squares with all colored respectively.

Task 4 was color shape pattern recognition task. In this task the participants were presented with a series of 5 images. Where each image has 3 geometric shapes with 2 colored and another uncolored, each subject was presented with a blank sheet. The participants were instructed to remember the colored geometric shape pattern with the position and draw them in the sheet given as shown in the image.

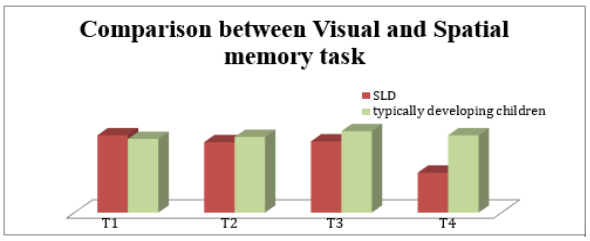
The academic performance record was collected from the teachers and documented. The data obtained were analyzed and was subjected to statistical analysis using SPSSS software version 17.

Results & Discussion

The aim of present study was to assess the interaction between visual and spatial working memory in individuals with SLD and to compare the results between typically developing children and individuals with SLD. The analyzed data was subjected to statistical analysis and the results revealed that there was a significant difference in overall performance of individuals with SLD and typically developing children. The individuals with SLD exhibit visuo spatial memory deficits.

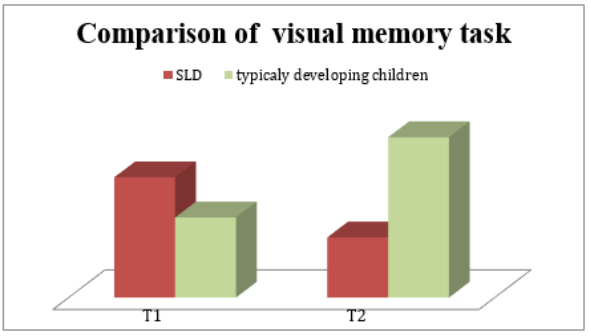
		Mean	Standard deviation	p value
Task 1	TDC	1.8125	0.046497	.084
	SLD	1.9000	0.43726	
Task 2	TDC	2.0000	0.0000	.015
	SLD	1.7500	0.62563	
Task 3	TDC	1.8687	0.42147	.000
	SLD	1.7375	0.53185	
Task 4	TDC	1.9000	0.38925	.000
	SLD	.9800	0.60269	

Table 1: Depicts the overall performance of individuals with SLD and typically developing children (TDC) in visual spatial working memory task.



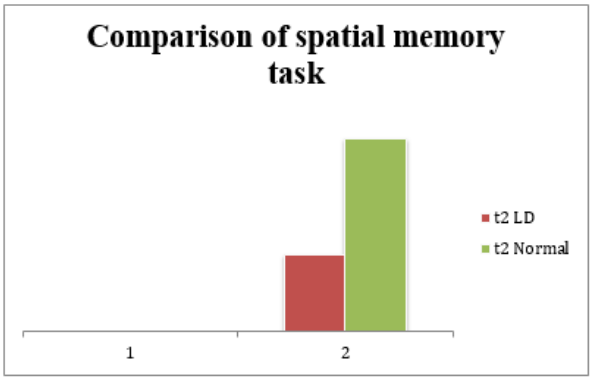
Graph 1: Depicts the comparison between the overall performance of individuals with SLD and typically developing children across the visual spatial memory tasks. It can be inferred from Graph 1 that there was a significant difference in performance of individuals with SLD and typically developing children indicating the children with SLD exhibit visuo spatial working memory deficits. The results of the present study is similar to the study done by Mammarella, Daniela Lucangeli, and Cesare Cornoldi, 2010 which reported that children with SLD experience difficulty in visual and spatial memory.

The second aim of the present study was to assess the interaction between visual and spatial working memory in individuals with SLD and TDC. Task 1 and Task 2 was designed to assess the VWM as it consisted of pattern recognition tasks.



Graph 2: Depicts the performance of visual memory task among individuals with SLD and TDC. The mean scores obtained on Task 1 for individuals with SLD in group one was 1.900 (SD=0.43) and group 2 (typically developing child) is 1.81(SD=0.46). The mean scores obtained on Task 2 for individuals with SLD is 1.75 (SD=0.62) and typically developing child 2(SD= 0.00). Task 1 and Task 2 consisted of pattern recognition task. Results suggested that all participants were able to remember the location of the stimulus and plot it across the matrix, this activity is performed using the visual working memory.

Task 3 consisted of spatial working memory task where the subjects had to store the information regarding features like colors and shapes. The graph 3 depicts the comparison of performance among individuals with SLD and typically developing children in spatial memory skills.



Graph 3: Depicts the performance of spatial memory tasks among individuals with SLD and typically developing children.

The mean scores obtained for individuals with SLD was 1.73

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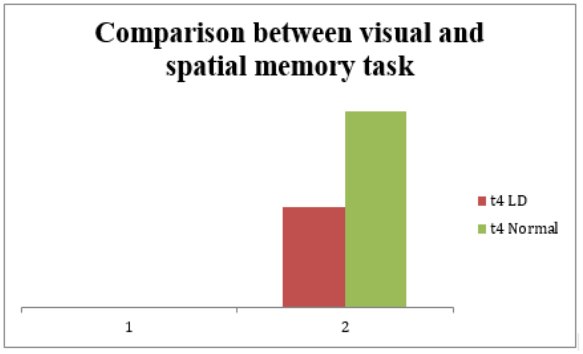
(SD=0.53) and whereas for typically developing children was 1.86 (SD=0.42). The results indicated that participants were able to retrieve the information regarding the coloured features alone which indicates the neural process of working memory can store the spatial features alone.

The Task 4 was to compare the performance between visual and spatial memory task among individuals with SLD and typically developing children. The graph 4 depicts the comparative scores between visual and spatial memory task.



Graph 3: Depicts the comparison between the performance of visual and spatial memory tasks among individuals with SLD and typically developing children. The mean scores obtained for individuals with SLD were 0.98 (SD=0.60) and whereas scores obtained for typically developing child was 1.90 (SD=0.38). The results indicated that the participants who performed well i.e, the typically developing children could complete the task 4 with better performance compared to individuals with SLD. The task 4 involved activities for storing information regarding pattern recognition and simultaneously process information regarding colour coding of shapes. These tasks involved the VWM and SWM to perform simultaneously.

The findings of our study shows that VWM and SWM can operate independently from each other if the participants remember the stimulus in neutral location. However, memory for all other object types (shapes, integrated color-shape objects, and colored objects that are tested at the same locations that they were encoded) requires resources from both VWM and SWM. As location and object information can be stored in separate, independently operating SWM and VWM memory buffers. Hence the performance of VWM and SWM task are interdependent and can perform certain activities independently as the number of locations that can be remembered from the location array will be independent from the number of objects retained from the object array, and vice versa. This indicates that the SWM is required to store object information in VWM also.

To preview the findings, the results of the present study suggested that VWM and SWM could operate independently from one another when observers remember colored objects that are tested at a neutral location. SWM is needed to bind colors and shapes to integrate objects representations in VWM and this has influence on academic performance of children with SLD. The result of our study is similar to the study done by Justin N. Wood (2011). The working memory has been suggested to contain more specialized sub systems for retaining spatio - temporal information object identify information and object tracking, this information has influence on academic performance.

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