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Auditory Measures of Attention & Working Memory in Children with Learning Disability & Typically Developing Children

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Abstract

Learning disability is a general term that describes specific kinds of learning problems. Children with learning disability have deficits in selective attention and working memory. It is believed that difficulties in working memory will influence the ability to attend to a task. The present study was done to investigate and compare the performances of children with learning disability and typically developing children in tasks evaluating auditory aspects of selective attention, divided attention and working memory capacity. 19 children with age range 10 to 14 years participated in the study. Typically developing children group consisted of 10 participants. Learning disability group consisted of 9 children. Dichotic Listening test, auditory stroop task and Digit Backward Recall task were the tests used for assessment of selective attention, divided attention and working memory capacity. Repeated measures of ANOVA was performed to investigate the effects of group (learning disability group and typically developing children group) and ear (Directed Right, directed left and free listening) in dichotic listening task. The test result showed significant main effect of group and ear as well as children in both the groups performed best for directed right condition of directed left task followed by free listening and directed left condition. Independent 't' test results revealed that there was a significant differences in stroop reaction time, digit backward recall and stroop score. In conclusion typically developing children performed better than that of children with learning disability in both tasks.

Keywords: learning disability, typically, children

1. Introduction

Learning may be defined as a central nervous system process in which a diverse amount of undeviating changes are produced that influence behavior, which improves adaptation of an individual to environment (Rotta & Guardiola, 1996). Learning disability (LD) is a general term that describes specific kinds of learning problems. Children with LD have difficulty learning and using certain skills such as reading, writing, listening, speaking, reasoning, and performing mathematical operations (National Dissemination Center for Children and Youth with

Disabilities, 2004).

Children with LD are found to have auditory processing deficits such as weakness in the ability to process verbal information. Various neuro-cognitive processes are involved in auditory tasks, some of which deal specifically with auditory stimuli while others involve functions such as selective attention, divided attention and working memory. Children with LD perform poorly in tasks of divided attention such as the binaural integration of dichotic listening (DL) task where a child is asked to recollect both stimuli. Pinheiro, Oliveira, Cardoso, & Capellini (2010) studied the dichotic listening task among children with LD and typically developing (TD) children, and reported of inferior performance of children with LD compared to TD children. Selective attention involves focusing on some mental activity to the detriment of others which can be assessed by using selective attention stage of DL task in which a person has to recover the stimulus heard in one of the ear irrespective of the other ear. This technique is still used by researchers to study how information is processed with respect to hemisphere specific tasks (Broadbent, 1954).

Stroop task is another test of selective attention which is found to be impaired in children with LD (Faccioli, Peru, Rubini & Tassinari, 2008). Stroop effect has been extensively studied in cognitive neuroscience. The classical stroop interference (Stroop, 1935) is a cognitive interference phenomenon observed in naming printed color of color words when the printed color is incongruent with colour designated by the word. Auditory stroop effect may result from congruency &/or in congruency between the linguistic and the non-linguistic parameters. Auditory conflict processing was investigated by means of behavioral and electrophysiological measures using auditory stroop task (Henkin, Soffer, Gilatt & Muchnik, 2010). A significant behavioral stroop effect was manifested by prolonged reaction time and reduced performance accuracy. The use of stroop effect was suggested to understand the impaired auditory and linguistic processing in clinical population.

Another important estimate of cognitive ability is working memory capacity (WMC) which is also found to be impaired in these children and it can be estimated using digit backward recall (DBR) task. DBR is often employed as a measure of working memory (Gathercole, Pickering, Ambridge, & Wearing, 2004). DBR task is used to measure number storage capacity of working-memory. Participants were presented with a series of digits (e.g., '8, 3, 4') and they had to immediately repeat them back in the reverse order. On successful performance, they are given a longer list (e.g., '9, 2, 4, 0'). Nature of auditory difficulties may vary across subpopulations of dyslexia. Individuals with a broader profile of linguistic deficits tend to have a broader profile of auditory deficits (Heath, Hogben, & Clark, 1999; McArthur & Hogben, 2001), which is often concurrent with somewhat broader cognitive deficits. Children with LD have deficits in selective attention and working memory. It is believed that difficulties in working memory will influence the ability to attend to a task. The present study was done to investigate and compare the performances of LD children and TD children in DL test, auditory stroop task and DBR task. These tasks were selected to evaluate the auditory aspects of selective attention, divided attention and WMC. The study aimed to investigate and compare the performance of children with LD and TD children in DL task, auditory stroop task and DBR task.

2. Method

19 children (13 males & 6 females) with age range 10 to 14 years participated in the study. The participants were enrolled in fourth to seventh standard of basic education in English medium schools in Mangalore. TD children group consisted of 10 participants. LD group consisted of 9 children who were diagnosed with learning disability.

Procedure

DL task: The auditory stimuli in the DL task consisted of six stop consonants paired with a vowel /a/ to form the CV-syllables /ba/, /da/, /ga/, /pa/, /ta/, /ka/. The syllables were presented as stimulus-pairs, one CV-syllable to the left ear and simultaneously another CV-syllable to the right ear. The CV-syllables were paired with each other for all possible combinations, yielding a total of 30 pairs. The data was scored as the number of correct responses from left and right ear, respectively, with a maximum score of 30 for each ear and condition [Free listening (FL), Directed right (DR), Directed left (DL)]. The syllables were originally read by a female speaker with constant intonation and intensity and were stored digitally on a laptop. Each CV syllable was 300–400 ms long, and the inter stimulus interval was approximately 5 seconds. Stimuli were presented at a comfortable level for all the conditions. In FL condition, all trials were dichotic presentations of the syllables, one syllable presented to the

left ear and another syllable presented to the right ear simultaneously. Participants were requested to repeat both the stimuli. In directed attention condition, instruction was to listen only to the right ear or the left ear and to ignore the stimulus in the other ear.

Auditory stroop task: Selective attention was measured for all participants using Stroop left right task (Pieters, 1981) using Alvin software. Participants were presented with 40 stimuli at a comfortable level using stereo headphones connected to a laptop. The stimuli used for the task were the words 'left' and right' which were presented randomly in one of the ears. The participants were asked to press 'L' in the keyboard if the word was heard in the left ear and 'R' if it was heard in the right ear irrespective of the word presented. The participants were asked to respond as fast as possible. The reaction time was measured automatically by the software for each of the stimulus. The average reaction time was calculated for the total correct responses for each participant.

Digit backward recall (Task of WMC): The test involved repetition of a series of spoken digits in backward order, beginning with a span length of 3 digits and progressing until a particular length was repeated incorrectly, in line with the method suggested by Kronenberger, Pisoni, Henning, Colson, and Hazzard (2011). With every correct response, the series increased in number/length till the subject responded incorrectly, following which the series length decreased by one step. The procedure was terminated after 4 consecutive trials. The last length of digits that was repeated correctly was taken as the final score.

3. Results

Repeated measures of ANOVA was performed to investigate the effects of group (learning disability group and typically developing children group) and ear (DR, directed left and FL) in DL task. The test result showed significant main effect of group ($F=9.544$, $p=<0.05$), this indicates that typically developing children performed better compared to that of children with learning disability in all three variables of DL task. The test results also revealed a significant main effect of ear ($p<0.05$) and children in both the groups performed best for DR condition of DL task followed by FL and directed left condition.

The participants in control group performed better than that of experimental group in both tasks. The mean and standard deviation values obtained for the tests performed are mentioned in table 1.
Table1. Representing the mean and standard deviation for stroop reaction time, digit backward recall and stroop score.

	MEAN	STD DEVIATION
Stroop reaction time		
LD	2.7381	449.96759
TD	2.1798	513.96181
Digit backward recall		
LD	2.0000	.70711
TD	3.2000	.63246
Stroop score		
LD	27.1111	9.08907
TD	37.2000	4.68568

Independent 't' test was performed to investigate any differences in the performance of children with learning disability and typically developing children for stroop reaction time, stroop score and DBR task. The results revealed that there was a significant differences in stroop reaction time ($t(17)=2.506; p<0.05$),digit backward recall($t(17)=-3.906; p<0.05$) and stroop score ($t(17)=-3.090; p<0.05$).

Mean values for Stroop reaction time and DBR are represented in Figure1 and Figure 2 respectively.

Figure 1. Representing stroop reaction time of LD and TD group

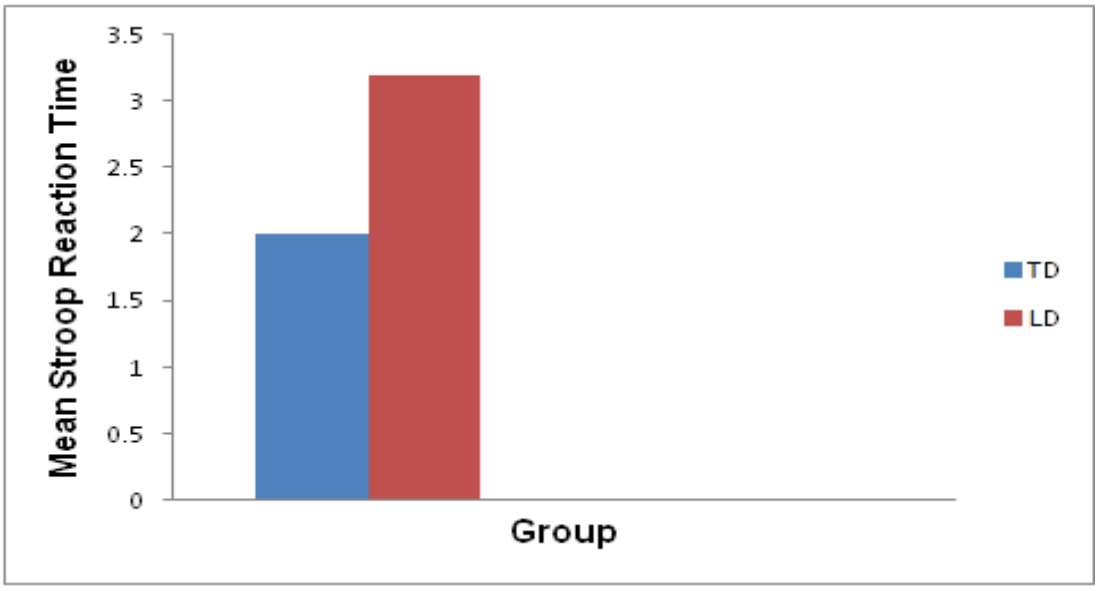
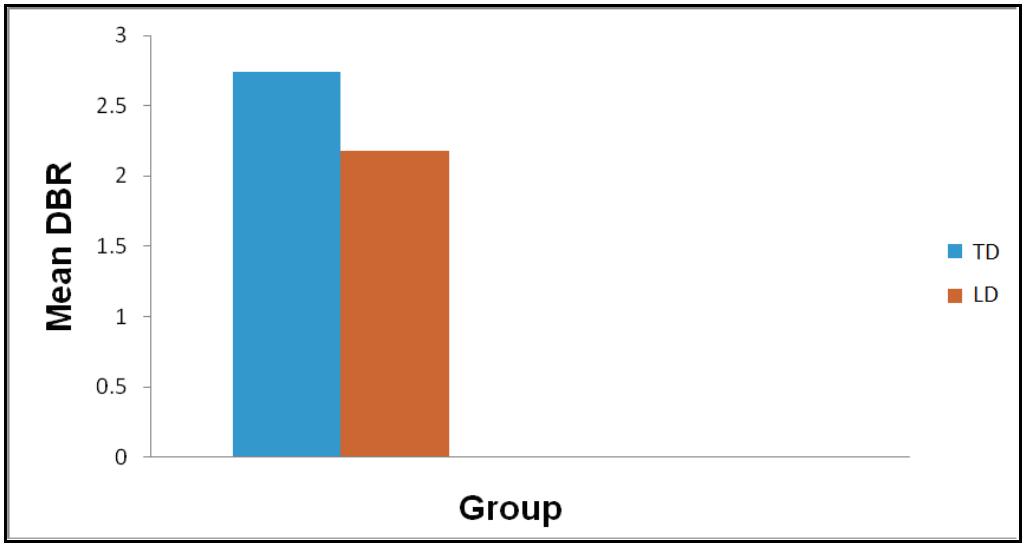


Figure 2. Representing DBR score of LD and TD group.



4. Discussion

The results of the present study revealed that the TD children performed better compared to that of children with LD in all three DL tasks. It is more likely that language is lateralized in both TD and LD children, but the efficiency of the language processor is less functional in those with LD and may represent one aspect of a more general maturational lag (Obrzut & Boliek, 1986). A study done to characterize and compare the performance of students with and without LD in dichotic listening tests, alternating dissyllable test showed that, the children with LD presented with inferior performance compared to TD children, both on dichotic listening tests and on alternating disyllable tests (Pinheiro, Oliveira ,Cardoso ,& Capellini, 2010).

Dichotic listening performance for two learning-disabled groups was significantly lower than that of the control subjects in all dichotic conditions (Tobey, Cullen & Rampp, 1979). Analysis of trials in which only one response was correct showed no differences between the groups in terms of magnitude or direction of ear-advantage (right). The present study children in both groups had right ear advantage (REA) followed by FR and directed left condition. Several studies relating cerebral dominance and reading disability revealed a REA in reading-disabled children (Bryden, 1970; Satz, Rardin, & Ross, 1971; Leong, 1976).

In the present study children with LD manifested more conflict in auditory processing behaviourally than TD children by prolonged reaction time in stroop task and reduced performance accuracy. The selective attention to reading hypothesis is based on the premise that interference occurs because attentional capacity is limited, and subjects are unable to fully suppress the automatic tendency to read words (Klein, 1964). This study shows that the children with LD depict deficits in stroop and DL tasks. Selective listening in good and poor readers indicated that the poor readers did not demonstrate atypical laterality or phonetic processing effects, although there was significant difference in their ability to identify both items on dichotic trials correctly (Dermody & Mackie, 1983). The results indicated that reading-disabled children exhibit a deficit in their capacity to process two items on dichotic tasks.

The present study revealed that children with LD performed poorly in DBR task of WMC. Research examining specific subtypes of LD has found that working memory deficits underlie the difficulties of students with reading and mathematical disabilities (Swanson, 1993) which is in consonance with our study.

5. Conclusion

In conclusion, the present study revealed that children with LD performed poorly as compared to TD children in tasks of selective attention and WMC. Auditory selective attentional deficits and WMC need to be examined in children with LD which would provide dimensions and baseline for the interventional process to be carried out. Hence the tests employed in the present study can be employed in future to investigate selective attention and WMC in children with LD.

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