The International Journal of Indian Psychology
ISSN 2348-5396 (Online) | ISSN: 2349-3429 (Print)
Volume 12, Issue 1, January- March, 2024
DIP: 18.01.213.20241201, DOI: 10.25215/1201.213
https://www.ijip.in

**Research Paper**

# Working Memory Intervention for Children with Specific Reading Disorder

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## ABSTRACT

In the present study, the effectiveness of a working memory intervention was demonstrated for improving memory among children having Specific Reading Disorder. A sample of ten students between the ages of 8 years to 9 years was drawn from clinical settings. The participants had average IQ and were diagnosed with Specific Reading Disorder. They were assigned to either the experimental (N=5) or the control group (N=5). Pre-test and posttest assessment (Test of Memory for Children by NIMHANS) was conducted to assess memory before and after the intervention. Results showed that participants from both groups showed improvement in memory, but the degree of improvement was greater in the experimental group, compared to the control group. There was a large effect size (Cohen's d= 3.51) in terms of the difference in post test scores of experimental groups versus control group. The findings indicate that working memory intervention is beneficial for improving memory among children with Specific Reading Disorder.

***Keywords:*** *Working Memory, Specific Reading Disorder, Individualized Intervention*

The term 'working memory' originated in the world of computer research (Newell & Simon, 1956), then entered the study of human memory, thanks to Miller, Pribram and Galanter (1960), and was further popularized by A. D. Baddeley and Hitch (1974). Working Memory (WM), which develops as early as 4 years (Alloway, Gathercole, & Pickering, 2006; Roebers & Zoelch, 2005), allows us to temporarily retain information about a task. This is crucial for complex activities like reasoning, planning, manipulating linguistic information, executive control, and coordinating perception and complex cognitive tasks., e.g. remembering phone numbers, one-time passwords, recalling routes to a destination, etc. Similarly, it is also involved in reading comprehension (Borella, Carretti, & Pelegrina, 2010; Carretti, Borella, Cornoldi, & De Beni, 2009).

### *Baddeley's model of working memory*

Working memory is a multicomponent system (Baddeley, 2003) with three parts. The phonological loop temporarily maintains verbal and auditory information. The visual–spatial sketchpad stores and processes static visual and spatial dynamic information. The central

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**Received: March 23, 2024; Revision Received: March 28, 2024; Accepted: March 31, 2024**

executive focuses and switches attention and plans, monitors and regulates cognitive processes. (Baddeley, 1996; Baddeley, 1986). This model has met with a broad consensus (Baddeley, 2012) and further developments of the model (Baddeley, 2000) have maintained the distinction between a modality-independent component and modality-dependent verbal and visuospatial components of STM. To answer some criticisms and questions about the integration of working memory with long term memory, (Baddeley, 1996), more recent versions of the WM model include the "episodic buffer," which allows the system to integrate data from several sources, including LTM (Baddeley, 2000). Other theoretical frameworks have also been developed, such as the Degradation Hypothesis, which states that higher order cognitive functions are also impacted when perceptual signals are degraded (Wilson et. al., 2014).

***Working memory and academic performance***

Working memory influences academic performance in various domains including reading and mathematics. This happens through processes like retaining retrieved information and using it with recent inputs (Swanson & Beebe-Frankenberger, 2004), planning studies efficiently (Kızılaslan & Tunagür., 2021), its role in executive function and problem solving (Miyake et al., 2000), the general process of acquiring knowledge and new skills (Lu, Weber, Spinath, & Shi, 2011; Pickering, 2006; St. Clair-Thompson & Gathercole, 2006), and even modulating the severity of learning difficulties (Gathercole. et.al., 2006). The influence of working memory on performance differs across the academic lifespan (Alloway & Copello, 2013; Alloway & Gregory, 2013); it is especially a significant predictor of academic success at the beginning of formal education, even more than IQ (Alloway & Alloway 2010). Reading deficits are connected to complex memory, language and phonological awareness, while mathematical ability is related to complex memory, phonological STM and phonological awareness (Gathercole, S. E..,2006).

***Working memory and reading***

Research has shown a moderate correlation between reading and working memory (Peng, et. al., 2018) and it affects classroom performance (Alloway & Alloway, 2010; Gathercole, Pickering, Knight, & Stegmann, 2004; Pickering, 2006; Masoura et.al., 2006). Reading involves complex cognitive processes (Alloway & Alloway, 2010), and children with dyslexia often struggle in this area. Because of difficulties in interpreting phonemes and morphemes, skipping or adding to texts, and interpreting words differently from their intended meanings, their daily learning processes are disturbed. As a result, they also face difficulty in planning, arranging, and execution of normal tasks that call for mentally creating a "to do" list structured by time and location- and those are some of the key deficits faced by individuals with lower working memory capacity.

***Processes involved in reading disorders***

Often, phonological processing is cited as one of the most important causes of dyslexia. Working memory is at least an equally important, if not more important, factor underlying reading difficulties (Kızılaslan and Tunagür, 2021; Maziero et. al., 2020), but it is relatively less researched (Warmington et al., 2013). In fact, phonological processing mediates the relationship between working memory and reading. (Knoop-van Campen, Segers & Verhoeven, 2018)

Children with reading difficulties and developmental dyslexia are consistently poor performers on measures of phonological processing, verbal short-term memory and verbal complex memory, when compared with typically developing peers. Auditory temporal

processing difficulties are also commonly observed in children with dyslexia (Ahissar, Protopapas, Reid & Merzenich, 2000) (Fostick et. al., 2012), making it a multi-deficit disorder (Fostick & Revah, 2018). Response inhibition, divided attention and auditory working memory are also negatively affected (Lonergan et. Al., 2019). Children with dyslexia also struggle with the ability to bind visual and phonological information (Toffalini, et. al., 2016).

Many of these processes are interrelated, e.g., working memory encodes, stores and retrieves auditory and verbal information (Fougnie, 2008), which facilitates phonological processing (Baddeley et al., 1998) (Schwarb, Nail & Schumacher, 2016). When auditory processing is impaired, encoding of speech sounds also suffers.

***Purpose of the present study***

The function of learning disability in the development of working memory is a less studied topic, and further research in this area is needed in the Indian setting. It is important to conduct research on samples from different countries because along with the presence of learning disabilities, a low socioeconomic status also hinders the development of working memory (Pandey and Tripathi, 2019). Hence, the current study was designed to look into the effect of a working memory intervention on memory among children with reading disorder, on a sample of students from a developing country like India.

## METHODOLOGY

***Sample***

The total sample of the study consisted of 10 participants between the ages 8 to 9 years. All participants had average IQ as assessed by the Raven's Colored Progressive Matrices (CPM) and met the ICD criteria for Specific Reading Disorder. They didn't have any comorbid psychiatric or neurological conditions, and were not undergoing any remedial training at the time of the intervention. They were studying in English medium schools, and had been in the same school for at least the past 2 years.

***Instruments***

- **Sociodemographic & clinical datasheet** (Prepared by investigator) Socio demographic & clinical datasheet was prepared by the investor to collect personal, sociodemographic and clinical data about the participants. It was also used to screen the participants according to inclusion and exclusion criteria.
- **CPM for intelligence screening:** CPM is a culture fair test developed by Court and Raven (1983). It is used as a measure of intelligence and general cognitive ability, including analysis-synthesis, visual reasoning, visuo-spatial judgement and problem solving. The child version of the test, known as coloured progressive matrices (CPM), has three sets of 12 items of progressively increasing order of difficulty in each set. This test will be used to screen participant's intelligence.
- **Test of memory for children by NIMHANS:** This test was developed by Barnabas I, Subakrishna, Kapur M, Uma H and U.K Sinha. It is a battery of twelve tests that assess memory in different forms. The test has norms for the age group of 7-11 years, with a test-retest reliability ranging from 0.51 to 0.97, and internal consistency validity ranging from 0.27 to 0.78, for different subtests. Profile analysis on all subtests for normal children as well as children with epilepsy indicates adequate clinical application.

***Procedure***

Five participants were assigned to the experimental and control group each. The experimental group received a working memory intervention for 9 weeks, with a 30 minutes session per day, on alternate days of the week. The intervention was individualized as per the pace of development of each participant, to be completed under parental supervision. The control group was not given any intervention. Pre-test and post-test assessment were conducted using the Test of Memory for Children by NIMHANS for both groups.

## RESULTS

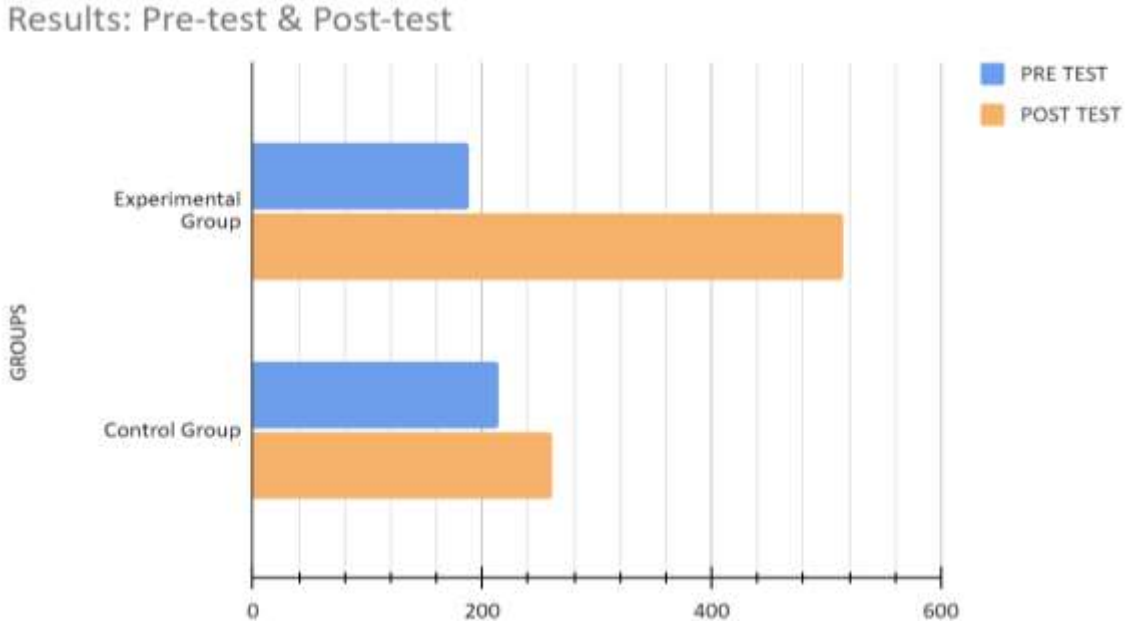


***Figure 1: Pre-test and post-test scores of experimental and control groups on NIMHANS TOMC***

Figure 1 indicates that both, the experimental group and control group participants, showed improvement in memory in the post-test assessment, compared to their pre-test scores. However, it is evident that the degree of improvement was greater in the experimental group than the control group.

***Table 1: Mean pre-test and post-test scores of the experimental group on TOMC***

| **Experimental group** | **n** | **Mean score** | **Std deviation** | **Cohen's d** |
|---|---|---|---|---|
| **Pretest** | 5 | 37.8 | 21.01 | 3.66 |
| **Posttest** | 5 | 102.8 | 13.71 | |

Table 1 shows that the total score obtained by all participants in the experimental group improved in the post-test, as compared to the pre-test. There was a large effect size in terms of difference between pre-test versus post-test scores (d=3.66), indicating significant improvement.

***Table 2: Pre-test and post-test scores of control group on TOMC***

| **Control Group** | **n** | **Mean score** | **Std deviation** | **Cohen's d** |
|---|---|---|---|---|
| **Pretest** | 5 | 42.8 | 14.11 | 0.64 |
| **Posttest** | 5 | 52.2 | 15.07 | |

Table 2 shows that the control group, even without intervention, showed improvement in its performance on TOMC. A medium effect size (d=0.64) was found in terms of difference in pre-test and post-test scores.

***Table 3: Comparison of post-test scores of experimental groups versus control group on TOMC***

| Post-test scores | n | Mean score | Std deviation | Cohen's d |
|---|---|---|---|---|
| **Experimental group** | 5 | 102.8 | 13.71 | 3.51 |
| **Control group** | 5 | 52.2 | 15.07 | |

In Table 3, when we compare the mean post-test score of the experimental group with that of the control group, we find a significant difference with a large effect size (d=3.51). This indicates that while both groups showed improvement, there was a notable difference in degree of improvement. The experimental group showed more improvement than the control group.

## DISCUSSION

The objective of the present study was to investigate whether a working memory intervention would improve memory among students with Specific Reading Disorder. It was found that children who received the intervention showed improvement memory. Those who didn't receive the intervention also showed improvement in memory, but to a lesser degree compared to those who had received intervention. The possible reason could be two children had already initiated some training program a week before the post-assessment was done.

Past findings have established a link between reading and working memory (Peng, et. al., 2018), partly because there is an overlap between the difficulties experienced by children with reading disorder and those with poor working memory. Even though working memory is equal in importance to phonological processing in terms of its role in dyslexia (Kızılaslan and Tunagür, 2021; Maziero et. al., 2020), it is relatively less researched (Warmington et. al., 2013). The present study has made a contribution to the growing body of research on role of working memory in reading disorders. Moreover, in the early years of formal education, working memory is an even bigger predictor of academic success than IQ (Alloway and Alloway, 2010), which means that the findings of the present study have important implications for the selected age group of 8 to 9 years.

Schools looking to introduce training programs for children who struggle with reading can utilize this intervention. Even special schools, clinics, etc. can administer this intervention with the help of psychologists, teachers, and special educators. In India, many training centers implement interventions that have been developed in foreign countries, or using programs that are not standardized. The present study provides a more effective alternative that has been tested in an Indian sample of students.

Future research could examine the effects of this intervention for a larger sample to validate the findings further. The present sample was homogenous in terms of educational experiences of participants. More studies with diverse samples in terms of socio-economic status and educational opportunities are required to examine whether the intervention is effective under different conditions. Apart from working memory, various other neuropsychological functions like executive function, can be assessed in connection with reading ability. Further exploration can also be done on the role of homework tasks in learning during working memory interventions.

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***Acknowledgment***

The author(s) appreciates all those who participated in the study and helped to facilitate the research process.

***Conflict of Interest***

The author(s) declared no conflict of interest.

***How to cite this article:*** Haleemunnissa, S., Venkatesan, S. & Godbole, R.A. (2024). Working Memory Intervention for Children with Specific Reading Disorder. *International Journal of Indian Psychology*, *12*(1), 2337-2344. DIP:18.01.213.20241201, DOI:10.25215/1201.213