International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

A Study Measuring the Impact of Memory Training and Phonological Processing Intervention on Verbal Working Memory and Phonological Skills in Children

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Abstract: ***The present study examined the effect of phonological processing and working memory intervention on the verbal working memory and phonological skills of children with Specific reading disorders. Ten participants between 7 to 10 years of age who met ICD 10 criteria for specific reading disorders, were assigned to an experimental group, or a control group. Intelligence screening was done using the Colored Progressive Matrices. Pre - test and post - test measures were the Test of Memory for Children (TOMC) and Informal Reading Assessment (IRA). The intervention group received 30 sessions of phonological processing intervention and working memory intervention. The control group received no intervention. Post - test assessments included TOMC and IRA. Participants who had received the intervention showed more improvement than controls. The majority of the participants in the experimental group performed higher post - intervention.***

Keywords: phonological processing, verbal working memory, specific reading disorder, phonological skills, individualized intervention

1. Introduction

Recent researchers suggest taking into consideration that reading as a skill mostly materializes in "socio - culturally constructed literacy practices" (Frankel et al., 2016). It necessitates the integration of visual, orthographic, phonological, and semantic information, creating an exceptionally complicated process. Impairments in children with Specific reading impede their ability to read fluently and turn into a barrier to achieving academic targets. Phonological awareness is known to be associated with reading disorders.

Consistent findings suggest deficits in verbal working memory and phonological awareness in children with developmental dyslexia (Maziero et al., 2020). Children with SRD have abnormalities in cognitive processes linked to verbal working memory and attention but not in global processing speed (Lotfi et al., 2022). The most widely known reading disorder is dyslexia.

Phonological processing has been determined to be the most effective single predictor of isolated dyslexia, and all phonological processing subcomponents (phonological awareness, lexical access, and verbal short - term memory) showed significantly worse performance in dyslexic children (Peters et al., 2020).

Research over the years has shown that people with SRDs face difficulty understanding and identifying these particular sounds, further storing these sounds (in short - term memory), and then retrieving them when speaking the language. So, based on the phonological theory, when the requisite awareness–phonological awareness– of these features does not exist or is a deficit, that gives rise to dyslexia (Fostick & Revah, 2018; Berent et al., 2013). Phonological awareness refers to a person's distinctive awareness of the sound structure of spoken words. Phonological memory is another component of working memory. It refers to a person's ability to store speech - based information in short - term memory. Rapid automatized naming (RAN) refers to a person's ability to access and retrieve information from their memory as quickly as possible. It includes the automatic naming of familiar things such as letters, numbers, colors, and objects. Students who have a weakness in one or more of these areas are more likely to experience learning difficulties even later on.

Interventions focusing on adaptive phonological training have proven to be beneficial. The interventions are typically focused on the three processing skills: phonological awareness, quick automated naming, and phonological short - term memory. The phonological training programs provided are often based on the mental representation of phonemes, their identity, and their locations in words. Research has shown that phonological training enhances retrieval of the phonological code (RAN) and phonological STM in addition to the PA commonly seen in children with reading disabilities (Layes et al., 2019).

Verbal working memory plays a crucial role in reading for several reasons: sentence comprehension, vocabulary acquisition, decoding and phonological processing, text

structure and organization, and problem - solving. Overall, verbal working memory is essential for holding and manipulating information in real - time, allowing us to comprehend and make sense of written text as we read (La Barge & Samuels, 2017; Pirozzolo & Wittrock, 2013).

Remediation programs for phonological awareness and verbal working memory have shown distinct improvements in children with reading disorders (Ferraz et al., 2018). The results of training on working memory have certain contradictions when compared to studies conducted over time (Cancer et al., 2019; Maehler et al., 2019; Tikdari & Kafi, 2018). Children with dyslexia are known to make more mistakes compared to children not diagnosed with dyslexia. The differences between the two groups primarily indicate the biggest discrepancies with phonological errors. Semantic stimulation is also known to benefit improvements in spelling and also lead to a reduction of errors that are more phonological and morphological in nature (Rijthoven et al., 2021).

2. Sample

Ten participants between 7 - 10 years of age with average intelligence, meeting the criteria for Specific Reading Disorder as per ICD 10, and studying in an English medium school were selected from clinical and school settings. Children with comorbid psychiatric and neurological conditions and children with prior remedial training were excluded. A socio - demographic and clinical datasheet and CPM were administered for background information and intelligence screening.

3. Instruments

3.1 CPM for intelligence screening:

CPM, or Colored Progressive Matrices, is a version of the Raven's Progressive Matrices given by Couert and Raven (1983). It is adapted for use with children between the ages of 5 to 11 years and people with suspected intellectual deficits. It is a measure of intelligence, cognitive ability, visual reasoning, and problem - solving. It 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.

3.2 Informal Reading Assessment (IRA):

Developed by Rukmini Krishnaswamy, the IRA was created to help teachers modify a child's reading program and assess a child's proficiency in three areas: reading comprehension on grade - based passages, word analysis skills (consonant sounds, consonant combinations, short vowel sounds, vowels in words, blending sounds), and vocabulary. It provides the baseline of the phonological skills in children to carry the intervention forward. To get an accurate assessment of Indian children's phonological awareness abilities this test will be used.

3.3 Test of memory for children by NIMHANS:

This test was developed by Barnabas I, Subbakrishna, 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 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.

4. Procedure

Five participants were assigned to the experimental and control group respectively. The experimental group received a phonological processing intervention for 8 - 9 weeks, with a 1 - hour session per day, 30 minutes of phonological processing tasks, and 30 minutes of memory training, on alternative days of the week. The intervention was individualized as per the pace of development of each participant. The control group was not given any intervention. Pre - test and post - test assessments included the Test of Memory to assess verbal components for Children and the Informal Reading Assessment to assess phonological skills.

The phonological processing intervention activities were selected and modified from the manual, 'The Gillon Phonological Awareness Training Programme for Children at Risk for Reading Disorder' (2008), and tasks developed by Dr. Akila Sadasivan, 2009, for her doctoral thesis, which were based on Professor Gail Gillon's model. The intervention consisted of activities in domains like phoneme identification, isolation, rhyming, segmentation, substitution, deletion, blending, phoneme manipulation, and tracking sound changes in words. The intervention activities were designed to help the children identify the link between speech and print and the decoding and encoding of non - words.

The working memory intervention included components of attention and verbal memory. A combination of the tasks was considered depending on the child's baseline performance.

The need for a multifaceted approach is very well implicated, especially when dealing with children with SRD, as its multidimensionality integrates concepts from neuropsychology, education psychology, and speech and language pathology. A single remedial program with only specific inputs might result in improvement in only a few individuals; incorporating other associated aspects and incorporating a combination of both phonological processing and working memory training into a remedial training program will have better outcome implications for a larger number of children with SRDs with different needs.

5. Results

Table 1 represents the pre - test and post - test scores of each participant in the experimental group. There was improvement observed in the scores of each participant in post - test. The total scores of the experimental group on the pre - test was 144 and the post - test was 421. This indicates a clear increase in the performance of children post - intervention.

Table 1: Represents the experimental group's pre - test and post - test scores on TOMC domains

DOMAINS	PM		AP		SJ		DK		JV	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Personal Information	2	5	2	4	4	5	3	4	3	5
Mental Control	2	12	0	10	10	13	8	13	4	12
Sentence Recall	3	5	1	4	5	9	3	6	2	8
Story Recall (I)	0	14	0	12	3	15	2	10	0	12
Story Recall (D)	0	14	0	9	3	13	2	8	0	10
Word Recall (M)	3	6	2	5	6	8	3	6	2	5
Digit Span	3	9	3	7	6	9	6	9	6	9
Word Recall (NM)	0	5	1	5	4	7	2	6	3	7
Delayed Recall Learning	0	2	0	1	2	4	1	3	2	3
Paired Association	2	15	2	12	10	18	7	14	6	14

Table 2: Represents the Control group's Pre - test and post - test scores on TOMC

DOMAINS	SA		IS		DH		SO		SM	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Personal Information	2	4	4	4	2	2	3	4	2	3
Mental Control	2	6	8	8	6	8	7	7	3	3
Sentence Recall	0	0	3	3	1	1	3	4	1	0
Story Recall (I)	2	4	0	0	4	4	6	8	2	2
Story Recall (D)	0	2	0	0	2	4	4	6	1	0
Word Recall (M)	3	3	3	3	5	5	5	6	2	3
Digit span	5	5	5	5	5	5	7	8	6	6
Word Recall (NM)	2	3	6	6	3	3	2	4	0	1
Delayed Recall Learning	1	1	1	1	2	2	2	2	0	0
Paired Association	4	6	4	4	7	8	6	9	3	5

Table 2 represents the pre - test and post - test scores of each participant from the control group. There was a very minor difference observed in the post - test scores. The total score of the control group on the pre - test was 157 and the post - test was 191. Therefore, it can be observed that though there were slight improvements in the post - test, they aren't comparable to the experimental group.

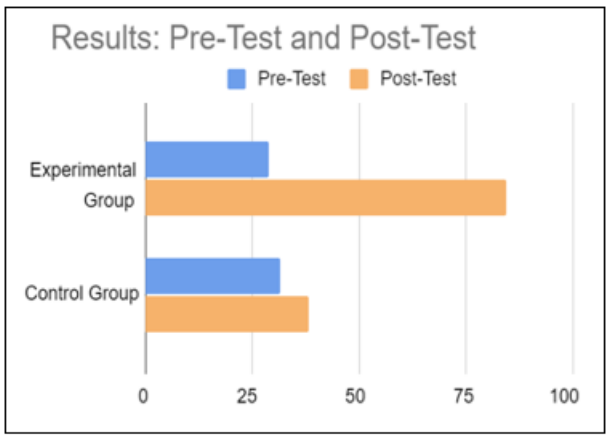

Figure 1: Represents the pre - test and post - test means of the experimental and control groups on TOMC

Figure 1 represents the comparison of mean scores in pre - test and post - test of experimental and control groups. In the experimental group, the mean pre - test score was 28.8 and the post - test score was seen to be 84.2. The results indicate a clear increase in post - test scores in the experimental group. The mean scores in the control group were 31.4 in the pre - test and 38.2 in the post - test indicating that there was only a slight increase in the control group.

Table 3: Represents experimental group and control group scores on IRA pre and post - test score

Domains Experimental Group	PM		AP		SJ		DK		JV	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Individual Consonant Sounds (0 - 16)	2	16	2	16	3	16	0	16	0	16
Consonant Combinations (0 - 8)	1	8	0	8	1	8	0	8	0	8
Short Vowel Sounds (0 - 5)	1	5	0	5	1	5	1	5	0	5
Vowels in Words (0 - 16)	4	16	2	15	6	16	1	16	1	16
Blending Sounds (0 - 6)	1	6	0	5	1	6	1	6	1	6
CONTROL GROUP										
Individual consonants sound (0 - 16)	2	2	5	5	4	4	1	1	1	1
Consonant combination (0 - 8)	0	0	3	3	0	0	1	1	0	0
Short vowels sound (0 - 5)	0	0	3	3	1	1	1	1	1	1

Vowels in word (0 - 16)	2	2	7	7	5	5	2	2	0	0
Blending sound (0 - 6)	1	1	2	2	1	3	1	1	0	0

Table 3 shows that the experimental group participants scored below 20% on all the domains of IRA in the pre - test. Post - intervention, everyone's scores improved. Most of them scored 100% on all domains, except for AP's score on vowels in words (15/16) and blending sounds (5/6). Whereas, in the control group, most of the participants showed no changes in their scores across all five domains, except for DH, whose score changed from 1/6 to 3/6 on the blending sound domain.

6. Discussion

The main goal of the present study was to assess the effectiveness of phonological processing and verbal working memory intervention on the phonological awareness of children having specific reading disorders. It was found that a majority of children who received the intervention showed improvement in reading skills.

The present study has demonstrated how phonological processing is linked to SRD. There is a large body of evidence confirming this connection including brain research. Yu and colleagues (2018) discovered a functional network that includes the left inferior frontal, left posterior occipitotemporal, and right angular gyri. The strength of this network is linked to phonological skills. Other brain areas and processes have also been linked to dyslexia, like the poor connection of the left putamen to the rest of the brain during phonological processing tasks (Wang et al., 2018). These FMRI studies also lend evidence to changes observed in the functional networks post - phonological processing intervention.

The results of the current study also confirm the already established links between phonological processing and verbal working memory impacting reading in children with SLD. Silva & Capellini (2015) found that phonological intervention improved phonological awareness and reading and writing skills among children at risk of developmental dyslexia. Banales et al. (2015) found that verbal working memory training can improve verbal working memory performance in some poor readers. The results of the study fall in line with these findings. However, certain studies like those of Isaki et al., 2008 indicate that verbal short - term memory and verbal working memory tasks with low to moderate difficulties are not found to have a relation with language acquisition and processing. However, the results of the current study contradict those findings. This could be attributed to the nature of tasks provided as intervention being attuned to the child's ability. Since the interventions were presented appropriately based on the child's capabilities, it does not seem to have encountered similar challenges.

The implications of this study can be translated into work carried out with children at risk for SRD and those currently diagnosed. It can be incorporated into remedial and training - based programs in school set - up. The interventions can also be further adapted according to the personnel delivering the program. They can be carried forward by Mental health professionals and special educators in clinical setups. Teachers can also be equipped to carry out these interventions, especially in settings where mental health resources are inadequate. Given that the study had been done on the Indian population, it can very well used in the Indian setting.

Upcoming studies can draw attention to associated psychological factors and parental attitudes to check for their impacts on the effective application of the intervention. This would draw emphasis onto the holistic improvement of children and not just their performance in specific domains. Other neuropsychological functions can also be addressed to build on research on cognitive functioning in children with SRDs.

Since the current study was carried out on a small sample, further research can focus on larger sample sizes and more diverse populations to increase generalizability. Further studies can also emphasize different modes of providing interventions through parents and educators to increase accessibility. Also administering it in a group format can be considered.

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