EFFICACY OF COGNITIVE TRAINING ON PROCESSING SPEED AND WORKING MEMORY OF CHILDREN WITH SPECIFIC LEARNING DISABILITY (SLD)

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Submitted by

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DECLARATION

I, **Farisha.A.T.P**, hereby declare that the thesis titled **"Efficacy of Cognitive training on Processing Speed and Working Memory of Children with Specific Learning Disability (SLD)"** was carried out by me at NIEPMD, Chennai, during the academic year 2021-2023, is an original research work carried out under the guidance and supervision of Dr. S. Karthikeyan, Head of the Department, Department of Clinical Psychology, NIEPMD, Chennai. This work has not formed the basis of award for any other degree.

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ABSTRACT

Specific Learning Disability is a life-long neurological condition wherein the academic skills of an individuals are seriously affected which causes significant negative impact on reading, writing and arithmetic skills of children. In India, 16.49% children are suffering from Specific Learning Disorders. The present study aims at finding out the efficacy of cognitive training on processing speed and working memory of children with Specific Learning Disability using a before-after two group quasi experimental design**.** Samples were selected through purposive sampling technique from NIEPMD and a CBSE school in Chennai. Both experimental group and control group consists of 10 children with age 8 to 16 years. Measures used were Personal Information Schedule and 2 sub-scales Working Memory Index (WMI) and Processing Speed Index (PSI) of Wechsler Intelligence Scale for Children (WISC). Pre-test and post-test were done for both experimental and control group, and experimental group was given 10 sessions intervention for a 2-month time period. The statistical techniques used were Shapiro-Wilk test, independent t test and paired t test to understand the efficacy of interventions given. The study concluded that Processing Speed and Working Memory of Children with Specific Learning Disability (SLD) was improved through cognitive training. This research is expected to have implications in enhancing academic skills of children with Specific Learning Disability through improving their underlying cognitive capacities.

Keywords*: Specific Learning Disability, Processing Speed, Working Memory, Cognitive Training.*

CHAPTER 1

INTRODUCTION

Specific Learning Disability is a life-long condition wherein the academic skills of an individuals are seriously affected which causes significant negative impact on reading, writing and arithmetic skills of children. Between 5% and 15% of school-age children from all languages and cultures have a distinctive learning disability in one or more of the academic subjects of reading, writing, or mathematics. Adult prevalence is unknown; however, it seems to be around 4%. Specific learning disorder is a neurodevelopmental disorder with cognitive defects that underlie the behavioural symptoms which has biological roots. The biological cause involves a complex interplay of genetic, epigenetic, and environmental factors that influence how effectively and efficiently the brain processes verbal or nonverbal information. Persistent difficulty with learning fundamental academic abilities such as reading, writing and arithmetic that begin during the years of formal schooling are crucial component of certain learning disorders. Academic skills (such as reading, spelling, writing, and mathematics) must be actively taught and learnt, in contrast to talking and walking, which are acquired developmental milestones that appear with brain maturation. The usual process of learning academic skills is disrupted by this condition, and it is not merely the result of a dearth of learning opportunities or insufficient training. SLD could be diagnosed for academic difficulties despite the availability of additional assistance at home or school, for at least 6 months. Other significant clinical indicators of poor academic skills include low academic achievement for age, interference in school performance and avoidance of activities that require the academic skills (American Psychiatric Association, 2013).

The fact that the learning challenges are regarded as "specific" is due to four reasons, which is another crucial diagnostic trait. First off, the academic difficulties cannot be attributed to intellectual disabilities; global developmental delay; hearing or

visual issues; neurological or motor diseases; or global developmental delay. Hence, SLD can also be diagnosed in children identified as intellectually gifted. Secondly, learning difficulties cannot be attributed to broader external issues such socioeconomic disadvantage, the environment, persistent absences, or a lack of education as it is normally offered in the person's community setting. Third, a neurological illness (such as a paediatric stroke) or motor disorder, as well as vision or hearing disorders-which are frequently linked to difficulties learning academic abilities but can be distinguished by the presence of neurological signs-cannot be blamed for the learning issue. Finally, academic skill is the only domain in which the children will have trouble learning (American Psychiatric Association, 2013).

1.1 Eight Areas of Specific Learning Disability

Eight Areas of Specific Learning Disability as described by Hess et al (2018) includes Basic Reading Skills, Reading Fluency Skills, Reading Comprehension, Listening Comprehension, Oral Expression, Written Expression, Mathematics Calculation, and Mathematics Problem Solving (Hess et al., 2018).

1. ***Reading Skills*** comprises phonemic awareness and/or phonics, which are essential reading skills that need the capacity to recognise individual sounds and manipulate them. It also involves the ability to recognise printed letters and their sounds and decode written words. Students who struggle with fundamental reading abilities may encounter difficulties with the mastery of letters and sounds; the ability to manipulate individual sounds in spoken words; blending sounds to form words; fluent decoding at upper grade levels and the use of language in written work that differs from their typical oral vocabulary.

2. ***Reading fluency*** refers to the capacity to read a word with accuracy at the right speed. Possessing the necessary expressiveness, intonation, or prosody when reading, is another aspect of reading fluency. Prosody, which relates to the patterns of stress and intonation in language, is one of the three key components of reading fluency; accuracy and rate of reading being the other two components. Students who have trouble with reading fluency may experience difficulties with basic reading abilities, that is phonemic awareness, rapid naming tasks involving colours, letter names, names of familiar objects, etc.; vocabulary development, given that they are exposed to a lot fewer words than fluent readers; and finally, the motivation to read.
3. ***Reading Comprehension*** is the ability of an individual to comprehend and extrapolate meaning from the written content. A child struggling in reading comprehension may have difficulties in developing oral language and vocabulary; understanding oral language; using more complex, age-appropriate language and vocabulary in oral and written work; forming complete sentences with proper word order; the capacity to infer and draw conclusions from text; checking for understanding while reading; and recognising and understanding text structure, including implications from titles, paragraph beginnings, and endings, headings, bulleted points, and illustrations.
4. ***Listening comprehension*** is the ability to comprehend the implications and apparent meanings of words and sentences used in spoken speech, and it often suggests problems with written expression and auditory processing of oral information. Children with poor listening comprehension reported to have difficulties in following oral instructions, remembering homework assignments, understanding oral narratives and text, being able to respond to questions about the

content of orally presented data critical thinking leading to logical conclusions, word associations, synonyms/antonyms, categorising and classifying, and note taking and dictation.

5. ***Oral Expression*** refers to explaining word associations, such as antonyms and synonyms; using complete and properly constructed sentences- either spoken or written; explaining grammatical processes, such as inflection, tense, and word derivations; learning new vocabulary; Retelling information, such as making inferences and predictions.
6. ***Written Expression*** entails being able to show proficiency in basic writing skills like handwriting and spelling, as well as composition abilities like capitalization, punctuation, structuring sentences, word and text fluency, preparing for writing, and reviewing and modifying written work. Students with deficits in written expression often has difficulties in fine motor skills that affect handwriting fluency and legibility; spelling; generating text that results in brief and poorly organised compositions at the sentence and paragraph levels; conventions of written expression such as wrong capitalization, punctuation errors, inappropriate use of verb and pronouns, and errors in subject-verb agreement; word retrieval such as lack of specific vocabulary; and reviewing and revising written compositions.
7. ***Mathematics calculations*** require the application of methods, fact knowledge, and fact retrieval. Calculation difficulties may affect students in activities such as number recognition, one-to-one correspondence that is, number sense); understanding arithmetic operations such as addition, subtraction, multiplication and division; recall of fundamental facts; and understanding the mechanics of operations and their significance.

8. ***Mathematics problem solving*** is the process of resolving issues by using mathematical computing abilities, language, reasoning, reading, and visual-spatial abilities. The actual "doing" of mathematics is the practical use of mathematical knowledge. Students who are weak in this area may have trouble with identifying key details and filtering out irrelevant information; identifying steps in problem-solving; metacognitive skills, or the capacity to assess one's own efforts to solve a problem; and math calculation skills.

1.1.1 SLD as explained by ICD-10

International Classification of Disorders (ICD-10), a classification system published by World Health Organization (WHO) termed this condition as Specific developmental disorders of scholastic skills, which enlisted various conditions such as Specific reading disorder (F81.0), Specific spelling disorder (F81.1), Specific disorder of arithmetical skills (F81.2), Mixed disorder of scholastic skills (F81.3), Other developmental disorders of scholastic skills (F81.8) and Developmental disorder of scholastic skills, unspecified (F81.9) (World Health Organization, 1993)

1. ***Specific reading disorder (F81.0)*** is diagnosed if an individual's reading accuracy or comprehension is below atleast 2 standard level than child's chronological age and general intelligence which is assessed based on the child's culture and educational system. Moreover, these deficits shouldn't be accounted for visual or hearing impairments or of a neurological disorder. At the same time, there shouldn't be any severe gaps in educational opportunities and the intellectual functioning of the child shouldn't be below 70 on an individually administered standardized test.

2. ***Specific spelling disorder (F81.1)*** can be diagnosed if an individual's spelling accuracy is below atleast 2 standard level than child's chronological age and general intelligence which is assessed based on the child's culture and educational system which significantly interferes with academic achievement or with activities of daily living that require spelling skills. Also, the scores on reading accuracy and comprehension and on arithmetic are within the normal range, with no history of significant reading difficulties in the past. Moreover, the spelling difficulties have been present from the early stages of learning to spell.
3. ***Specific disorder of arithmetical skills (F81.2)*** can be diagnosed if an individual's score on a standardized arithmetic test is at least 2 standard errors of prediction below the level expected on the basis of the child's chronological age and general intelligence, which significantly interferes with academic achievement or with activities of daily living that require arithmetical skills. The scores on reading accuracy and comprehension and on spelling are within the normal range, and no history of significant reading or spelling difficulties. D. School experience is within the average expectable range.
4. ***Mixed disorder of scholastic skills (F81.3)*** is a condition which is ill-defined, inadequately conceptualized category of disorders in which all academic skills including reading, writing and maths skills are significantly impaired, and not attributed to mental retardation or schooling inadequacy. It was coded when a child has more than one condition of learning disability in the absence of visual or hearing impairments or any major neurological disorder.

1.1.2. SLD as explained by DSM-V

Diagnostic and Statistical Manual of Mental Disorders (DSM-V), a classification system published by the American Psychiatric Association (APA) named

Specific Learning Disability as Specific Learning Disorder, which described the characteristics of each condition elaborately (American Psychiatric Association, 2013)

According to DSM-V, Specific Learning Disorder is characterised by challenges with academic skills, as shown by the presence of at least one symptom listed below that has persisted for at least six months despite the availability of interventions that address those challenges.

1. Inaccurate or laborious word reading, constantly guessing words and having trouble sounding out words
2. Having trouble deciphering the meaning of what is read
3. Difficulties with spelling such as adding, omitting, or substituting vowels or consonants
4. Inability to clearly communicate concepts in writing such as committing repeated grammatical or punctuation errors within sentences and poor paragraph organisation
5. Inability to master number sense, number facts, or calculation such as lacking grasp of numbers, their magnitude, and relationships; counting on fingers to add single-digit numbers rather than remembering the math fact. Similarly, gets confused while performing arithmetic computation and may switch procedures for computations.
6. Problems with mathematical thinking, such as having a lot of trouble using mathematical ideas, facts, or techniques to solve quantitative problems.

Similarly, individually administered standardised achievement tests and thorough clinical evaluations demonstrate that the affected academic skills are significantly and quantitatively below those anticipated for the person's chronological

age and significantly interfere with academic or occupational performance or daily living activities. For people who are 17 years old or older, a history of significant learning challenges may be used in place of the standardised test. The learning difficulties start when a person is in the school-age years, but they might not become fully evident until the demands for the affected academic skills exceed the person's limited capacities. For example, in timed tests, reading or writing lengthy complex reports for a tight deadline, or excessively heavy academic loads. Furthermore, intellectual disabilities, untreated visual or auditory acuity, other mental or neurological illnesses, psychosocial adversities, a lack of competency in the language of academic teaching, or insufficient educational instruction are not better explanations for the learning challenges. The above diagnostic criteria should be correlated with the clinical synthesis of the person's developmental history, medical history, family history and educational history; along with sufficient school records, and psychoeducational evaluation to make the diagnosis.

In addition, DSM-V also explains the degree of severity of Specific Learning Disorder as Mild, Moderate and Severe. In Mild Specific Learning Disorder, a child will have some learning challenges in one or two academic domains, but of a severity that, with the right accommodations or support services, particularly during the school years, the person may be able to make up for the difficulties or function well. In Moderate Specific Learning Disorder, there will be a marked difficulties learning abilities in one or more academic fields, making it unlikely that the individual will become adept without a few periods of intensive and specialised instruction over the school years. To execute tasks accurately and effectively, it may be necessary to make certain modifications or use supported services for at least part of the day at school, the job, or home. Severe Specific Learning Disorder is characterised by a significant impact

on multiple academic domains, making it unlikely for them to acquire those abilities without continual, rigorous, individualised, and specialised instruction over the majority of the school years. Even with a wide range of suitable accommodations or assistance at home, school, or the office, the person might not be able to finish all tasks effectively.

1.1.3. Manifestations of SLD across the ages

Pre-schoolers may struggle to acquire nursery rhymes and show little interest in games that include linguistic sounds such as repetition and rhyming. Specific learning disorders in pre-schoolers can cause them to regularly use baby language, mispronounce words, and struggle to recall the names of letters, numbers, or days of the week. They could struggle to learn to count and have problems identifying the letters in their own names. At Kinder-Garten level, children with certain learning disorders may struggle to recognise and write letters, struggle to write their own names, or even use created spelling. They could struggle to separate spoken phrases into their component syllables and struggle to identify words that rhyme.

Children in kindergarten may also struggle to associate letters with their sounds, as well as struggle to identify phonemes. At elementary school-age, children, with specific learning disorder typically shows significant difficulty in learning letter-sound correspondence, fluent word decoding, spelling, or math facts; reading aloud is laborious, inaccurate, and slow; and some kids have trouble understanding the magnitude that a spoken or written number represents. It may also be manifested as behavioral problems such as reluctance to engage in learning or exhibiting oppositional behaviors.

In primary grades, 1st-3rd, children continue to struggle in identifying and manipulating phonemes, read common one-syllable words such as rat or hop), or recognise frequent words with unusual spellings such as said, two etc. They frequently make reading mistakes such as misreading "big" for "got" or having trouble putting numbers and letters in the right order. They may struggle to recall mathematical operations such as addition, subtraction etc, and may claim that reading or math is difficult and put off practising it.

In the middle grades 4th-6th, children with SLD may mispronounce or omit portions of long, multisyllabic words, saying "animal" as “aminal”, similarly, mix up words that have a similar sound for example, volcano for tornado. They struggle to finish their schoolwork or to take their tests on time because they might have problems remembering dates, names, and phone numbers. They also have difficulty in reading short function words such as that, the, an, in, and have poor comprehension, or read slowly, laboriously, and inaccurately. They might produce subpar written work and really bad spelling. They may accurately pronounce the initial half of a word, then guess wildly for example, reading "clover" as "clock"), and they may also display dread when reading aloud or refuse to read aloud (American Psychiatric Association, 2013).

1.2 Processing speed

Processing Speed has been defined as the capacity to carry out cognitive activities easily and effortlessly, particularly when pressure is applied to maintain focused attention and concentration (Prifitera, Saklofske and Weiss, 2008). According to McGrew and Flanagan (1998), processing speed is the capacity to quickly look for and contrast visual symbols that are presented side by side or independently in a visual field.

1.2.1 Processing speed of children with Specific Learning disability

Performance is an indicator of how quickly a student can correctly comprehend simple or routine information. Many learning tasks combine the processing of simple information like reading with the processing of complicated information like reasoning. The effort of understanding novel information may be more time-consuming and challenging if there is a slowdown in the processing speed of ordinary information. A youngster may lack the time and mental resources necessary for the challenging effort of comprehending new content if they have trouble with basic visual scanning and tracking. These lower-order processing skills are consequently connected to higher-order cognitive functioning. Similarly, children who are having scholastic challenges in the classroom are more likely than kids who are not to exhibit the pattern of lower processing speed abilities than reasoning abilities (Wechsler, 1991, 2003).

In samples of students with learning disabilities both Processing Speed Index and Working Memory Index were found to be lower compared to their Verbal Comprehension Index and Perceptual Reasoning Index scores, as well as compared with the normal population (Prifitera & Dersh, 1993)

Processing Speed, as measured by perceptual speed tests, exhibits a strong and persistent link with the growth of reading and arithmetic achievement, particularly during the elementary school years (Flanagan & Mascolo, 2005). Children in elementary school are strengthening their reading and math skills as well as their speed and automaticity in use. These fundamental academic skills are automatically employed by older students when they incorporate them into more challenging tasks including problem solving, writing about a specific subject, and complicated reading.

Compared to children without processing speed deficits, children with processing speed deficits may learn less information in the same amount of time or take longer to learn the same amount of information. Because performing normal chores requires more cognitive effort, these kids may also get mentally tired more easily. As a result, there may be more mistakes made, less time spent learning, and perhaps even frustrated outbursts. On the other hand, a propensity for information processing quickly might make it easier to gather fresh knowledge (Prifitera, et al, 2008).

1.3 Working memory

It is very pivotal capacity of an individual to keep some information in our mental space, manipulate it, reproduce or use this information for further processing. For example, listening to the notes dictated by the teacher and writing it down following their pace, keeping in mind the lengthy phone numbers to dial etc requires some form of memory which is named as working memory which holds the information for a short period of time. Similarly, when you someone tells you the route to a particular place and you are driving to that place, it's our working memory which holds the information which deletes the routes which you already have taken and retains the information until you reach the destination in particular sequence. While playing a puzzle or chess, we may have to make moves in our mind to decide the actual move which is made possible by the function of working memory. These quick mental actions of storing and manipulating information are collectively called as working memory (Varshney & Darolia, 2015).

The research on working memory commenced when Ebbinghaus found out from his studies that one could recall 7 syllables after reading in 1885. In subsequent years, James explored about human's cognitive ability for temporary holding of information and named it as primary memory in 1890. Miller in 1956 found out our memory

capacity as 7±2, which he named it as magical number which can be stored through the process of chunking. These models were followed by Atkinson and Shiffrin's model in 1968 who spoke about Short Term Memory (STM) which holds the information for a brief period, unlike Sensory Store and Long Term Memory (LTM) (cited from Varshney & Darolia, 2015).

According to Anderson (1995), working memory refers to the information that are currently available to work on a problem. It is not uncommon that we use the terms working memory and short term memory interchangeably though both are different constructs. Short term memory as explained by Atkinson and Shiffrin (1968) operates in a single uniform fashion, whereas, working memory (hereafter referred as WM) as modelled by Baddeley & Hitch (1974) has multiple components which operates in a complex fashion. In the initial model, there were 3 components for WM- central executive, phonological loop and visuo-spatial sketch pad. Central executive was concerned about attention to the information on-hand, phonological loop was associated with the articulation and listening to information within one-self and visuo-spatial sketch pad was responsible for visualising the available information in minds space for the manipulations to be done. Both phonological loop and visuo-spatial sketch pad comes under the control of central executive.

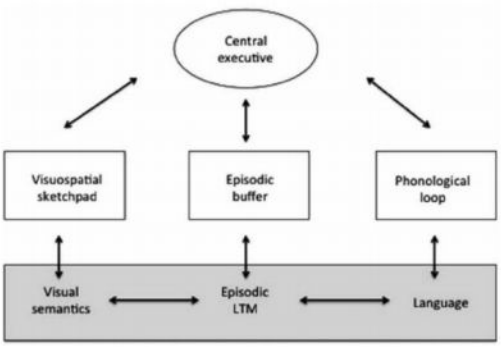


Figure: 1.1 Baddeley's model (2000) of Working Memory

1.3.1 Working memory of children with Specific Learning disability

Though WM was considered as the significant measure of general intelligence by many psychologists (e.g., Engle, Kane, & Tuholski, 1999; Kyllonen, Patrick & Dennis. (1996), WM was also identified as a significant predictor of information storage which is significant in learning process. Hence, WM has a greater role in reading comprehension, spatial ability, reasoning ability (Engle, Tuholski, Laughlin & Conway, 1999) and academic achievement (Gathercole & Pickering, 2000) as well. Baddeley & Hitch (1974) also has emphasized that various cognitive tasks such as e.g., language, comprehension, mental arithmetic, reasoning, problem solving demands working memory functioning, which is evidence that poor working memory can be a significant predictor of reading difficulty and poor comprehension.

These results are entirely consistent with research showing that children with poor memory skills at the beginning of school go on to make poor academic progress (Gathercole et al., 2003; Alloway et al., 2005), and that the majority of children with learning disabilities have significant working memory issues (Swanson & Beebe-Frankenberger, 2004).

1.4 NEED AND SIGNIFICANCE

Specific Learning disability is a neurological condition that affect the cognitive functioning of a child which significantly affect academic domain specifically. Prevalence of specific learning disability in India ranges from 5%–15% in various studies (Singh, et al 2017). In accordance with the 38th Annual Report to Congress on the Implementation of IDEA (2016), children with SLD account for 39.2% of all students with disabilities followed by speech and language impairments at 17.6%. The prevalence of primary school children with SLD in South India is 15.17%, particularly

Dylexia -11.2%; Dysgraphia -12.5% and Dyscalculia -10.5% (Mogasale, Patil, Patil, and Mogasale, 2011). In India, 16.49% children are suffering from Specific Learning Disorders (Chacko and Vidhukumar, 2020). Similarly, in the statistics published by National Centre for Educational Statistics, 7.2 million children (ie, 15% of all public-school students with 3-21 years) received remedial training service during the year 2020-2021 under the Individuals with Disabilities Education Act (IDEA), among which the mostly received category was Specific Learning Disability (ie, 33%).

When cognitive abilities of children with specific learning disability was compared with children without SLD, it was found that there were significant cognitive impairments in children with specific learning disability (Karande, Sawant, Kulkarni, Kanchan and Sholapurwala, 2005). Similarly, children with SLD has cognitive deficits especially in processing speed (Moll, Gobel, Gooch, Landerl and Snowling, 2016) and working memory (McLean & Hitch, 1999; Cai, Li & Deng, 2013). A review carried out by Anis, et al (2018) highlights the importance of intervening the underlying cognitive functions rather than limiting to remediating with literacy and numeracy skills. Moreover, it was evident from research that cognitive remedial therapy along with regular remedial education was found to be the best effective strategy for SLD (Karande, et al, 2005). Above all, in a recent study by Huijsmans, Kleemans, and Kroesbergen (2021), it was concluded that children with specific learning disability have a unique profile of inter-related strength and weakness, wherein they can compensate their weakness with strength through adequate intervention strategies which can result in learning gains in the affected domain, which doubles the importance of the present study. Hence, an intervention addressing the cognitive deficit is expected to give an enhancement in the cognitive functioning of the child which may bring underlying neurological changes, and there by facilitating scholastic skills.

1.5 STATEMENT OF THE PROBLEM

Children with specific learning disability was found to have inadequate processing speed and working memory. The cognitive training intervention is expected to improve processing speed and working memory which can have a positive impact on the academic skills of children with specific learning disability.

1.6 DEFINITION OF KEY TERMS

Efficacy

Theoretical and operational definition: The systematic and scientific evaluation of whether a treatment works (Levant, 2005)

Cognitive retraining

Theoretical and operational definition: A therapeutic strategy that seeks to improve or restore a person's skills in the areas of paying attention, remembering, organizing, reasoning and understanding, problem-solving, decision making, and higher level cognitive abilities (Catherine & Raskin, 1999).

Processing speed

Theoretical and operational definition: Processing speed is a measure of the time required to respond to and/or process information in one's environment (Horning & Davis, 2012)

Working memory

Theoretical and operational definition: The small amount of information that can be held in an especially accessible state and used in cognitive tasks (Cowan, 2014)

Children: *Theoretical and operational definition:* Any person under the age of 18 (UNICEF)

Specific Learning Disability

Theoretical and operational definition: Specific Learning Disability is disorder in one or more of basic psychological processes involved in understanding or in using language, spoken or written, which may manifest itself as an imperfect ability to listen, think, speak, read, write, spell or do mathematical calculations. Such term includes such conditions as perceptual disabilities, brain injury, minimal brain dysfunction, dyslexia and developmental aphasia. Such terms does not include a learning problem that is primarily the result of visual hearing or motor disabilities, or mental retardation, of emotional disturbance, or of environmental, cultural, or economic disadvantage (IDEA, 2004).

Ministry of Social Justice and Empowerment (2018) defines Specific learning disabilities (SLDs) are heterogeneous group of conditions wherein there is a deficit in processing language, spoken or written, that may manifest itself as a difficulty to comprehend, speak, read, write, spell, or to do mathematical calculations and includes such conditions as perceptual disabilities, dyslexia, dysgraphia, dyscalculia, dyspraxia and developmental aphasia

CHAPTER 2

REVIEW OF LITERATURE

2. 1. Processing speed of children with Specific Learning Disability (SLD)

Processing speed is the rate at which you can take in visual or auditory information, interpret it, and then act on it. Processing speed, in a sense, can be defined as the time it takes to complete a task. Certain academic tasks may take a student with sluggish processing speed longer than it would for the ordinary student. Reading directions or recognising a teacher's hand gestures are examples of visual processing, which refers to how rapidly a student's eyes take in information and transmit it to the brain. Processing speed of an individual often gets reflected through words or through actions. The verbal processing refers to the pace at which a student receives a stimulus and reacts to it such as following oral instructions or participating in a discussion. Measures of processing speed were able to predict naming time, but not age. Furthermore, reading comprehension and reading recognition were both related to naming time (Kail & Hall, 1994).

Whereas, the motor processing indicates how great a student's fine motor agility is, leading to academic fluency such as filling out timed arithmetic worksheets. The capacity to take in information, comprehend it, and then come up with an audible, written, or physical answer is referred to as processing speed in the classroom. This procedure can be difficult for learners who digest information slowly because it requires more time and effort for each stage to be completed (Burgess, 2023). In the case of motor processing speed, Kerr and Hughes (1987) examined the motor challenges faced by learning disabled children, and found that successful motor performance is inextricably linked to cognitive abilities. Employing 16 different target combinations on a Fitts' reciprocal tapping problem, the learning impaired youngsters were able to manage the increased task difficulty in the same way as the controls, suggesting that the issue may not be a serious processing loss. Getting the information into the system

may be where the issue lies at the very beginning of the processing mechanism indicating that motor processing speed was not significantly impaired among children with SLD.

From empirical evidences, it was found that the processing speed of children with SLD gets impaired due to several factors inspite of having good intellectual functioning. For instance, to determine which of the four main factor indexes and two additional indexes can distinguish between the two groups, the WISC-IV was used to compare the intellectual profiles of two groups of children: one with specific learning disorders (SLDs), the other with intellectual disabilities (ID). For 267 kids with a diagnosis of SLD or ID and ages ranging from 6 to 16 years, we gathered data on WISC-IV scores. Children with SLD outperformed children with ID across the board. The four main factor indexes only showed significant differences in the SLD children and not the ID children, and their scores on the extra General Ability Index (GAI) were greater than those on the Cognitive Proficiency Index (CPI). Similar patterns were observed in children with SLD whose Full-Scale Intelligence Quotient (FSIQ) who was below 85. The findings support the idea that, while children with ID have a broad intellectual disability, those with SLD typically have high GAI scores but have specific processing speed and working memory deficits. When making diagnostic judgements in borderline cognitive cases, these findings should be taken into account as they have significant diagnostic and clinical implications (Cornoldi, Giofre, Orsini, & Pezzuti, 2014).

Similarly, Willcutt et al., (2005) reported that the children with reading disabilities not only showed considerable impairments in reading and language skills, but also in processing speed, verbal working memory, and reaction inhibition. As aforementioned study reports, the fundamental deficit in processing speed was associated with reading and math difficulties, and students with dual disabilities are

particularly hampered in this area (Ackerman, & Dykman, 1995). The connections between processing speed (PS), mental health issues, and learning impairments are examined by Kramer et al as well in their 2020 study. They found that specific and significant correlations between PS and reading and math disabilities through regression analysis. A signal detection investigation of the vigilance deficit in children with learning disabilities by Swanson (1981) confirms the idea that children with learning disabilities experience a decline in processing capacity as opposed to a loss of sustained attention over time.

Moreover, they were studies done to analyse the processing speed deficit associated with the developing age of children. Researchers such as Weiler, Forbes, Kirkwood and Waber (2003) looked at whether the same general mechanism thought to be in charge of the developmentally expected increase in processing speed could also be connected to the processing speed deficits seen in children with learning disabilities. For children with and without learning difficulties, there were no changes in the relationship between age and the development of processing speed. These results, in our interpretation, indicated that the relative processing speed deficiencies identified in children with learning difficulties and the usual developmental shift in processing speed had different underlying aetiologies also, when the authors investigated if the processing speed deficits seen in children with learning disabilities might be related to the same global mechanism thought to be responsible for the normal developmental gain in processing speed. The results indicates that the fundamental causes of the differences between the relative impairments in processing speed seen among children with learning problems and the typical developmental improvement in processing speed were different.

Some studies were also carried out by researchers to assess how the processing speed varies with respect to nature of the information. A study by Cardillo, Mammarella, Garcia and Cornoldi (2017) contrasted children with dyslexia and Nonverbal Learning Disabilities (NLD) with controls who were normally developing (TD) to see which group processed visual information more locally or globally. The findings displayed that the children with NLD had more issues with the visuo-constructive version of the task, whereas children with dyslexia had less trouble with the visuo-constructive version but more trouble with the perceptual version, particularly in terms of response times. These results are explained by the slower visual processing speed of dyslexic youngsters, their visual construction issues, and their difficulty using flexibly-experienced global versus local processes.

Processing speed variations across different types of specific Learning Disability was explored by various theorists. Mathematical aptitude was best predicted by processing speed once reading ability was controlled, and short-term memory did not contribute any further distinctive variance. It was determined that youngsters who struggle with basic math skills have issues automating those operations, which may be related to a general speed-of-processing disadvantage (Bull & Johnston, 1997). Similarly, children with Mathematical Learning Disability (MLD) performed worse in planning, simultaneous processing, and consecutive processing than the group of children without MLD. While simultaneous processing was the only predictor in the MLD sample, executive processes were the only factor predicting arithmetic problem solution as per the findings in a study carried out among children with ADHD (Iglesias-Sarmiento et al., 2017).

When processing speed of children with SLD was compared to children with ADHD, children with reading disabilities show worse processing speed impairments

(Shanahan et al., 2006) reiterating the severity of condition and its consequences for the affected children. However, these findings imply that processing speed scores alone cannot be used to accurately measure timed academic skills because there will frequently be large discrepancies between the two. As a result, researchers like Lovett et al. (2022) suggests that more precise assessments of the pertinent academic skills should be used when making diagnostic determinations such as learning disability diagnoses or treatment recommendations such as for extended time testing accommodations.

2.2 Working memory of children with Specific Learning Disability

According to a review of the literature, working memory of children with LD differs from that in children who are typically developing. Due to the high working memory demands of the learning task frequently exceeding their working memory capacity, children with LD frequently struggle in school. If working memory issues are not detected early enough and the ensuing learning issues are not resolved, the kid may struggle with this invisible handicap and may even stop attending school (Gupta & Sharma, 2017). From reviewing articles, it was found that working memory is a significant capacity for learning and children with learning issues have significant deficits in this domain which interferes with his or her academic performance. For instance, the study by Gathercole, Lamont and Alloway (2006) identified that there is a strong correlation between children's success on academic achievement measures and their working memory abilities. Young people who do poorly on complicated memory span activities that require processing and short-term storage of verbal reading content typically get low scores on reading and math standardised tests. Similarly, the findings show that LD children have poor working memory and naturalistic measures, but their

naturalistic memory deficits don't seem to be related to consequential or suggestible recall tasks (Swanson & Trahan, 1990).

Swanson (1993) examined the extent to which working memory discrepancies are there between children with learning disabilities and those without disabilities, and came with a finding that learning-disabled children suffer generalized working memory deficits, possibly due to storage constraints in the executive system than the group of children without learning disabilities. Same was confirmed in another study which found out that there was a considerable overall working memory deficit among children with learning problems (Tai-sheng, 2006a; En, 2007). The findings support the Baddeley (1986) tripartite working memory model which demonstrated that the functional linkages between working memory components are mostly constant throughout childhood (Michalczyk, Malstadt, Worgt, Konen, & Hasselhorn, 2013). However, numerous studies confirm the fact that working memory can be improved through various interventions and strategies. According to Vaz, Cordeiro, Macedo, and Lukasova (2010) working memory development continues into the elementary school years, suggesting that linked brain regions mature slowly

Children with learning difficulties are distinguished from those who have intellectual disabilities using the discrepancy criterion. Infact, the belief that children with learning difficulties with vs without discrepancy to IQ exhibit fundamentally different characteristics is the basis for the discrepancy criterion for the diagnosis of learning disorders. However, it's unclear whether these two groups actually exhibit different cognitive performance. This issue was investigated in three studies that looked at a number of Baddeley's working memory functions. Children with learning disabilities (dyslexia, dyscalculia, or mixed disorders of scholastic skills) and normal IQ, children with the same issues but lower IQ, and control groups of children with

regular school achievement and normal IQ were all given individual sessions with a working memory battery that included tasks for the phonological loop, the visual-spatial sketchpad, and central executive skills. The results show that, as compared to the control groups, the groups with learning difficulties had distinct deficits in working memory. There were no distinctions between the impaired groups with normal intelligence and those with lower intelligence, nevertheless. These results raise questions regarding the validity of the discrepancy criterion since they do not support the idea that discrepant cognitive functioning results from group variations in IQ (Maehler & Schuchardt, 2009).

Various studies were carried out assessing the working memory capacity across different subtypes of SLD. One among them is a factorial design carried out by Brandenburg, Klesczewski, Fischbach, Schuchardt, Büttner, and Hasselhorn (2015), wherein the researchers examined the unique and overlapping working memory profiles related to reading-versus-spelling learning impairments. They identified that child with spelling disabilities had more obvious phonological loop problems when compared to children with reading disabilities. On the other hand, spelling disability was not linked with domain-general central-executive dysfunctions; whereas reading disability was. However, no deficits were discovered in the visuospatial sketchpad.

Similarly, children who struggle with reading and those who struggle with spelling appear to have different working memory profiles. Hence, the study suggests that it is crucial to consider both reading and spelling when examining cognitive components of literacy challenges in transparent orthographies. In line with this research, a study by Weerdt, Desoete, and Roeyers (2013) concluded that measures of the phonological loop and the central executive showed children with mathematical impairments had lower span scores than children with ordinary achievement. Only

listening recall showed a significant interaction effect between reading problems and mathematical disabilities, and it only had a modest, partial impact size. In the same year, related study findings was published that children with reading challenges who experience working memory issues may really have a central executive function deficiency (Wang and Gathercole, 2013). In a study by Siegel, & Ryan (1989), it was found out that a unique working memory deficiency in connection to processing numerical information characterises children with an arithmetic handicap instead of a generalised language loss. Growing working memory for language and numerical knowledge seems to be a key factor in the development of reading and computational arithmetic skills. There were severe and widespread working memory impairments among children with arithmetic difficulties (Tai-sheng, 2006b).

A contradictory study was also published stating poor working memory capacity associated with reading abilities as well. The explanation for the poor working memory among children with SLD was extensively studied by researchers, and a finding by Jong (1998) showed that reading-disabled children underperformed on all working memory capacity tests. Both ineffective processing and a lack of linguistic short-term memory ability were insufficient to account for their worse performance. The capacity for the simultaneous processing and storage of verbal information appears to be generally lacking in reading-disabled youngsters. A generalised lack of working memory itself seems to be the cause of reading difficulty according to Siegel and Ryan (1989).

Studies were carried out on how SLD impacts the different forms and dimensions of working memory. Measures of central executive function, particularly visuo-spatial memory, showed pronounced abnormalities in children with low levels of curriculum attainment. The majority of children failing to attain the standards of performance set by the government were successfully detected using a single cut-off

score derived from the battery of tests. Children's cognitive development during the first few years of school is highly related to their ability to use complex working memory. Children who are at risk of making little academic development can be screened using an examination of working memory skills (Gathercole & Pickering, 2000).

In a study by Maziero, Tallet, Bellocchi, Jover, Chaix, and Jucla, (2020), children with Developmental Dyslexia (DD) exhibited problems with verbal working memory, especially in phonological loop, whereas children with Developmental Coordination Disorder (DCD) had problems with visuospatial working memory. Comorbid children performed worse in the visuospatial working memory like the group with DCD and verbal working memory like the group with DD domains. The findings highlight how crucial it is to consider co-morbidity when measuring working memory in children with learning impairments. Moreover, studies also found that the verbal working memory is more important than the spatial working memory as far as learning is concerned (En, 2007). When compared to children who were CA-matched, the findings showed that learning-disabled readers performed worse on verbal and visual-spatial working memory measures under high demand settings (maintenance). The outcomes lend credence to the idea that limitations in a central executive storage system cause learning-disabled readers to do poorly on demanding working memory tasks (Swanson, Ashbaker, & Lee, 1996).

These findings imply that working memory span performance in learning disability and typically developed individuals may reflect different working memory constraints and that people with generalised learning difficulties might handle cognitive tasks qualitatively distinct ways from people who are typically developing (Bayliss, Jarrold, Baddeley, & Leigh, 2005).

2.3. Studies related to interventions for Working Memory and Processing Speed

There were few literatures which explored the effectiveness of interventions to improve working memory and processing speed of children which are reviewed here. The relevance of enhancing these cognitive capacities was proven in many researchers. According to the findings, cognitive functioning in children with developmental disabilities can be improved through interventions (Kozulin et al, 2010). Learning disability is commonly connected with poor working memory function of a child that interferes with his or her academic performance (Abduh & Tahar, 2018). Working memory was viewed as a key component in how children with special needs acquire their literacy skills when reading, and the interventions to enhance working memory may aid children in becoming more adept at reading comprehension (Dahlin, 2011). Hence the authors of the study suggests that if it is successful to improve working memory with interventions, especially computer-based working memory training could be a useful and affordable remedy for this group of young children (Lohaugen et al, 2014).

According to Maehler and Schuchardt (2016), when diagnosing and helping children with learning issues, individual working memory capacities should be taken into consideration. However, recent research raises questions about the practical applicability of working memory training programmes as well as their efficacy as means of boosting cognitive functioning in children and healthy individuals who are typically developing (Melby-Lervag and Hulme, 2013). A number of studies have shown that working memory training can increase memory or at least scores on cognitive tasks designed to evaluate memory, but these benefits typically do not translate to improved academic performance (Banales, Kohnen, & McArthur, 2015).

An investigation by Abduh & Tahar (2018) tried to pinpoint the most efficient strategies that could improve the working memory capacity of students with learning disabilities. Three groups of five students each were divided into the control, Brain Gym, and Brain Training intervention groups for this quasi-experimental investigation. Throughout the first semester of school, the Brain Gym intervention group engaged in daily Brain Gym ® Superspace exercises for four weeks. The intervention group was given a daily Brain Training intervention for four weeks. During their leisure time at school, they were each given a 5-minute Brain Training game. The study findings indicate a considerable improvement in both intervention groups' working memory performance. Additionally, it was discovered that participants in the intervention group had significantly improved their spatial memory and digit span memory abilities. Similarly in another intervention study by Cornoldi et al., (2015) also reported their training regimen improved working memory and metacognitive activities, which had a good impact on one's capacity to solve difficulties.

Another intervention study was carried out by Holmes, Gathercole and Dunning (2009), wherein the authors used adaptive training to improve children's weak working memory over time. For roughly 35 minutes each day for at least 20 days in a span of 5-7 weeks, children trained on a variety of working memory activities in a computerised game environment. These results suggest that this behavioural therapy may be used to address typical working memory deficits and related learning problems. The use of a grouping strategy for tasks requiring verbal working memory and visuospatial short-term memory increased significantly with adaptive training, and adaptive training was linked with selective increases in untrained working memory assessments. These findings suggest that training-related gains in working memory may be mediated by implicit and unintentional adjustments in the methods utilised to divide information into

groups for recall when the tasks employed for testing and training are similar (Dunning & Holmes, 2014).

The role of computer-based interventions for enhancing the cognitive skills cannot be ignored. The goal of computerised working memory programmes like Cog Med (Klingberg et al., 2005) and Jungle Memory (Alloway, 2012) is to increase working memory capacity. Computerised working memory programmes concentrate on boosting working memory capacity with the understanding that transfer or generalisation to everyday situations, such as classroom learning, will occur. The results imply that school-based working memory training may be an effective strategy for treating children with attention issues or hyperactivity, which calls for additional research (Mezzacappa, & Buckner, 2010).

Children with working memory deficiencies have shown increased attention and working memory skills when using computerised cognitive training as an intervention strategy, and children who have finished cognitive training protocols have shown performance improvements in reading and maths, which is contradictory to the findings shared by Banales, Kohnen and McArthur (2015). Following cognitive training, the children's attention and working memory was increased, and it was also discovered that the variables being assessed showed pre- to post-training changes in cognitive structure. The implications for clinical practise and interventions used in schools were also examined by the researchers (Wiest et al., 2022). The early numeracy intervention primarily enhanced early numeracy skills in preschoolers, but the working memory intervention also improved both early numeracy and working memory skills.

Though there were few studies of intervening the working memory, interventions among SLD were lacking in the literature. Moreover, there were no

studies available examining the effectiveness of interventions for processing speed. A study done for processing speed compared phonological awareness, rapid automated naming (RAN), morphological awareness, word reading, vocabulary knowledge and processing speed between Chinese and English children. There were 3 groups including children with dyslexia, age-matched (AM) controls, and reading-matched (RM) controls. The study came with the findings that RAN impairments are likely to be the most significant deficits among them in dyslexic Chinese youngsters (Zhou, et al 2014).

DeMarie and L'opez (2013) suggested that instead of teaching students only procedures of what to do to learn, teachers need to spend instructional time helping students to understand how to study, and why using particular strategies will help them to learn different types of material, they effectively summarise the teacher's role. Memory Mates is a novel classroom-based working memory intervention that addresses the two classroom-oriented approaches simultaneously: (1) training the teacher to become aware of and to provide adjustments to facilitate students' attention and working memory; and (2) giving each student personal strategies to use on their own to manage attention and working memory difficulties. However, regardless of intellect, children with below-average academic performance exhibited deficiencies in working memory performance. Working memory should be seen as a crucial indicator of academic achievement that might result in both surprising overachievement and academic failure. Hence the researchers suggests that individual working memory capacities should be considered when diagnosing and treating children with learning issues (Maehler & Schuchardt, 2016).

CHAPTER 3

METHOD

A good research method is always a strength for scientific research which will provide scientifically sound findings. A properly planned method gives a clear direction for a researcher to navigate in the right direction. This not only keeps the researcher on the track, but also helps the other similar researchers to replicate the research in future and recheck the reliability of the findings.

3.1 Objectives

3.1.1 Major objective:

To find out the efficacy of cognitive training on processing speed and working memory of children with Specific Learning Disability

3.1.2 Specific objectives:

1. To find out the efficacy of Rapid Automatized Naming, Free association of letters and Coding on Processing speed of children with specific learning disability
2. To find out the efficacy of Digit backword, Number-Letter sequencing and Chain game activity on Working memory of children with specific learning disability
3. To compare the processing speed and working memory of children who has undergone cognitive training and who has not.

3.2 Hypotheses

H1: The intervention module will enhance Processing speed of children with specific learning disability

H2: The intervention module will enhance Working memory of children with specific learning disability

H3: The processing speed and working memory of children undergone cognitive training will be greater than the children who has not undergone the training

3.3 Design

A research design provides a plan and outline of route for conducting a study. Any research achieves its successful completion within its timeline with the help of an appropriate research design which provides a frame work to guide its progress.

The present study is based on a quasi-experimental design following a quantitative approach. Quasi-experiments are study designs that are typically employed outside of the laboratory to evaluate the causal ramifications of long-term interventions. In quasi-studies, treatment allocation is determined by self-selection or researcher's discretion rather than randomization, as in actual experiments (Cook, 2015).

3.4 Sample

Universe: NIEPMD, Chennai and CBSE school in Chennai

Sample: Children diagnosed with Specific Learning Disability certified by a Clinical psychologist coming for assessments and intervention

Sampling technique: Purposive sampling

Sample size: 20 (Experimental group=10 and control group=10)

Inclusion criteria:

- Children with Intelligence Quotient above 85 in a standardised intelligence test
- Children who are willing for 2 months commitment for intervention
- Children with age 8 years to 16 years
- Children studying in 4^{th}-12^{th} grade.
- Both girls and boys

Exclusion criteria:

- Children with any psychiatric illness or neurological problems
- Children who are non-verbal
- Children with comorbid conditions or having chronic physical illness
- Children attending any other cognitive training programs.

3.5 Variables

Independent Variable (IV): Cognitive training

Dependent Variable (DV): Working Memory (WM) and Processing Speed (PS)

3.6 Measures

3.6.1 Personal Information Schedule- This includes the basic information about the participants of the research such as initials, age (in months), Date of birth, gender, grade of study, place of stay etc.

3.6.2. Wechsler Intelligence Scale for Children (WISC IV)- Two Sub-scales Working Memory Index (WMI) and Processing Speed Index (PSI)

Wechsler Intelligence Scale for Indian Children -IV is a measure of general intellectual functioning which has 4 index scores Verbal Comprehension Index (VCI), Perceptual Reasoning Index (PRI), Processing Speed Index (PSI) and Working Memory Index (WMI). This test includes both verbal and non-verbal tests, consisting of 10 core subtests and 5 supplementary tests.

In the present research, the core tests of 2 subtests of WISC-IV - Working Memory Index (WMI) and Processing Speed Index (PSI) was used.

Working Memory Subtests

- *Digit span* composed of forward and backward series. In digit forward, the child has to repeat the series of numbers in the order as read aloud by the examiner, and digit backward requires the child to repeat the numbers in the reverse order of what examiner presented. Each item of the series composed of 2 trials with the same span length. There are eight items in both forward and backward series.

  Scoring: the total number of correctly recalled will be considered for the scoring. The raw score will be converted to scaled score.

- *Letter -Number sequencing-* The child is read a sequence of numbers and letters, and has to recall both numbers and letter in an ascending order. This subtest consists of 10 items which has 3 trials each

  Scoring: the total number of correctly recalled series will be considered for the scoring. The raw score will be converted to scaled score.

  Working Memory Index (WMI): the scaled scores of both Digit span tests and Letter -Number sequencing will be added to get sum of scaled scores, and converted to working memory index based on the norms in the WISC -IV manual.

Processing Speed Subtests

- *Coding-* Child has to copy symbols that are paired with simple geometric shapes or numbers as given in the sample. The participant has to draw each symbol in its corresponding box within 2 minutes.

  Scoring: the total number of correctly coded symbols will be considered for the scoring. The raw score will be converted to scaled score.

- *Symbol search*- The child has to scan a search group and indicate whether the target symbol matches any of the symbols in the search group within 2 minutes. A tick mark on 'yes' has to be put if either of the symbol is there in the search group, and 'no' if both the symbols are not there.

Scoring: the total number of correctly marked responses will be considered for the scoring. The raw score will be converted to scaled score.

Processing Speed Index (PSI): the scaled scores of both coding and symbol search will be added to get sum of scaled scores, and converted to Processing Speed Index based on the norms in the WISC -IV manual.

Reliability and validity: WISC-IV was found to have convergent and discriminant validity provided by the correlational studies with instruments such as WISC-III, WPPSI-III, WAIS-III etc. The reliability coefficient for WISC-IV composite scales range from 0.88 to 0.97.

3.7 Session plan

Duration of 1 session: 30 minutes a day

Session distribution: 2 days per week (6 students per day)

Total number of sessions for a child: 10 sessions

Total duration of study: 2 months

***3.*8 Procedure**

First of all, in order to collect data from the institute, the permission for data collection was priorly taken. The parents of children with Specific Learning Disability

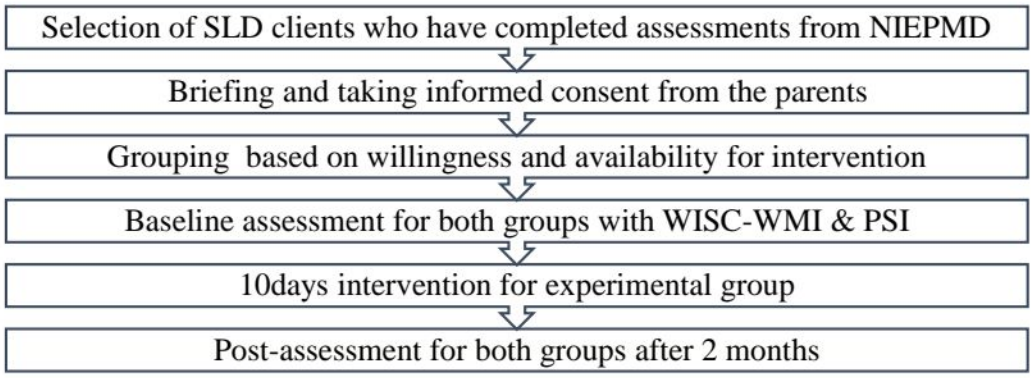
in NIEPMD was met during the last session of assessments after they receive the report of the diagnosis. Parallelly, a CBSE school in Chennai was approached where there is a resource room facility for children with SLD. Both the parents of selected children were psycho-educated about the disability condition and its associated disturbances. They were oriented about what are the services as well which they can take to improve the overall academic performance of their child. After these detailing, the parents were introduced about the research and its objective. They were given detailed information about the nature, duration and expectations during the intervention procedures. They were also given consent form in both English and Tamil version, and collected willingness from parents for participating in the study. Based on their availability for the intervention, children were categorised to experimental group and control group. For the participants in experimental group, information regarding the frequency of sessions and total duration of the research was informed in detail. Whereas for the participants in control group, the frequency and time for pre-test and post-test was informed well in advance so that time factor doesn't influence the study findings. Pre-test were done individually for all participants in both the groups. After the pre-test, 10 session intervention was given only for the experimental group, and their performance in each activity was noted down in the recording sheets. They were also given worksheets to practice at home. Parents were oriented about how to carry out the activities at home with the help of siblings as well. After a period of 2 months, post-test was carried out for both the groups individually. The participants who were interested to continue the intervention in both experimental group and control group was oriented about the procedures to carry out the activities at home so that the effects of the intervention maintain for the experimental group, and control group also gets the benefit

of improving their working memory and processing speed at their own pace and interest.

Groups	Pre-test	Intervention	Post-test
Experimental Group	WMI & PSI	Cognitive training	WMI & PSI
Control Group	WMI & PSI	No intervention	WMI & PSI

3.9 Flow of research process

Figure 3.1: flow of research process



3.10 Intervention module

Strategies to improve working memory

1. *Digit backward series*

   List of numbers starting from 2 digits to 6 digits were prepared. The list consists of 50 series, wherein the participants will be trained for 10 series every day as 10 trials. Upon getting trained in 2-digit series, the training was pushed to next set of series. The series was read out to the participants one by one until they were able tell the series without any error. Participants was encouraged to

visualise the number series in a sequence in their visual field, or repeat the numbers within mind based on their preferences.

2. *Number-letter sequencing (NL)*

   List of number-letter series starting from 2 to 6 N-L combinations were prepared. The list consists of 50 series, wherein the participants will be trained for 10 series every day as 10 trials. Upon getting trained in 2 N-L combinations, the training was pushed to next set of series. The series was read out to the participants one by one until they were able tell the series without any error.

3. *Chain game activity*

   This activity has 5 trials every session. The researcher and participant will create a chain of nouns based on each theme ranging from 2 to 6 names. Researcher starts with saying name of one fruit, wherein the participant has to say the name said by the researcher and add a new fruit name. As a third step researcher continues saying both the name in correct sequence and then adding new fruit name to the list. By the end of each trials the participant was able to say names of 6 fruits in the same sequential order. The same procedure will be repeated for themes such as animals, vegetables, places, flowers, birds, furniture, etc

Strategies to improve processing speed

1. *Rapid Automatic Naming*

   This activity involves 6 set of reading sheets based on complexity levels. The first 4 sheets consist of 3-6 colours. First sheet consists of 3 colours, 2nd sheet 4 colours and so on. Participant was asked to read the colours continuously as fast as possible. Each sheet was practiced 10 trials for 2 days, and the time taken for completing reading was also noted. 5th sheet consisted of shapes such as circle,

triangle, square and diamond wherein participant was asked to name the shapes. 6th sheet consisted of images wherein the participants was asked to name the images such as flower, shocks, doll etc.

2. *Coding*

Coding activity has 3 complexity levels starting from simple coding of symbols to coding of letters. In the first 2 levels, the participant was asked to code the symbols corresponding to numbers. In the final level letters were coded for the images based on the first letter of the image. 3 trials were done during each session, and for all levels, total time taken was noted down.

3. *Free association of words*

In this activity, participant was given an alphabet and he/she was asked to say maximum words which starts with that particular letter within 1minutes. In each session, participant will be given 5 letters, and the number of words told will be tallied down. They were constantly encouraged to think and tell the words within a minute.

3.11 **Statistical analysis**

- ***Shapiro-Wilk test-*** To check the normality of sample distribution
- ***Paired t-test-*** To compare the pre-test and post test scores on processing speed and working memory of experimental groups and control group before and after cognitive training.
- ***Independent t-test-*** To compare the pre-test scores of experimental group and control group and post test scores of experimental groups and control group on processing speed and working memory

3.12 Ethical considerations

- Initial approval from the departmental and institutional ethical committee, followed by accommodating to the changes given.
- Informed consent will be taken from the parents after briefing about the study
- Anonymity of the participants and the confidentiality of the data will be maintained.
- If receiving a positive result from the study, the same intervention will be given to the control group as well
- The intervention for any child will be terminated if the techniques involved in the study is affecting negatively on any aspect.

CHAPTER 4

RESULTS AND DISCUSSION

RESULT

Children with Specific Learning Disability (SLD) was found to have deficits in processing speed and working memory capacity (Jong, 1998 & Willcutt et al., 2005). The cognitive training intervention given in this research was expected to improve processing speed and working memory which can have a positive impact on the academic skills of children with SLD. Hence, the present study mainly focussed on finding out the efficacy of cognitive training on processing speed and working memory of children with SLD. Specifically, the research aimed to find out the efficacy of Rapid Automatized Naming, Free association of letters and Coding on Processing speed of children with specific learning disability; and to find out the efficacy of Digit backword, Number-Letter sequencing and chain game activity on working memory of children with SLD. Moreover, the study also compares the processing speed and working memory of children who has undergone cognitive training and who has not.

Hence, this research has hypothesised that the intervention module will enhance Processing speed and Working memory of children with SLD, and the processing speed and working memory of children undergone cognitive training will be greater than the children who has not undergone the training

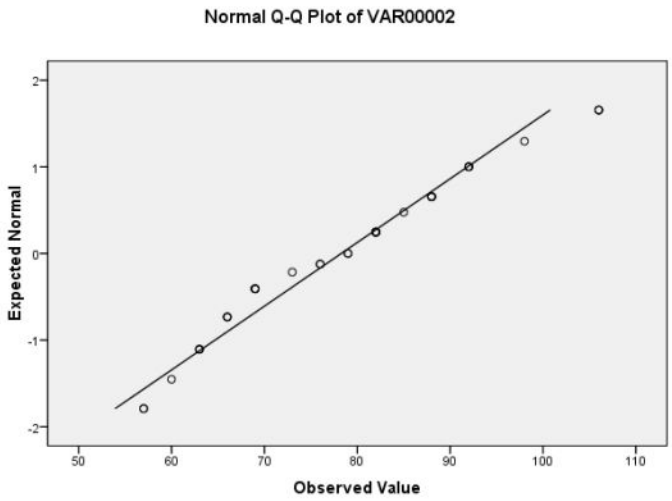
Table 1: *Gender wise sample distribution of samples in the experimental group and control group*

	Experimental group		**Control group**	
	Girls	Boys	Girls	Boys
	6	4	6	4
Age range	8-16 years		9-16 years	

4.1 Analysis exploring the normality of sample distribution

A Shapiro-Wilk test was conducted to assess the normality of the scores. The test was not significant, W (40) = 0.949, p = 0.71, indicating that the scores were normally distributed.

Figure 4.1 *p-p plot of test of normality*



The p-p plot reveals that the sample distribution meets the basic assumption of normality. Hence further analysis of data was carried out using parametric tests such as independent sample t-test and paired sample t-test to find out the difference between experimental-control groups; and between pre-test and post test scores of 2 groups

4.2 Efficacy of cognitive training on Working Memory

Table 2: *Pre-test raw scores, scaled scores and Working Memory Index of experimental group*

Sl no	Initial	Digit span	Scaled score	Letter-number	Scaled score	Sum of scaled score	Working Memory Index (WMI)

1	ABN	13	5	19	10	15	85
2	JVT	13	4	20	10	14	82
3	PNA	13	5	15	7	12	76
4	NGA	14	5	18	8	13	79
5	LOG	14	6	15	6	12	76
6	NHA	12	2	17	4	6	57
7	SAI	15	9	10	5	14	82
8	RWN	13	4	15	5	9	66
9	KSHR	13	5	18	9	14	82
10	ADV	13	4	15	5	9	66

Table 2 shows the pre-test raw scores, scaled scores and WMI of experimental group. The raw score of the participants in digit span ranged from 12-15 and the corresponding scaled score ranged from 2-9. Similarly, the raw score of the participants in letter-number sequencing ranged from 10-20 and the corresponding scaled score ranged from 4-10.

Table 3: *Post-test raw scores, scaled scores and Working Memory Index of experimental group*

Sl no	**Initial**	**Digit span**	**Scaled score**	**Letter-number**	**Scaled score**	**Sum of scaled score**	**Working Memory Index (WMI)**
1	ABN	21	12	19	10	22	106
2	JVT	17	8	18	8	16	88
3	PNA	14	6	20	11	17	92
4	NGA	16	7	20	10	17	92

5	LOG	17	8	19	9	17	92
6	NHA	24	11	22	11	22	106
7	SAI	16	10	19	12	22	106
8	RWN	16	7	19	9	16	88
9	KSHR	16	8	20	11	19	98
10	ADV	16	7	20	10	17	92

Table 3 shows the post-test raw scores of experimental group on working memory. The raw score of the participants in digit span ranged from 14-24, whereas that during pre-test was 12-15. The corresponding scaled score ranged from 6-12, whereas that during pre-test it was 2-9. Similarly, the raw score of the participants in letter-number sequencing ranged from 18-22, whereas that during pre-test was 10-20 and the corresponding scaled score ranged from 8-12, whereas that during pre-test was 4-10.

Table 4: *Pre-test raw scores, scaled scores and Working Memory Index of control group*

Sl no	**Initial**	**Digit span**	**Scaled score**	**Letter-number**	**Scaled score**	**Sum of scaled score**	**Working Memory Index (WMI)**
1	ASW	11	2	16	6	8	63
2	SBN	15	4	18	5	9	66
3	HAF	7	1	13	5	6	57
4	RAJ	15	4	16	4	8	63
5	JND	18	9	18	7	16	88
6	KBRN	11	2	19	8	10	69

7	LKSRN	12	3	17	7	10	69
8	SHLN	13	4	17	6	10	69
9	BADR	15	4	21	10	14	82
10	KAT	14	5	18	8	13	79

Table 4 shows the pre-test raw scores of control group on working memory. The raw score of the participants in digit span ranged from 7-18 and the corresponding scaled score ranged from 1-9. Similarly, the raw score of the participants in letter-number sequencing ranged from 13-20 and the corresponding scaled score ranged from 4-10.

Table 5: *Post-test raw scores, scaled scores and Working Memory Index of control group*

Sl no	**Initial**	**Digit span**	**Scaled score**	**Letter-number**	**Scaled score**	**Sum of scaled score**	**Working Memory Index (WMI)**
1	ASW	11	3	15	5	8	63
2	SBN	16	5	17	4	9	66
3	HAF	10	2	13	5	7	60
4	RAJ	15	4	17	4	8	63
5	JND	20	10	16	6	16	88
6	KBRN	12	3	18	7	10	69
7	LKSRN	13	4	17	6	10	69
8	SHLN	15	5	18	6	11	73
9	B	17	6	20	8	14	82

10	KAT	14	5	19	9	14	82

Table 5 shows the post-test raw scores of control group on working memory. The raw score of the participants in digit span ranged from 10-20 and the corresponding scaled score ranged from 2-10. Similarly, the raw score of the participants in letter-number sequencing ranged from 13-20 and the corresponding scaled score ranges from 4-9.

Table 6: *Results of Paired t-test- comparing the pre and post test scores of experimental group and control group in WMI*

	Experimental group			**Control group**		
	Mean	SD	t score	Mean	SD	t score
Pre-test	75.10	9.13	5.76**	70.50	9.61	1.93NS
Post-test	96	7.42		71.50	9.51	

*** Significant at 0.01 level* *NS Not significant*

Table 6 shows the mean, standard deviation and the t- scores of experimental group and control group in Working Memory Index before and after cognitive training. Table shows the mean score of pretest in experimental group is 75.10 and that of post test is 96. Similarly, the pretest mean of control group is 70.50 and that of post test is 71.50.

4.3 Efficacy of cognitive training on Processing speed

Table 7: *Pre-test raw scores, scaled scores and Processing Speed Index of control group*

Sl no	Initial	Coding	Scaled score	Symbol search	Scaled score	Sum of scaled score	Processing Speed Index (PSI)
1	ABN	38	7	23	9	16	89
2	JVT	47	7	35	13	20	100
3	PNA	47	10	18	7	17	91
4	NGA	48	13	18	6	19	97
5	LOG	52	9	24	9	18	94
6	NHA	70	12	36	11	23	109
7	SAI	27	6	18	9	15	86
8	RWN	54	9	25	8	17	92
9	KISHR	42	8	22	8	16	89
10	ADHV	42	6	24	8	14	83

Table 7 shows the pre-test raw scores and scaled scores of experimental group on processing speed. The raw score of the participants in coding ranged from 27-70, and the corresponding scaled score ranged from 6-13. Similarly, the raw score of the participants in Symbol search ranged from 18-36, and the corresponding scaled score ranges from 6-13.

Table 8: *Post-test raw scores, scaled scores and Processing Speed Index of experimental group*

Sl no	Initial	Coding	Scaled score	Symbol search	Scaled score	Sum of scaled score	Processing Speed Index (PSI)
1	ABN	58	13	27	11	24	112
2	JVT	71	13	30	10	23	109
3	PNA	58	13	27	11	24	112
4	NGA	60	11	28	10	21	103
5	LOG	70	14	34	13	27	121
6	NHA	73	12	40	12	24	112
7	SAI	41	11	19	10	21	103
8	RWN	46	7	26	9	16	89
9	KISHR	50	10	24	11	21	103
10	ADHV	57	10	31	11	21	103

Table 8 shows the post-test raw scores of experimental group on processing speed. The raw score of the participants in coding ranged from 41-73, whereas that during pre-test it was 27-70; and the corresponding scaled score ranged from 7-14, whereas that during pre-test it was 6-13. Similarly, the raw score of the participants in symbol search ranged from 19-40, whereas that during pre-test it was 18-36, and the corresponding scaled score ranges from 9-13, whereas that during pre-test was 6-13.

Table 9: *Pre-test raw scores, scaled scores & Processing Speed Index of control group*

Sl no	Initial	Coding	Scaled score	Symbol search	Scaled score	Sum of scaled score	(PSI)
1	AISW	35	4	17	5	9	66
2	SHBN	79	14	37	11	25	115
3	HAF	23	3	10	4	7	60
4	RAJ	66	11	27	8	19	97
5	JVND KRBG	35	4	24	8	12	76
6	RN LOGS	72	13	29	10	23	109
7	RN	42	6	30	10	16	89
8	SHLN	61	10	32	10	20	100
9	BAD	47	7	35	13	20	100
10	KAT	48	13	18	6	19	97

Table 9 shows the pre-test raw scores and scaled scores of control group on processing speed. The raw score of the participants in coding ranged from 23-79, and the corresponding scaled score ranged from 4-14. Similarly, the raw score of the participants in Symbol search ranged from 10-37, and the corresponding scaled score ranged from 4-13.

Table 10: *Post-test raw scores, scaled scores and Processing Speed Index of control group*

Sl no	Initial	Coding	Scaled score	Symbol search	Scaled score	Sum of scaled score	PSI
1	AISW	36	4	17	5	10	69
2	SHBN	77	13	37	11	24	112
3	HAF	26	4	11	4	8	63
4	RAJ	68	11	28	8	19	97
5	JVND	38	5	25	8	13	80
6	KRBGRN	66	11	32	11	22	106
7	LOGSRN	46	7	30	10	17	91
8	SHLN	62	10	30	9	19	97
9	BAD	54	8	38	12	20	100
10	KAT	64	12	22	7	19	97

Table 10 shows the post-test raw scores of control group on processing speed. The raw score of the participants in coding ranged from 26- 77 and the corresponding scaled score ranged from 4-13. Similarly, the raw score of the participants in symbol search ranged from 11-38 and the corresponding scaled score ranges from 8-24.

Table 11: *Results of paired t-test – comparing pre-tests and post-tests scores of experimental and control group on Processing Speed Index (PSI)*

	Experimental group			**Control group**		
	Mean	SD	t score	Mean	SD	t score

Pre-test	93	7.513	4.47**	90.90	18.10	0.35NS
Post-test	106.70	8.577		91.20	15.78	

*** Significant at 0.01 level* *NS Not significant*

Table 11 shows the mean, standard deviation and the t- scores of experimental group and control group on processing speed before and after cognitive training. Table shows the mean score of pretest in experimental group is 93 and that of post test is 106.7. Similarly, the pretest mean of control group is 90.90 and that of post test is 91.20.

4.4 Comparison between Experimental and Control group

Table 12: Results of Independent t-test comparing the pre-test scores of experimental group and control group ; post-test scores of experimental group and control group

	Experimental group		**Control group**		
	Mean	SD	Mean	SD	t score
Pre-test WMI	75.10	9.13	70.50	9.618	1.097NS
Post-test WMI	96.0	7.42	71.50	9.53	6.42**
Pre-test PSI	93.0	7.51	90.90	18.10	0.33NS

Post-test PSI	106.70	8.57	91.20	15.78	2.72*

*** Significant at 0.01 level* * *Significant at 0.05 level*

Table 12 shows difference between the mean scores of experimental and control group before and after the intervention. On working memory, the mean score of experimental group before intervention was 75.10 and that of control group was 70.50. Similarly, on processing speed, the mean score of experimental group before the intervention was 93.0 and that of control group was 90.90.

The mean score of experimental group after intervention was 96.0 and that of control group was 71.50. Similarly, when looking into the post-test scores of experimental and control group on processing speed, the mean score of experimental group after intervention was 106.70 and that of control group was 91.20.

DISCUSSION

4.2 Efficacy of cognitive training on Working Memory

Working memory is an essential cognitive skill necessary for academic learning. There is a plethora of studies which have proven that the working memory capacity of children with SLD are compromised (eg. Jong, 1998) which resulted in struggling in an educational setting not only with academic performance, but also in the way he or she performs within a classroom setting, and difficulties to respond to the questions of teachers. Evidences even reported that children who struggled in classroom are likely to drop out from the school as the consequence of difficulty to fit into the classroom requirements considering the deficit as a handicap (Gupta & Sharma, 2017).

Table 2 shows the pre-test raw scores, scaled scores and WMI of experimental group. from the table, it was found that though few participants scored similarly in digit span test, their scaled score was different due to their age difference revealing that age has only less significance on the working memory capacity of the children. The range of sum of scaled scores in sub-tests of working memory is 6-15 with corresponding Working Memory Index ranging from 57-85, which indicates that there is a significant deficit in working memory capacity among the children with SLD, since all the scores came below average score of 90 according to Wechsler's classification system. These pre-test results are consistent with the findings of existing review of the literature (Tai-sheng, 2006; En, 2007) that, there is a significant deficit in working memory capacity of children with LD when compared with children who are normally developing.

Among the 10 participants, participant no: 6, 8 and 10 obtained the least score in Working Memory Index which demanded attention on an individual basis. These findings in present research are consistent with the previous research by Jong (1998)

that reading-disabled children underperformed on all working memory capacity tests when compared to the other groups, which was attributed to a lack of capacity in simultaneous processing and storage of verbal information.

Table 3 shows the post-test raw scores, scaled scores and Working Memory Index of experimental group. There was a change of scores which indicated a positive improvement in the scores on digit span and letter-number sequencing tests among all the samples under the study, revealing an improvement in the working memory capacity of the samples. The range of sum of scaled scores in sub-tests of working memory in post-test is 16-22, whereas that during pre-test was 6-15. Moreover, the corresponding Working Memory Index in post-test ranged from 88-106, which indicates that the range changed from pre-test range of 57-85; changing from below average scores to average range of scores of working memory capacity.

When looking into individual scores, the participant no: 6 who scored very least in the pre-test was one among the participant who scored highest in the post-test. However, the participant no: 8 obtained WMI of 88 which was still a below average score. It may be due to the lack of adherence to the home-based worksheets assigned to this specific sample and irregularity in attending the sessions. Participant no: 10 also showed significant improvement in the post-test scores on WMI.

Table 4 shows the pre-test raw scores of control group on working memory. The range of sum of scaled scores in sub-tests of working memory is 6-16 with corresponding Working Memory Index ranging from 57-88, which indicated that there is a significant deficit in working memory capacity among the children with SLD since all the scores came less than 90 according to Wechsler's classification system.

From the scores of working memory of both control group and experimental group of children with SLD, it was evident from the present study as well, that there is a significant deficit in working memory associated with SLD. When looking to literatures about which components of working memory capacity was getting impaired among different subtypes of SLD, Brandenburg et al (2015) identified that child with spelling disabilities had more obvious phonological loop problems when compared to children with reading disabilities. However, they have found that spelling disability was not linked with domain-general central-executive dysfunctions; whereas reading disability was linked to it. At the same time, reviews also shows that no deficits were discovered in the visuospatial sketchpad of the children with reading and arithmetic difficulties having working memory deficits.

Table 5 shows the post-test raw scores of control group on working memory. The range of sum of scaled scores in sub-tests of working memory is 7-16 with corresponding Working Memory Index ranged from 60-88, which indicated that the significant deficit in working memory capacity was similar to their pre-test scores which is less than 90. This can be attributed to the no intervention given to the control group.

Table 6 shows the mean, standard deviation and the t- scores of experimental group and control group in Working Memory Index before and after cognitive training. When comparing the mean scores of experimental group before and after cognitive training, it is evident that the mean value of post-test 96 of experimental group was comparatively higher with a standard deviation of 7.42 than the pre-test scores of experimental group which has the mean score was 75.10 and a standard deviation 9.13. The t value of 5.76 clearly shows a significance at 0.01 level indicating that the Working

Memory Index of experimental group has improved after giving 10 session interventions systematically.

The scope of present research comes is more obvious from the evidences of numerous studies which confirmed that working memory capacity can be improved through various interventions and strategies. Moreover, it was also proven that the working memory development continues into the elementary school years in children, confirming that brain areas associated with it mature slowly responding to interventions (Vaz, Cordeiro, Macedo, and Lukasova, 2010).

It was evident from literature that intervening a child with SLD should address their working memory capacities (Maehler & Schuchardt, 2016). However, the practical applicability of working memory training programmes as well as their efficacy for boosting cognitive functioning was still controversial (Melby-Lervag and Hulme, 2013).

The efficacy of 2 forms of interventions was experimented by Abduh & Tahar (2018) to improve the working memory capacity of students with learning disabilities. The first group was given brain training interventions, whereas the second group was given brain Gym. Third group was a control group for whom no interventions were given. The findings reveals that there was a considerable improvement in both intervention groups' working memory performance when compared to the control group. Similarly Cornoldi et al., (2015) also reported a good impact on one's capacity to solve difficulties as a result of intervening with training regimen to improve working memory and metacognitive activities.

In the present study a single session was for 30 minutes, which was found to be effective based on the results. A similar study (Holmes, Gathercole and Dunning, 2009)

also found that 35 minutes intervention was effective to improve working memory capacity which was given for 20 days spread to 5-7 weeks. These authors have given adaptive training to enhance the weak working memory in a computerised game environment, and they suggested that behaviour therapy may be used to address typical working memory deficits and related learning problems.

Since this research found an effectiveness in enhancing working memory, the scope to intervene the cognitive capacities of SLD children is found to be more, which can be achieved with more advanced intervention strategies making use of the technologies to save man power and time. Some of them are recommended by other researchers such as Cog Med (Klingberg et al., 2005) and Jungle Memory (Alloway, 2012). It was found that the computerised working memory programmes concentrate on boosting working memory capacity through understanding that transfer or generalisation to everyday situations, such as classroom learning, will occur.

At the same time, looking at the mean scores of control group before and after cognitive training, it was evident that the mean value of pre-test was 70.50 with a standard deviation 9.61. Similarly, the mean value of post-test was 71.50 with a standard deviation of 9.51 which was similar to the pre-test scores. Whereas, the t value 1.93 shows that the there was no significant change in the mean scores of control group at any level after 2 months period due to lack of proper training to address the deficit. The t value was not significant in control group revealing that there were no significant changes in working memory of children due to passage of 2 months' time without intervening it. This obviously admits the fact that giving proper interventions for enhancing working memory deficits are very crucial for the children with SLD. This is expected to help the children to deal effectively with their academic skills and there by improve their achievements in classroom setting.

The relationship between achievement in academics and their working memory capacities are well established in the research carried out by Gathercole, Lamont and Alloway (2006). Supporting the same Swanson and Trahan (1990) reported that children who scored poor in memory span activities got low scores on reading and math standardised tests in the academic setting. According to Tai-sheng (2006), a significant key factor in the development of reading and computational arithmetic skills are working memory capacity required for language and numerical knowledge, and it was also found that there were severe and widespread working memory impairments among children with arithmetic difficulties. The impact of specific learning impairments on various components of working memory was extensively studied by Gathercole and Pickering (2000), and they found that there were pronounced abnormalities in visuo-spatial memory of children with low levels of curriculum attainment. On the contrary, it was also reported from previous research that the extent to which the improved working memory will benefit the academics is also not empirically tested or proved. Studies have shown that working memory training can increase memory, however these benefits typically do not translate to improved academic performance (Banales, Kohnen, & McArthur, 2015) which is again a subject to be investigated scientifically.

When reviewing the extent of the deficits in working memory capacity of children with SLD, the explanation of why such deficits exists was described in the research done by Swanson (1993), and came with a finding that learning-disabled children experienced generalized deficit in working memory capacity and was attributed to storage limitations in the executive system when compared to the children without learning disabilities. Moreover, it was seen that the working memory profiles are different for children having difficulties in reading and spelling. According to Weerdt, Desoete, and Roeyers (2013), children with mathematical impairments had

lower memory span scores than children with ordinary achievement in measures of the phonological loop and the central executive.

A few significant and valid suggestions were made by researchers DeMarie and L'opez (2013) that instead of teaching students only procedures of what to do to learn, teachers need to spend instructional time helping students to understand how to study, and why using particular strategies will help them to learn different types of material, which effectively summarised the teacher's role in enhancing academic outcome. Maehler and Schuchardt (2016) also stated that working memory should be seen as a crucial indicator of academic achievement that might result in both surprising overachievement and academic failure.

4.3 Efficacy of cognitive training on Processing speed

Processing speed refers to the rate at which an individual can take information, and act after interpreting the incoming information. It is the time taken to complete a task on hand. Processing speed is an essential cognitive ability required for quick responses to the environmental demands. Especially in academics, students are expected to give verbal responses to the questions asked by the teachers which is facilitated by their processing speed capacity in them. It was evident from several studies that the processing speed of children with SLD is impaired when compared to children without SLD (Swanson (1981); Kramer et al, 2000 & Willcutt et al., 2005), though they have got average intellectual functioning. This makes the children with SLD to respond with delay in an academic setting.

Table 7 shows the pre-test raw scores and scaled scores of experimental group on processing speed. The pretest assesses the processing speed of children through searching test and coding test which requires the children to act fast through writing

responses. This activity demands quick brain processing to complete the maximum task within the given time limit. Pretest scores shows that most of the children in the present study showed a significant deficit in processing speed capacity as evident in the test findings (Burgess, 2023).

Hence, the range of sum of scaled scores in sub-tests of working memory is 14-23 with corresponding Processing Speed Index (PSI) ranging from 83-109, which indicates that some of the samples in the study falls under 90 in their processing speed capacity.

These results are found to be consistent the findings of several previous researches that the capacity to receive information, understand it, and respond through written or physical answer can be difficult for learners who digest information slowly because it requires more time and effort for each process to be completed (Burgess, 2023). The struggle in writing tasks for children with SLD was not because of any motor deficit, but because of their deficit in certain cognitive abilities as concluded by Kerr and Hughes (1987), which is referred as motor processing speed. At the same time, there were contradictory research findings which also revealed that the motor processing speed was not significantly impaired among children with SLD.

A significant area which hits the academic skill is mathematical aptitude of the children with Specific Learning Disability (Bull & Johnston, 1997). Studies among children with SLD specifically Dyscalculia identified significant impairments in planning, simultaneous processing, and consecutive processing than the group of children without Mathematical Learning Disability (Iglesias-Sarmiento et al., 2017).

Among the 10 participants, participant no: 1,7,9 and 10 obtained below 90 in Processing Speed Index (PSI) for whom the training can be helpful to improve the

capacity to an average level. The effectiveness of interventions for processing speed was evident from a study carried out by Zhou, et al (2014). They compared phonological awareness, Rapid Automated Naming (RAN), morphological awareness, word reading, vocabulary knowledge and processing speed between Chinese and English children, wherein they focussed mainly 3 groups such as children with dyslexia, age-matched (AM) controls, and reading-matched (RM) controls. The authors came with the findings that RAN impairments are likely to be the most significant deficits among dyslexic Chinese youngsters. Researchers (Weiler, et al 2003) who investigated on the fundamental causes of the differences between the relative impairments in processing speed seen among children with learning problems and the typical developmental improvement in processing speed found that the causes are different in both groups.

The age range of sample in the study was 8 to 16 years and their processing speed ranged from 89 to 109 which is consistent with the findings of studies done to analyse the processing speed deficit associated with the developing age of children. It was found that for children with and without learning difficulties, there were no changes in the relationship between age and the development of processing speed. The post test scores reveals that there were improvements in all age ranges of the sample accepting the findings of existing literature.

Table 8 shows the post-test raw scores of experimental group on processing speed. The change of score ranges in Table 8 indicate a positive improvement in the scores on coding and symbol search among all the samples under the study, revealing an improvement in the processing speed capacity of the samples. The range of sum of scaled scores in sub-tests of working memory in post-test was 16-27, whereas that during pre-test was14-23. Moreover, the corresponding Processing Speed Index (PSI)

in post-test ranged from 89-112, which indicates that the range changed from pre-test range 83-109; revealing changing from below average scores to average range of scores in processing speed capacity. From the results it was evident that all the participants except no: 8 had improvements in their processing speed scores. However, the participant's pre-test score was 92 and that for in post-test was 88 indicating a mild decrease in the score. This lack of improvements in score was also seen for Working Memory Index of the same participant due to the lack of adherence to the home-based worksheets assigned to this specific sample and irregularity in attending the sessions. The gap between the intervention sessions was comparatively high for this sample when compared to other samples in the study due to absenteeism for the sessions.

In a research conducted to identify processing of visual information more locally or globally by Cardillo, Mammarella, Garcia and Cornoldi (2017), the authors compared children with dyslexia and Nonverbal Learning Disabilities (NLD) with children who were Typically Developing (TD) without any learning disabilities and found that children with NSLD had trouble with visuo-constructive version of the task when compared with children with SLD. Whereas children with SLD was more struggling with the response timing in perceptual version of the task, which was attributed to the deficits in processing speed of dyslexia.

Table 9 shows the pre-test raw scores and scaled scores of control group on processing speed. Pretest scores shows that some of the children in the present study showed a significant deficit in processing speed capacity as evident in the test findings. The range of sum of scaled scores in sub-tests of working memory is 7-25 with corresponding Processing Speed Index (PSI) ranging from 60-115, which indicated that some of the samples in the study falls under 90 in their processing speed capacity for

their age level. These findings were again found to be consistent the research conclusion by Burgess (2023).

Table 10 shows the post-test raw scores of control group on processing speed. The range of sum of scaled scores in sub-tests of processing speed is 8-24 with corresponding Processing Speed Index ranged from 63-112, which indicated that there was a significant deficit in processing speed capacity of some participants, similar to their pre-test scores which is less than 90. This can be attributed to the no intervention given to this control group.

Table 11 shows the mean, standard deviation and the t- scores of experimental group and control group on processing speed before and after cognitive training. When comparing the mean scores of experimental group before and after cognitive training, it is evident that the mean value of post-test 106.70 of experimental group was comparatively higher with a standard deviation of 8.577 than the pre-test scores of experimental group of which the mean score was 93 and a standard deviation 7.513. The t value of 4.47 clearly shows significance at 0.01 level indicating the processing speed of experimental group has improved after the interventions given.

Interpreting the mean scores of control group before and after cognitive training, it was evident that the mean value of pre-test was 90.90 with a standard deviation 18.10. Similarly, the mean value of post-test was 91.20 with a standard deviation of 15.78 which is similar to the pre-test scores. Whereas, the t value of 0.35 shows that the there was no significant change in the mean scores of control group after 2 months period due to lack of proper training to address the deficit. The t value was not significant in control group revealing that there were no significant changes in processing speed of children due to passage of 2 months period in the absence of any interventions for the same. This results clearly reveals the need for proper systematic cognitive training to

enhance the cognitive capacities of children with SLD which can have an indirect effect on their literacy and numeracy skills.

4.4 Comparison between Experimental and Control group

Table 12 shows difference between the mean scores of experimental and control group before and after the intervention. On working memory, the mean score of experimental group before intervention was 75.10 and that of control group was 70.50. Since the t value 1.097 was not significant any level, it was found that both the groups were similar to each other on working memory capacity before the intervention given. Similarly, on processing speed, the mean score of experimental group before the intervention was 93.0 and that of control group was 90.90. Since the t value 0.33 was not significant any level, it was found that both the groups were similar on processing speed capacity as well before the intervention given. The aforementioned t-values states that the experimental and control group was similar in their working memory and processing speed capacity before the intervention procedures which shows that the extraneous factors were controlled when grouping the participants to study by making the 2 groups uniform.

Examining the post-test scores of experimental and control group on working memory, the mean score of experimental group after intervention was 96.0 and that of control group was 71.50. Since the t value 6.42 was significant at 0.01 level, it was found that the working memory capacity of experimental group was higher than control group after the interventions given, indicating the effectiveness of intervention. Similarly, when looking into the post-test scores of experimental and control group on processing speed, the mean score of experimental group after intervention was 106.70 and that of control group was 91.20. Since the t value 2.72 was significant at 0.05 level,

it was found that the processing speed of experimental group was higher than control group after the interventions given, indicating the effectiveness of intervention.

The table values show a significant difference in both working memory and processing speed among experimental and control group after the intervention, which is consistent with the findings from existing literatures. It was evident from the studies of Kozulin et al (2010) that cognitive functioning in children with developmental disabilities can be improved through interventions. The interventions to enhance working memory and processing speed of children with SLD was carried out with the assumption to enhance these cognitive capacities which can have an indirect effect on the academic performance of children. Especially, the interventions to enhance working memory may aid children in becoming more adept at reading comprehension (Dahlin, 2011). Also, it was suggested that if it is successful to improve working memory with interventions, especially computer-based working memory training could be a useful and affordable remedy for this group of young children (Lohaugen et al, 2014).

Hence, the research hypotheses H1, H2 and H3 were accepted that the intervention module enhanced Processing speed and Working memory of children with SLD, and the processing speed and working memory of children undergone cognitive training was greater than the children who has not undergone the training.

CHAPTER 5

SUMMARY AND CONCLUSION

Specific Learning Disability is a life-long neurological condition wherein the academic skills of an individuals are seriously affected which causes significant negative impact on reading, writing and arithmetic skills of children. In India, 16.49% children are suffering from Specific Learning Disorders (Chacko and Vidhukumar, 2020). Similarly, in the statistics published by National Centre for Educational Statistics, 7.2 million children (ie, 15% of all public-school students with 3-21 years) received remedial training service during the year 2020-2021 under the Individuals with Disabilities Education Act (IDEA), among which the mostly received category was Specific Learning Disability (ie, 33%). Children with SLD was found to have several cognitive deficits especially in processing speed (Moll, Gobel, Gooch, Landerl and Snowling, 2016) and working memory (McLean & Hitch, 1999; Cai, Li & Deng, 2013).

When cognitive abilities of children with specific learning disability was compared with children without SLD, it was found that there were significant cognitive impairments in children with specific learning disability (Karande, Sawant, Kulkarni, Kanchan and Sholapurwala, 2005). A review carried out by Anis, et al (2018) highlights the importance of intervening the underlying cognitive functions rather than limiting to remediating with literacy and numeracy skills. Moreover, it was evident from research that cognitive remedial therapy along with regular remedial education was found to be the best effective strategy for SLD (Karande, et al, 2005). Above all, in a recent study by Huijsmans, Kleemans, and Kroesbergen (2021), it was concluded that children with Specific Learning Disability have a unique profile of inter-related strength and weakness, wherein they can compensate their weakness with strength through adequate intervention strategies which can result in learning gains in the affected domain, which doubles the importance of the present study. Hence, an intervention addressing the cognitive deficit is expected to give an enhancement in the cognitive functioning of the

child which may bring underlying neurological changes, and there by facilitating scholastic skills.

5.1 O**bjectives of the research**

1. To find out the efficacy of Rapid Automatized Naming, Free association of letters and Coding on Processing speed of children with SLD
2. To find out the efficacy of Digit backword, Number-Letter sequencing and chain gaming activity on Working memory of children with SLD
3. To compare the processing speed and working memory of children who has undergone cognitive training and who has not.

5.2 Hypotheses of the research:

1. The intervention module will enhance Processing speed of children with SLD
2. The intervention module will enhance Working memory of children with SLD
3. The processing speed and working memory of children undergone cognitive training will be greater than the children who has not undergone the training

5.3 Method

The research followed before-after two group quasi experimental design**.** Children diagnosed with Specific Learning Disability were selected through purposive sampling from NIEPMD, Chennai and a CBSE school in Chennai. Both experimental group and control group consists of 10 children each. Children with age 8 to 16 years, studying in 4^{th}-12^{th} grade having Intelligence quotient above 85 in a standardised intelligence test, and who are willing for participation were included in the study. Similarly, children with any psychiatric illness or neurological problems, comorbid conditions or having chronic physical illness, who are non-verbal and attending any

other cognitive training programs were excluded. Measures used were Personal Information Schedule and 2 sub-scales Working Memory Index (WMI) and Processing Speed Index (PSI) of Wechsler Intelligence Scale for Children (WISC). Pre-test and post-test were done for both experimental and control group, and experimental group was given 10 sessions intervention for a 2-month time period. Each session of the intervention lasted for 30 minutes a day which was given for 3 days per week. Hence each child in experimental group received. The statistical analysis were done using SPSS using the techniques Shapiro-Wilk test, independent t test and paired t test to understand the efficacy of interventions given

5.4 Major findings

- Rapid Automatized Naming, Free association of letters and Coding was found to be effective in enhancing Processing speed of children with SLD
- Digit backword, Number-Letter sequencing and chain gaming activity was found to be effective in enhancing Working memory of children with SLD
- The processing speed and working memory of children who has undergone cognitive training was high when compared to children who has not undergone the intervention

5.5 Conclusion -Cognitive training enhances Processing Speed and Working Memory of Children with Specific Learning Disability (SLD).

5.6 Implications of the research

- Highlighting the importance of cognitive training on enhancing cognitive functioning of children with SLD which can have a positive impact on the literacy and numeracy skills

- Reiterating that the interventions from a psychologist at a cognitive level is important for the children with SLD as we tend to make recommendations to attend remedial training as the only strategy for SLD ignoring the underlying foundation
- Creating awareness among parents about the necessity of taking cognitive interventions from psychologist as well along with remedial training as parents has a notion that only remedial training is enough for children with SLD
- Intervention module can be experimented for the other clinical conditions such as borderline intellectual functioning, mild cognitive impairments etc. Similarly for other cognitive deficits for children with SLD

5.7 Limitations

- Due to limitations in availability of sample willing for intervention, the number of samples in the current study was less.
- Socio-demographic variables were not considered for analysis due to limitations in number of samples
- Some children in experimental group were attending remedial training as well which could be an extraneous factor, and could not control in the current study.
- No interventions were given to the control group due to the unavailability of control group participants during the course period.

5.8 Recommendations for future research

- The same intervention can be repeated with a greater number of samples so that large number of children benefits from the research and findings could be generalised
- The inhouse school counsellors can be given training in intervention so that the research can be carried out in more geographical locations under researcher's supervision.

- True experimental designs such as Randomised Control Trials could be tried by researchers so that some of the extraneous factors could be monitored and controlled.
- Analysis based on socio-demographic variables could be carried out with more samples to understand for which age group and grade level the interventions are more effective.
- Samples could be grouped to more than one experimental group with sample attending remedial training and not attending remedial training to get more accurate understanding about the effectiveness of the cognitive training alone for the selected variables.
- The impact of these enhanced cognitive capacities on academic performance also could be studied by the researchers to find the mediating role of cognition on academic skills.
- Future research can also focus on other cognitive variables such as attention, semantic memory, reasoning etc which also has significant role in academic performance.

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APPENDICES

Appendix A

Personal Information Schedule

Initials:

Age (in months):

Date of birth:

Gender:

Grade of study:

Place of stay:

Diagnosis:

Diagnosed by:

Diagnosed year:

Appendix B

National Institute for Empowerment of Persons with Multiple Disability (NIEPMD)

Ministry of Social Justice and Empowerment, Govt. of. India

Muttukadu, ECR Road, Chennai – 603 112

NIEPMD PHONE NO. 044-27472113, 27472046;

E-mail: farishthashah@gmail.com

EFFICACY OF COGNITIVE TRAINING ON PROCESSING SPEED AND WORKING MEMORY OF CHILDREN WITH SPECIFIC LEARNING DISABILITY (SLD)

Researcher: Ms. Farisha A.T.P Guide: Dr. S Karthikeyan

STUDY INFORMATION SHEET- (Experimental Group)

I am Farisha.A.T.P, II Year Scholar, Mphil Clinical Psychology at NIEPMD. As a part of my course, I am doing research entitled 'Efficacy of cognitive training on processing speed and working memory of children with Specific Learning Disability. In this research, I plan to enhance processing speed and working memory of students diagnosed with Specific Learning Disability using cognitive training for 2 months (12 sessions). An assessment will be carried out before and after the intervention to identify the effectiveness of the intervention given. Each session will last for 30 minutes. Apart from this, students will also be given worksheets and activities which they can practice

at home for better results. All the worksheets and instructions will be given to students for practicing.

Does this study involve any expenses?

No, it does not have any fees.

Is it legally enforceable?

No, this is not a legally binding document. It is a research document.

How many days commitment should I make?

You will need to be a part of the intervention group/control group for 8 weeks followed by an assessment. So, you are expected to be present for a period including the baselines measure for 2 months.

What are my benefits if my child participates in the study?

Based on the theoretical assumptions and the findings of previous research, it is hypothesized that the cognitive training enhances the processing speed and working memory.

Will there be any negative consequences if my child participates?

No, this study procedure will not have any negative effects for the participant. If there are any emotional/psychological repercussions followed by the session, psychological help will be ensured.

Is it compulsory for my child to participate?

No. Your participation in this study is completely voluntary and you can refuse to be a part of this process.

Can I withdraw from the study if my child is not comfortable with the process?

You are free to choose whether you want to be a part of this study. Saying "NO" will not affect your relationship with the researcher or the institute. This study does not involve any laboratory tests or any invasive procedure. If you feel any uneasiness during the process, it can be rescheduled.

Can you ensure the confidentiality of the data?

The personal information given by you will be kept confidential. Only members of the research team will know your name and details. Your name will not appear in any report

or publication. However, the overall results of the study will be published in the research journals.

Undertaking by the researcher

Your consent to participate in the above research by Ms. Farisha.A.T.P, M.Phil Clinical Psychology, NIEPMD, Chennai is sought. You have the right to refuse consent or withdraw the same during any part of the research without giving any reason. If you have any doubts about the research, please feel free to clarify the same. Even during the research, you are free to contact the researcher (Ms. Farisha.A.T.P) for clarification if you desire (Mob.: 9400770145).

The information provided by you will be kept strictly confidential.

Consent to participate in research study

	YES/NO
I confirm that I have had adequate explanation and have clearly understood the information sheet of the study and have had the opportunity to ask questions.	
I understand that my participation is voluntary and that I am free to withdraw from the study at any time without giving a reason.	
I understand that trained researcher will conduct the intervention followed by assessments after 12 sessions	
I understand that all personal information I share will be kept confidential and will not be shared with anyone other than those involved in the research study.	
I have received a copy of the study information sheet and consent form	

Name of the Participant: Signature: Date:

Name of the researcher: Signature Date:

Appendix C

ஒன்றுக்கும் மேற்பட்ட ஊனமுற்றோரின் மேம்பாட்டிற்கான தேசிய நிறுவனம் (NIEPMD)

சமூக நீதி மற்றும் அதிகாரம் வழங்கல் அமைச்சகம், இந்திய அரசு

முட்டுக்காடு, கிழக்கு கடற்கறை சாலை, சென்னை – 603 112

தொ.பே: 9526115304, NIEPMD தொ.பே: 044-27472113, 27472046

மின்னஞ்சல்: farishthashah@gmail.com

குறிப்பிட்ட கற்றல் குறைபாடு (SLD) உள்ள குழந்தைகளின் செயலாக்க வேகம் மற்றும் வேலை நினைவகம் மீதான அறிவாற்றல் பயிற்சியின் செயல்திறன்

ஆராய்ச்சியாளர்: திருமதி ஃபரிஷ்தா ஏ.டி.பி

வழிகாட்டி: டாக்டர் எஸ் கார்த்திகேயன்

ஆய்வுத் தகவல் தாள்

நான் ஃபரிஷ்தா.ஏ.டி.பி, இரண்டாம் ஆண்டு அறிஞர், என்.ஐ.இ.பி.எம்.டி.யில் எம்.பில் மருத்துவ உளவியல். எனது பாடத்திட்டத்தின் ஒரு பகுதியாக, ' குறிப்பிட்ட கற்றல் குறைபாடு திறன் கொண்ட குழந்தைகளின் செயலாக்க வேகம் மற்றும் வேலை நினைவகத்தில் அறிவாற்றல் பயிற்சியின் செயல்திறன்' என்ற தலைப்பில் ஆராய்ச்சி செய்து வருகிறேன். இந்த ஆராய்ச்சியில், 2 மாதங்களுக்கு (12 அமர்வுகள்) அறிவாற்றல் பயிற்சியைப் பயன்படுத்தி குறிப்பிட்ட கற்றல் குறைபாடு கண்டறியப்பட்ட மாணவர்களின் செயலாக்க வேகம் மற்றும் பணி நினைவகத்தை மேம்படுத்த திட்டமிட்டுள்ளேன் . கொடுக்கப்பட்ட தலையீட்டின் செயல்திறனை அடையாளம் காண தலையீட்டிற்கு முன்னும் பின்னும் ஒரு மதிப்பீடு மேற்கொள்ளப்படும். ஒவ்வொரு அமர்வும் 30 நிமிடங்கள் நீடிக்கும். இது தவிர, சிறந்த முடிவுகளுக்காக மாணவர்கள் வீட்டிலேயே பயிற்சி செய்யக்கூடிய பணித்தாள்கள் மற்றும் செயல்பாடுகளும்

வழங்கப்படும். பயிற்சி செய்வதற்கான அனைத்து பணித்தாள்கள் மற்றும் அறிவுறுத்தல்கள் மாணவர்களுக்கு வழங்கப்படும்.

இந்த ஆய்வில் ஏதேனும் செலவுகள் உள்ளதா?

இல்லை, அதற்கு எந்த கட்டணமும் இல்லை.

இது சட்டரீதியாக அமல்படுத்தப்படக் கூடியதா?

இல்லை, இது சட்டரீதியாக பிணைக்கப்பட்ட ஆவணம் அல்ல. இது ஒரு ஆராய்ச்சி ஆவணம்.

நான் எத்தனை நாட்கள் அர்ப்பணிப்பு செய்ய வேண்டும்?

நீங்கள் 8 வாரங்களுக்கு தலையீட்டுக் குழு / கட்டுப்பாட்டுக் குழுவின் ஒரு பகுதியாக இருக்க வேண்டும், அதைத் தொடர்ந்து ஒரு மதிப்பீடு. எனவே, நீங்கள் 2 மாதங்களுக்கு அடிப்படை அளவீடு உட்பட ஒரு காலத்திற்கு ஆஜராக வேண்டும் என்று எதிர்பார்க்கப்படுகிறது.

ஆய்வில் எனது குழந்தை பங்கேற்றால் எனக்கு என்ன நன்மைகள் கிடைக்கும்?

கோட்பாட்டு அனுமானங்கள் மற்றும் முந்தைய ஆராய்ச்சியின் கண்டுபிடிப்புகளின் அடிப்படையில், அறிவாற்றல் பயிற்சி செயலாக்க வேகம் மற்றும் வேலை நினைவகத்தை மேம்படுத்துகிறது என்று அனுமானிக்கப்படுகிறது.

என் குழந்தை பங்கேற்றால் ஏதேனும் எதிர்மறையான விளைவுகள் ஏற்படுமா?

இல்லை, இந்த ஆய்வு செயல்முறை பங்கேற்பாளருக்கு எந்த எதிர்மறையான விளைவுகளையும் ஏற்படுத்தாது. அமர்வைத் தொடர்ந்து ஏதேனும் உணர்ச்சி / உளவியல் விளைவுகள் ஏற்பட்டால், உளவியல் உதவி உறுதி செய்யப்படும்.

எனது பிள்ளை பங்கேற்பது கட்டாயமா?

இல்லை. இந்த ஆய்வில் நீங்கள் பங்கேற்பது முற்றிலும் தன்னிச்சையானது மற்றும் இந்த செயல்முறையின் ஒரு பகுதியாக இருக்க நீங்கள் மறுக்கலாம்.

இந்த செயல்முறைய எனது குழந்தைக்கு வசதியாக இல்லாவிட்டால் நான் ஆய்விலிருந்து விலகலாமா?

நீங்கள் இந்த ஆய்வின் ஒரு பகுதியாக இருக்க விரும்புகிறீர்களா என்பதைத் தேர்வுசெய்ய உங்களுக்கு சுதந்திரம் உள்ளது. "இல்லை" என்று சொல்வது ஆராய்ச்சியாளர் அல்லது நிறுவனத்துடனான உங்கள் உறவை பாதிக்காது. இந்த ஆய்வில் எந்த ஆய்வக சோதனைகள் அல்லது எந்த ஆக்கிரமிப்பு செயல்முறையும் இல்லை. செயல்பாட்டின் போது உங்களுக்கு ஏதேனும் அசௌகரியம் ஏற்பட்டால், அது மறுசீரமைக்கப்படலாம்.

தரவின் ரகசியத்தன்மையை உறுதி செய்ய முடியுமா?

நீங்கள் கொடுக்கும் தனிப்பட்ட தகவல்கள் ரகசியமாக வைக்கப்படும். ஆராய்ச்சிக் குழுவின் உறுப்பினர்களுக்கு மட்டுமே உங்கள் பெயர் மற்றும் விவரங்கள் தெரியும். உங்கள் பெயர் எந்த அறிக்கை அல்லது வெளியீட்டிலும் இடம்பெறாது. இருப்பினும், ஆய்வின் ஒட்டுமொத்த முடிவுகள் ஆராய்ச்சி இதழ்களில் வெளியிடப்படும்.

ஆராய்ச்சியாளரின் உறுதிமொழி

மேற்குறிப்பிட்ட ஆராய்ச்சியில் பங்கேற்க திருமதி ஃபரிஷா.ஏ.டி.பி., எம்.பில் கிளினிக்கல் சைக்காலஜி, என்.ஐ.இ.பி.எம்.டி., சென்னை உங்கள் ஒப்புதல் கோரப்படுகிறது. ஆராய்ச்சியின் எந்தப் பகுதியிலும் எந்தக் காரணமும் கூறாமல் ஒப்புதலை மறுக்க அல்லது திரும்பப் பெற உங்களுக்கு உரிமை உண்டு. ஆராய்ச்சி பற்றி உங்களுக்கு ஏதேனும் சந்தேகங்கள் இருந்தால், தயவுசெய்து அதை தெளிவுபடுத்த தயங்காதீர்கள். ஆராய்ச்சியின் போது கூட, நீங்கள் விரும்பினால்

விளக்கத்திற்காக ஆராய்ச்சியாளரை (திருமதி. ஃபரிஷா.ஏ.டி.பி) தொடர்பு கொள்ளலாம் (மோப்.: 9400770145).

நீங்கள் வழங்கும் தகவல்கள் மிகவும் ரகசியமாக வைக்கப்படும்.

ஆராய்ச்சி ஆய்வில் பங்கேற்க ஒப்புதல்

	ஆம்/இல்லை
நான் போதுமான விளக்கத்தைப் பெற்றுள்ளேன் மற்றும் ஆய்வின் தகவல் தாளை தெளிவாகப் புரிந்துகொண்டேன் மற்றும் கேள்விகளைக் கேட்க எனக்கு வாய்ப்பு கிடைத்தது என்பதை நான் உறுதிப்படுத்துகிறேன்.	
எனது பங்கேற்பு தன்னிச்சையானது என்பதையும், எந்தக் காரணத்தையும் கூறாமல் எந்த நேரத்திலும் ஆய்விலிருந்து விலக எனக்கு சுதந்திரம் உண்டு என்பதையும் நான் புரிந்துகொண்டேன்.	
பயிற்சி பெற்ற ஆராய்ச்சியாளர் தலையீட்டை நடத்துவார் என்பதை நான் புரிந்துகொள்கிறேன், அதைத் தொடர்ந்து 12 அமர்வுகளுக்குப் பிறகு மதிப்பீடுகள்	
நான் பகிரும் அனைத்து தனிப்பட்ட தகவல்களும் ரகசியமாக வைக்கப்படும் என்பதையும், ஆராய்ச்சி ஆய்வில் ஈடுபட்டுள்ளவர்களைத் தவிர வேறு யாருடனும் பகிர்ந்து கொள்ளப்படாது என்பதையும் நான் புரிந்துகொள்கிறேன்.	
ஆய்வு தகவல் தாள் மற்றும் ஒப்புதல் படிவத்தின் நகலை நான் பெற்றுள்ளேன்	

பங்கேற்பாளரின் பெயர்: கையொப்பம்: தேதி:

ஆராய்ச்சியாளரின் பெயர்: கையொப்பம்: தேதி:

Appendix D

National Institute for Empowerment of Persons with Multiple Disability (NIEPMD)

Ministry of Social Justice and Empowerment, Govt. of. India

Muttukadu, ECR Road, Chennai – 603 112

NIEPMD PHONE NO. 044-27472113, 27472046;

E-mail: farishthashah@gmail.com

EFFICACY OF COGNITIVE TRAINING ON PROCESSING SPEED AND WORKING MEMORY OF CHILDREN WITH SPECIFIC LEARNING DISABILITY (SLD)

Researcher: Ms. Farisha A.T.P Guide: Dr. S Karthikeyan

STUDY INFORMATION SHEET

I am Farisha.A.T.P, II Year Scholar, Mphil Clinical Psychology at NIEPMD. As a part of my course, I am doing research entitled 'Efficacy of cognitive training on processing speed and working memory of children with Specific Learning Disability. In this research, I plan to enhance processing speed and working memory of students diagnosed with Specific Learning Disability using cognitive training for 2 months (12 sessions). An assessment will be carried out before and after the intervention to identify the effectiveness of the intervention given. Each session will last for 30 minutes. Apart from this, students will also be given worksheets and activities which they can practice at home for better results. All the worksheets and instructions will be given to students for practicing.

Does this study involve any expenses?

No, it does not have any fees.

Is it legally enforceable?

No, this is not a legally binding document. It is a research document.

How many days commitment should I make?

You will need to be a part of the intervention group/control group for 8 weeks followed by an assessment. So, you are expected to be present for a period including the baselines measure for 2 months.

What are my benefits if my child participates in the study?

Based on the theoretical assumptions and the findings of previous research, it is hypothesized that the cognitive training enhances the processing speed and working memory.

Will there be any negative consequences if my child participates?

No, this study procedure will not have any negative effects for the participant. If there are any emotional/psychological repercussions followed by the session, psychological help will be ensured.

Is it compulsory for my child to participate?

No. Your participation in this study is completely voluntary and you can refuse to be a part of this process.

Can I withdraw from the study if my child is not comfortable with the process?

You are free to choose whether you want to be a part of this study. Saying "NO" will not affect your relationship with the researcher or the institute. This study does not involve any laboratory tests or any invasive procedure. If you feel any uneasiness during the process, it can be rescheduled.

Can you ensure the confidentiality of the data?

The personal information given by you will be kept confidential. Only members of the research team will know your name and details. Your name will not appear in any report or publication. However, the overall results of the study will be published in the research journals.

Undertaking by the researcher

Your consent to participate in the above research by Ms. Farisha.A.T.P, M.Phil Clinical Psychology, NIEPMD, Chennai is sought. You have the right to refuse consent or withdraw the same during any part of the research without giving any reason. If you

have any doubts about the research, please feel free to clarify the same. Even during the research, you are free to contact the researcher (Ms. Farisha.A.T.P) for clarification if you desire (Mob.: 9400770145).

The information provided by you will be kept strictly confidential.

Consent to participate in the research study

	YES/NO
I confirm that I have had adequate explanation and have clearly understood the information sheet of the study and have had the opportunity to ask questions.	
I understand that my participation is voluntary and that I am free to withdraw from the study at any time without giving a reason.	
I understand that a trained researcher will conduct two assessments with a 2 month duration apart	
I understand that all personal information I share will be kept confidential and will not be shared with anyone other than those involved in the research study.	
I have received a copy of the study information sheet and consent form	
I understand that the intervention can be received after the study based on our availability	

Name of the Participant: Signature: Date:

Name of the researcher: Signature Date:

Appendix E

ஒன்றுக்கும் மேற்பட்ட ஊனமுற்றோரின் மேம்பாட்டிற்கான தேசிய நிறுவனம் (NIEPMD)

சமூக நீதி மற்றும் அதிகாரம் வழங்கல் அமைச்சகம், இந்திய அரசு

முட்டுக்காடு, கிழக்கு கடற்கறை சாலை, சென்னை – 603 112

தொ.பே: 9526115304, NIEPMD தொ.பே: 044-27472113, 27472046

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குறிப்பிட்ட கற்றல் குறைபாடு (SLD) உள்ள குழந்தைகளின் செயலாக்க வேகம் மற்றும் வேலை நினைவகம் மீதான அறிவாற்றல் பயிற்சியின் செயல்திறன்

ஆராய்ச்சியாளர்: திருமதி ஃபரிஷ்தா ஏ.டி.பி

வழிகாட்டி: டாக்டர் எஸ் கார்த்திகேயன்

ஆய்வுத் தகவல் தாள்

நான் ஃபரிஷ்தா.ஏ.டி.பி, இரண்டாம் ஆண்டு அறிஞர், என்.ஐ.இ.பி.எம்.டி.யில் எம்.பில் மருத்துவ உளவியல். எனது பாடத்திட்டத்தின் ஒரு பகுதியாக, ' குறிப்பிட்ட கற்றல் குறைபாடு திறன் கொண்ட குழந்தைகளின் செயலாக்க வேகம் மற்றும் வேலை நினைவகத்தில் அறிவாற்றல் பயிற்சியின் செயல்திறன்' என்ற தலைப்பில் ஆராய்ச்சி செய்து வருகிறேன். இந்த ஆராய்ச்சியில், 2 மாதங்களுக்கு (12 அமர்வுகள்) அறிவாற்றல் பயிற்சியைப் பயன்படுத்தி குறிப்பிட்ட கற்றல் குறைபாடு கண்டறியப்பட்ட மாணவர்களின் செயலாக்க வேகம் மற்றும் பணி நினைவகத்தை மேம்படுத்த திட்டமிட்டுள்ளேன் . கொடுக்கப்பட்ட தலையீட்டின் செயல்திறனை அடையாளம் காண தலையீட்டிற்கு முன்னும் பின்னும் ஒரு மதிப்பீடு மேற்கொள்ளப்படும். ஒவ்வொரு அமர்வும் 30 நிமிடங்கள் நீடிக்கும். இது தவிர, சிறந்த முடிவுகளுக்காக மாணவர்கள் வீட்டிலேயே பயிற்சி செய்யக்கூடிய பணித்தாள்கள் மற்றும் செயல்பாடுகளும் வழங்கப்படும். பயிற்சி செய்வதற்கான அனைத்து பணித்தாள்கள் மற்றும் அறிவுறுத்தல்கள் மாணவர்களுக்கு வழங்கப்படும்.

இந்த ஆய்வில் ஏதேனும் செலவுகள் உள்ளதா?

இல்லை, அதற்கு எந்த கட்டணமும் இல்லை.

இது சட்டரீதியாக அமல்படுத்தப்படக் கூடியதா?

இல்லை, இது சட்டரீதியாக பிணைக்கப்பட்ட ஆவணம் அல்ல. இது ஒரு ஆராய்ச்சி ஆவணம்.

நான் எத்தனை நாட்கள் அர்ப்பணிப்பு செய்ய வேண்டும்?

நீங்கள் 8 வாரங்களுக்கு தலையீட்டுக் குழு / கட்டுப்பாட்டுக் குழுவின் ஒரு பகுதியாக இருக்க வேண்டும், அதைத் தொடர்ந்து ஒரு மதிப்பீடு. எனவே, நீங்கள் 2 மாதங்களுக்கு அடிப்படை அளவீடு உட்பட ஒரு காலத்திற்கு ஆஜராக வேண்டும் என்று எதிர்பார்க்கப்படுகிறது.

ஆய்வில் எனது குழந்தை பங்கேற்றால் எனக்கு என்ன நன்மைகள் கிடைக்கும்?

கோட்பாட்டு அனுமானங்கள் மற்றும் முந்தைய ஆராய்ச்சியின் கண்டுபிடிப்புகளின் அடிப்படையில், அறிவாற்றல் பயிற்சி செயலாக்க வேகம் மற்றும் வேலை நினைவகத்தை மேம்படுத்துகிறது என்று அனுமானிக்கப்படுகிறது.

என் குழந்தை பங்கேற்றால் ஏதேனும் எதிர்மறையான விளைவுகள் ஏற்படுமா?

இல்லை, இந்த ஆய்வு செயல்முறை பங்கேற்பாளருக்கு எந்த எதிர்மறையான விளைவுகளையும் ஏற்படுத்தாது. அமர்வைத் தொடர்ந்து ஏதேனும் உணர்ச்சி / உளவியல் விளைவுகள் ஏற்பட்டால், உளவியல் உதவி உறுதி செய்யப்படும்.

எனது பிள்ளை பங்கேற்பது கட்டாயமா?

இல்லை. இந்த ஆய்வில் நீங்கள் பங்கேற்பது முற்றிலும் தன்னிச்சையானது மற்றும் இந்த செயல்முறையின் ஒரு பகுதியாக இருக்க நீங்கள் மறுக்கலாம்.

இந்த செயல்முறைய எனது குழந்தைக்கு வசதியாக இல்லாவிட்டால் நான் ஆய்விலிருந்து விலகலாமா?

நீங்கள் இந்த ஆய்வின் ஒரு பகுதியாக இருக்க விரும்புகிறீர்களா என்பதைத் தேர்வுசெய்ய உங்களுக்கு சுதந்திரம் உள்ளது. "இல்லை" என்று சொல்வது ஆராய்ச்சியாளர் அல்லது நிறுவனத்துடனான உங்கள் உறவை பாதிக்காது. இந்த ஆய்வில் எந்த ஆய்வக சோதனைகள் அல்லது எந்த ஆக்கிரமிப்பு செயல்முறையும் இல்லை. செயல்பாட்டின் போது உங்களுக்கு ஏதேனும் அசௌகரியம் ஏற்பட்டால், அது மறுசீரமைக்கப்படலாம்.

தரவின் ரகசியத்தன்மையை உறுதி செய்ய முடியுமா?

நீங்கள் கொடுக்கும் தனிப்பட்ட தகவல்கள் ரகசியமாக வைக்கப்படும். ஆராய்ச்சிக் குழுவின் உறுப்பினர்களுக்கு மட்டுமே உங்கள் பெயர் மற்றும் விவரங்கள் தெரியும். உங்கள் பெயர் எந்த அறிக்கை அல்லது வெளியீட்டிலும் இடம்பெறாது. இருப்பினும், ஆய்வின் ஒட்டுமொத்த முடிவுகள் ஆராய்ச்சி இதழ்களில் வெளியிடப்படும்.

ஆராய்ச்சியாளரின் உறுதிமொழி

மேற்குறிப்பிட்ட ஆராய்ச்சியில் பங்கேற்க திருமதி ஃபரிஷா.ஏ.டி.பி., எம்.பில் கிளினிக்கல் சைக்காலஜி, என்.ஐ.இ.பி.எம்.டி., சென்னை உங்கள் ஒப்புதல் கோரப்படுகிறது. ஆராய்ச்சியின் எந்தப் பகுதியிலும் எந்தக் காரணமும் கூறாமல் ஒப்புதலை மறுக்க அல்லது திரும்பப் பெற உங்களுக்கு உரிமை உண்டு. ஆராய்ச்சி பற்றி உங்களுக்கு ஏதேனும் சந்தேகங்கள் இருந்தால், தயவுசெய்து அதை தெளிவுபடுத்த தயங்காதீர்கள். ஆராய்ச்சியின் போது கூட, நீங்கள் விரும்பினால் விளக்கத்திற்காக ஆராய்ச்சியாளரை (திருமதி. ஃபரிஷா.ஏ.டி.பி) தொடர்பு கொள்ளலாம் (மோப்.: 9400770145).

நீங்கள் வழங்கும் தகவல்கள் மிகவும் ரகசியமாக வைக்கப்படும்.

ஆராய்ச்சி ஆய்வில் பங்கேற்க ஒப்புதல்

	ஆம்/இல்லை
நான் போதுமான விளக்கத்தைப் பெற்றுள்ளேன் மற்றும் ஆய்வின் தகவல் தாளை தெளிவாகப் புரிந்துகொண்டேன் மற்றும் கேள்விகளைக் கேட்க எனக்கு வாய்ப்பு கிடைத்தது என்பதை நான் உறுதிப்படுத்துகிறேன்.	
எனது பங்கேற்பு தன்னிச்சையானது என்பதையும், எந்தக் காரணத்தையும் கூறாமல் எந்த நேரத்திலும் ஆய்விலிருந்து விலக எனக்கு சுதந்திரம் உண்டு என்பதையும் நான் புரிந்துகொண்டேன்.	
ஒரு பயிற்சி பெற்ற ஆராய்ச்சியாளர் 2 மாத கால இடைவெளியுடன் இரண்டு மதிப்பீடுகளை நடத்துவார் என்பதை நான் புரிந்துகொள்கிறேன்	
நான் பகிரும் அனைத்து தனிப்பட்ட தகவல்களும் ரகசியமாக வைக்கப்படும் என்பதையும், ஆராய்ச்சி ஆய்வில் ஈடுபட்டுள்ளவர்களைத் தவிர வேறு யாருடனும் பகிர்ந்து கொள்ளப்படாது என்பதையும் நான் புரிந்துகொள்கிறேன்.	
ஆய்வு தகவல் தாள் மற்றும் ஒப்புதல் படிவத்தின் நகலை நான் பெற்றுள்ளேன்	
எங்கள் கிடைக்கும் தன்மையின் அடிப்படையில் ஆய்வுக்குப் பிறகு தலையீடு பெறலாம் என்பதை நான் புரிந்துகொள்கிறேன்	

பங்கேற்பாளரின் பெயர்: கையொப்பம்: தேதி:

ஆராய்ச்சியாளரின் பெயர்: கையொப்பம்: தேதி: