COGNITIVE FLEXIBILITY IN HIGH SCHOOL CHILDREN WITH AND WITHOUT LEARNING DISABILITY

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A dissertation submitted in part fulfillment of degree of

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University of Mysore, Mysuru.

ALL INDIA INSTITUTE OF SPEECH AND HEARING,

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JULY 2020

CERTIFICATE

This is to certify that this dissertation entitled ***"Cognitive flexibility in high school children with and without Learning Disability"*** is a bonafide work submitted in part fulfillment for degree of Master of Science (Speech-Language Pathology) of the student registration Number: (18SLP033). This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysuru,
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DECLARATION

This is to certify that this dissertation entitled **"Cognitive flexibility in high school children with and without Learning Disability"** is the result of my own study under the guidance of Dr. Venkatesan ,Professor - HOD, Department of Clinical Psychology and co-guidance of Dr. Anjana B Ram , Assistant Professor in Speech Pathology, Department of Speech Language Pathology, All India Institute of Speech and Hearing , Mysuru, has not been submitted earlier to any other university for the award of any other Diploma or Degree.

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“I WILL GIVE THANKS TO YOU, LORD, WITH ALL MY HEART;

I WILL TELL OF ALL YOUR WONDERFUL DEEDS.”

Psalm 9:1

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Chapter 1

Introduction

Cognitive flexibility (CF) or shifting is a critical function that allows a person to move attention from one stimulus to another in a seamless, efficient manner (Anderson, 2008). It is an integral part of the more substantial attention and working memory (WM) system. Such shifting can occur in response to environmental stimuli, such as being interrupted, or when one's thought process moves across stimuli.

CF is a crucial executive function that can be broadly defined as being capable of adapting behaviors in response to environmental changes. The term 'executive function' is added in neuropsychology (Lezak, 1982). It refers to “a shorthand description of a multidimensional construct referring to a variety of loosely related higher-order cognitive processes including initiation, planning, hypothesis generation, CF, decision making, regulation, judgment, feedback utilization, and self-perception. All these functions are necessary for bringing about effective and contextually appropriate behavior. It comprises numerous subordinate components of cognitive operations in which WM is the most important” (Tranel et al., 1994).

Executive functions are known as the distinct but related, neurocognitive mechanisms of the higher-order that regulate thoughts and actions aimed at achieving a goal or purpose. Therefore they control actions and cognitive and emotional activity through a collection of adaptive capacity. CF refers to rapidly reconfiguring the mind, and moving between tasks. It involves the creation and selection of innovative work

strategies (linked to creativity) from various alternatives for performing a task and modifying the action plan at any given time, depending on the conditions.

Types of CF

CF refers to looking at the objects/events from many vantage points, mainly when dealing with a novel context. It is divided into

- Reactive
- Spontaneous components (Eslinger & Grattan, 1993).

Reactive Flexibility

Reactive flexibility refers to the ability to easily switch cognition or actions in response to variation in tasks or situational demands. Different cognitive process and reactive changes occurs in response to different task and circumstances.

Two distinctive types of reactive shifts are:

- Intra Dimensional Shifts (IDS); and,
- Extra-Dimensional Shifts (EDS; Slamecka, 1968).

Intra-dimensional shift. When a subject who is trained to respond to a particular dimension of stimuli such as color or form has to pass the rule to a new set of examples of the same dimension of the stimulus an IDS occurs. Assessment of IDS can be done informally by tasks which shifts the dimension, such as color, shape, or material or shift in the task dimension, such as measuring different objects.

Extra - dimensional shift. Moving the focus to a collection of newly applicable environmental features to preserve efficiency is called an EDS. WCST (Grant& Berg, 1948), and Stroop Color Test (Stroop, 1935) are used to assess the EDS.

The Idea of flexibility is followed by spontaneous flexibility. It means the opportunity to generate different ideas, or consider alternatives to the answer, and to change plans. Spontaneous flexibility is further divided into ideational fluidity and spontaneous semantic flexibility.

Ideational Fluency. Ideational fluency is the ability to produce a more significant number of ideas, whereas the ability to produce diverse ideas is spontaneous semantic flexibility. Ideational fluency test measures the total number of responses produced regardless of quality or uniqueness.

Semantic Spontaneous Flexibility. "Semantic spontaneous flexibility is divergent thinking that highlights the variety, quantity, and relevance of information. Divergent thinking is the proliferation of different ideas" (Chapey, 1994). Based on the variety of unique ideas produced semantic spontaneous flexibility is calculated. To assess CF three main types of verbal fluency tasks are used they are Verbal fluency tasks, Design fluency and Tests of Divergent Thinking. Aphasia Batteries include verbal fluency subtests: The Multilingual Aphasia Examination (Benton et al., 1994); Neuro-sensory Center Comprehensive Examination for Aphasia (Spreen& Benton, 1977) ;Boston Diagnostic Aphasia Examination (Good glass & Kaplan, 1983), Western Aphasia Battery (Kertesz, 1982), Design fluency task: The Ruff Figural Fluency Test (Ruff, 1988), Graphic Pattern Generation Task (Glosser & Good glass, 1990).

Development of CF

CF skills tend to develop in early childhood, with a marked increase in ability between 7 and 9 years of age. CF develops mostly at the age of ten, but abilities continue to improve in the plateau between 21 and 30 years during adolescence and adulthood. Executive function components in CF adopt various developmental trajectories. Inhibition takes place as early as 12 months and is typically common by age 10–12. WM also appears early in childhood and tends to develop through puberty since components of the executive functions involved in CF may not adopt similar trajectories in growth. Adults will perform better children on CF tasks if the task design does not take steps to control inhibitory and WM demands. Behavioral research indicates that children implement flexible cognition using qualitatively specific approaches from adults. Children between the ages of 8 and 9 change their control strategies by focusing on the appropriate stimulus features to use associations with the cue-stimulus response. Inhibition and WM contribute to successful CF starting at around the age of 4, driven by improvements in children's target representation skills. Faster and more reliable adult CF skills can be attributed to enhanced perceptual capacity, better WM, and improved interference resistance from the trivial task use of associative processing, and improved task set reconfiguration capabilities.

Neural basis of CF

CF is determined by using various paradigms that involve rules, stimuli, reactions and turning tasks. Cognitive versatility during these paradigm stimulates ventrolateral prefrontal cortex (VLPFC), Dorsolateral prefrontal cortex (DLPFC), parietal association

cortex, striatum. In these activities the motor-regulation is mediated by striatum primarily.

Although VLPFC and DLPFC are instrumental in inhibiting reaction and switching, the top-down control of attention is mediated byprefrontal and parietal cortex.(Barber et al., 2005; Sohn et al., 2000).

CF Theory

The theory of CF focuses on the essence of learning in diverse and ill-structured environments. Spiro & Jehng (1990, p.165) states: "CF means the capacity to restructure one's information spontaneously, in many ways an adaptive answer to dramatically changing situational demands.

CF is a feature of both how information is interpreted (e.g., along with multiple rather than single conceptual dimensions) and the mechanism operating on such mental representations (e.g., schema assembly processes rather than intact schema recovery). Transfer of knowledge and skills beyond their initial learning situation is the main focus of the theory. For this purpose, the focus was put on presenting knowledge from various viewpoints and numerous case studies which provide specific examples. It also argues that active learning is based on context; therefore, training must be very precise. The theory also emphasizes the importance of constructing knowledge; so to learn correctly, learners should be able to build their information representations. The CF theory was mainly proposed to encourage the use of interactive technology (e.g., video, hypertext). Knowledge of the literature, history, biology and medicine were the primary applications.

Applications

- Teaching methods must have multiple subject representations.
- Instructional materials should avoid making the subject area oversimplified and endorsed context-dependent information.
- Training should be case-based and emphasize the building of awareness, no information transmission.
- The origins of information should be integrated rather than structured

Learning Disability

Learning Disabilities (LD) is a general term that refers to "a heterogeneous group of disorders manifested by significant difficulties in the acquisition and use of listening, speaking, reading, writing, reasoning, or mathematical skills. These disorders are intrinsic to the individual, presumed to be due to central nervous system dysfunction, and may occur across the life span. Problems in self–regulatory behaviors, social perception, and social interaction may exist with learning disabilities but do not by themselves constitute a learning disability".

"Although LD may occur concomitantly with other disabilities (e.g., sensory impairment, mental retardation, serious emotional disturbance), or with extrinsic influences (such as cultural differences, insufficient or inappropriate instruction), they are not the result of those conditions or influences (NJCLD, 1990; 2016)".

DSM-5 uses the term 'Specific Learning Disorder' (rather than the term 'disability') and recognizes it as one of the Neurodevelopmental Disorders with the following diagnostic criteria:

1. “Persistent difficulties in reading, writing, arithmetic, or mathematical reasoning skills during formal years of schooling. Symptoms may include inaccurate or slow and effortful reading, a poor written expression that lacks clarity, difficulties remembering number facts, or inaccurate mathematical reasoning.”
2. “Current academic skills must be well below the average range of scores in culturally and linguistically appropriate tests of reading, writing, or mathematics. Accordingly, a person who has dyslexia must read with great effort and not in the same manner as typical readers.”
3. “Learning difficulties begin during the school-age years.”
4. “The individual’s difficulties must not be better explained by developmental, neurological, sensory (vision or hearing), or motor disorders and must significantly interfere with academic achievement, occupational performance, or activities of daily living” (APA, 2013).

The International Classification of Diseases (ICD-10; WHO, 2008) uses a long-phrase called 'Specific Developmental Disorder of Scholastic Skills to designate this condition. There is no agreement across nations in the world on 'learning disability' (Venkatesan, 2017). In a recent study on concept analysis of LD based on research articles published on this theme in the country, there is minimal agreement on the preferred nomenclature, inclusion and exclusion criteria, official definitions, use of diagnostic criteria, in understanding the course and consequences about the condition (Venkatesan, 2016). Despite these challenges and limitations, studies targeting this clinical population are an urgent necessity in the country.

Incidence and Prevalence of Learning Disability

According to Hallahan and Kauffman (1994), LD's prevalence is 4-5% in children within 6-17 years of age. There is a higher prevalence of LD in boys than in girls, with males being twice as likely to get the disorder. The prevalence is estimated to be between 3-10% in India (Ramaa, 2000).

Language Characteristics of Learning Disability

Pragmatics

- Little problem with turn taking
- Difficulty in requesting clarification or answering questions
- Difficulty or inability to initiate or maintain conversation

Semantics

- Difficulty in relational term (comparative, spatial, temporal)
- Problems in Figurative language and dual definition.
- Problems in Word –finding and defining
- Conjunction (and, but, so, because, etc.) confusion.

Syntax/Morphology

- Difficulty in construction of negative and passive, adjective forms, contractions, and relative clauses.
- Difficulty in pronouns, verb tense markers and possession.
- Able to repeat sentences but often in reduced form, indicating difficulty learning different sentence forms.

- Article (a, an, the) confusion.

Phonology

- Inconsistent sound production, especially when complexity increases.

Comprehension

- Wh-question confusion.
- Receptive vocabulary similar to that of chronological-age-matched peers developing normally.
- Poor strategies of interactions with printed information.
- Confusion of similar letters and words that sounds similar.

Need for the Study

Executive function is important for the development of academic and social skills in childhood along with children's executive functions which implicates development of skills like arithmetic and regulation of emotions (Bull &Scerif, 2001).

In particular, CF leads to many significant outcomes in life, like academic achievement. (Titze & Karbach, 2014). For example, Cole et al. (2014) concluded that CF predicts reading skills in second graders. For both math and reading skills in children aged 4 to 13 years CF was identified as a significant predictor in recent meta-analysis. (Yeniad et al. 2013).

Literature on CF and children with and without LD is equivocal. Some investigators have noticed CF deficit in the LD population (Cartwright et al. 2017; Dajani& Uddin, 2015), while others disagree (Amani, Fadaei, Tavakoli, Shiri, & Shiri, 2018; Gerber,

1983). It would be worthwhile to study the performance of children with LD on the Stroop test and the WCST (Wisconsin Card Sorting Test) as test of CF. In a related study, the Stroop Color Word Test was used to measure selective attention to differentiate children with and without LD (Lazarus et al., 1984). In another study, the Dimensional Change Card Sorting Task was carried out to measure CF in preschoolers. Three-year olds were found to have problems in spontaneous classification of one object in two different ways (Kloo et al., 2008). Research studies on CF carried out upon children in India is almost non-existent. Jena et al. (2019) assessed the relationship among the factors of inhibition control, WM, and CF in relation to cognitive development of children. Mohanlal et al. (2010) studied 12 children with LD and 12 ages in the age group of 9-10 years who typically matched developing children. The experimental collection included 20 images in 4 lexical categories. They were animals, fruits, stationary objects and parts of the body. The stimuli were added and revealed using DMDX softwareto the participants. Following one from a different lexical category, four images in the same lexical category was shown one after the other in the screen of computer. Participants were instructed upon the presentation of the stimuli to name the pictures immediately. From the application of a stimulus to the detection of responses participants' response latencies were determined by name. Differences between the response time for the fourth and the fifth item were calculated to get a CF index. Given the paucity of research in this area and the importance of CF in LD, a study in this direction is justified.

Chapter 2

Review of literature

2.1 Association between CF and academic skills

Some scholars have made an effort to include CF in reading and reading comprehension. Metalinguistic awareness development was associated to concrete operational thinking, which shares features of CF.

Meta-linguistic awareness involves shift of attention from meaning of the word to other language properties like phonology. An item-selection task (Jacques &Zelazo, 2001) was used by Blair and Razza (2007) to find the correlation between CF, phonological awareness and letter knowledge in nursery school children.

Correlation was also found between flexibility (Dimensional card shift task) and emerging literacy skills such as phonology and print knowledge (Bierman et al., 2008) and also between mind theory (Unexpected Location/ Contents and Mistaken Identity tasks), rhyming skills (Farrar & Ashwell, 2012) and flexibility (Wisconsin Card Sorting Task) in pre-school children.

Flexibility in the process of phonological and semantic information coordination which appeared as a significant correlation of language comprehension of word and passage reading of second grade children was found by Colé and Duncan (2014). However, CF had the most significant potential as a predictor of understanding beyond traditional language abilities.

Purpura and Schmitt (2017) examined the association between the cognitive process which included three executive functions they were CF, WM, and response inhibition and the mathematic components and skills of literacy in preschool children individually. Their study investigated which part of the executive function is associated to which elements of mathematics and literacy skills in preschool children. One hundred twenty-five participants included in that study. They used 12 mathematics tasks to assess mathematics skills. Test of Preschool Early Literacy used to determine literacy skills. They used a modified Stroop like task to evaluate response inhibition and computerized listening recall task was used from the Automated WM Assessment. They used a 3-Dimensional change card sort test to assess CF. Their result revealed that the narrow range of mathematics skills was associated with the WM and slightly related to formal addition skills and WM was related to phonological awareness in literacy skills also. Response inhibition was associated with basic mathematics skills like verbal counting, cardinality, and also associated with some complex mathematics skills like number order, set-to-numerals in literacy skills, response skills were slightly associated with print knowledge. CF was associated with few mathematics skills such as cardinality, number order, numerical identification, and literacy skills marginally associated with print knowledge. The study supported that the component of executive functions is markedly associated with early mathematics and literacy elements.

Johann, et al. (2020) aimed to find out how the fluid intelligence executive functions like CF, WM and inhibition distinctively influence reading. They also investigated how reading speed and comprehension are associated with executive functions and fluid intelligence.186 participants included in this study. They have used

complex span tasks for WM, Stroop like tasks for inhibition, task switching for CF, and raven matrices for fluid intelligence and comprehension and speed of reading. They have used ELFE 1-6 (Lenhard & Schneider, 2016). Their result suggests that the WM, inhibition, and fluid intelligence were associated with speed of reading. Also an association was found between higher reading speed and higher WM capacity, better inhibitory abilities, and higher fluid intelligence. Better reading comprehension was associated with higher CF and fluid intelligence.

The above mentioned studies highlighted the importance of CF in academic skills. These studies are supporting the association between CF and academic skills.

2.2 CF in dyslexic children

Reiter, et al. (2005) studied executive function in children with dyslexia, such as WM, fluency functions, inhibition, problem-solving, flexibility, andconcept formation. Comparison was made between the performance of children who are dyslexic and non-dyslexic, and that result suggests dyslexic children had difficulty in tests measuring WM. Inhibition of inappropriate reactions in more demanding task not simple onewas impaired in dyslexic children. Verbal and figural fluency also affected and problem-solving partially impaired in children with dyslexia.

Bhat, Shankar (2010) investigated the CF in children with LD. Their result suggests significant difference in CF which indicated that the children with learning disability took long time to shift their cognitive set in response to the change in stimuli when compared to TDC (Typically Developing Children). In their study they haven’t use any formal test to assess CF and they have done in only 9-10 yrs old children. This is the

first study conducted in Indian population .No studies are reported on high school children in Indian settings.

Rodrigues et al. (2014) assessed neuropsychological characteristics of children with dyslexia. They aimed to identify the neuropsychological features of children with dyslexia. Neuropsychologically seventy-three children were evaluated and were divided into groups of two i.e., a group of controls and a group with dyslexia. Concerning the skills like mathematics, reading, writing, semantic and phonological fluency, forward and backward digit span, total number of cards in the WCST, a number of categories completed and as well as discrimination of right and left significant difference were observed between the groups. Lower numbers of categories were completed by dyslexic children than the other children in WCST. It shows that CF impairment was present in children with dyslexia. But in their study, they have not analyzed any other scores of WCST. Thus this study recommended further studies on executive function in individuals with dyslexia which leads to the development of new strategies in the management in these conditions.

Above mentioned reviewed studies were stated that there was the relationship between the CF and academic skills. Studies were supported that there is CF impairment in LD. There was not many studies were done in High school children. To our knowledge not even one study was done in high school children in Indian context. This study aimed to find out the nature of CF, and there was any difference in TDC and children with LD in High school children in terms of CF? So in the present study Stroop test, the WCST was used to assess the CF in children with LD. The LD population is an increase in the

Indian context. There was a dearth of study. For this reason, the study focused on CF in high school children with and without LD.

Chapter 3

Method

3.1 Aim

The study aimed to primarily investigate CF in Kannada speaking TDC and the children diagnosed with LD children in the class range of 8^{th} -10^{th}std using to tests – WCST, Stroop test. The secondary aim of the study was to compare the performance between the TDC and LD.

3.2 Objective

- To compare Stroop test scores between children with LD and TDC.
- To compare WCST scores between children with LD and TDC.

3.3 Hypothesis

1. There is no significant difference in Stroop test scores between children with LD and TDC.
2. There is no significant difference in WCST scores between children with LD and TDC.

3.4 Research Design

The present study used the standard group comparison type of research. Hence the study compared the CF of children with LD (Group I) and TDC (Group-II).

3.5 Participants

A total of (26) participant from 8th to 10th standard children was included in the study .Group I consisted of 13 children diagnosed with LD and Group II consisted of 13 TDC.

3.5.1 Participant's selection criteria

Inclusion criteria

- All participants were from Mysore city;
- All the participants considered from 8th to 10th standard belonging to CBSE or State Education Boards;
- All the participants should be holding a certified official report of the clinical condition issued by an authorized rehabilitation professional from a recognized government institution;
- Participants in the control group were screened informally and recruited based on class teacher reports that the pupils had no problems related to academic performance and that they did not ever suffer any structural, behavioral, emotional and sensory impairment or difficulties;

Exclusion criteria

Children who were slow learners, identified as having sensory impairments, or intellectual disabilities, chronic health issues, epilepsy, or first-generation learners with the report of poor academic performance were excluded from the study.

3.6 Procedure

Written consent was taken from all the participants before their involvement in the study(See. APENDIX B) and Social demographical data was collected.(See. APENDIX A). Stroop and WCST were carried out in a quiet environment. Each of the tests was administered for each child separately.

3.6.1 Material and Measures

Tests mentioned below were used in the study

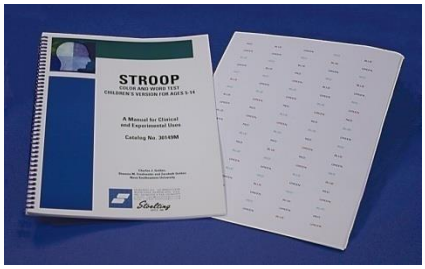
3.6.1 .1 The children's version of STROOP COLOR AND WORD TEST (Golden, Freshwater, Zarabeth, & Nova, 2003).

3.6.1. 2.WCST (WCST–Revised and Expanded; Heaton et al., 1993).

3.6.1.1 Stroop test. The children's version of STROOP COLOR AND WORD TEST (Golden, Freshwater, Zarabeth, & Nova, 2003) developed for ages 5-14 was used in this study. As per the manual (Figure 3.1) for use of this test, there were 3 conditions for each of the tasks.

Figure 3.1

Stroop Test Manual



In condition-1, the child was asked to read a list of color words (e.g., red and green) printed in black ink. (Figure 3.2)

Figure 3.2

Stroop Test Word List

In condition-2 was a contained column of non-word stimuli (XXXX) printed in different colors,(Figure 3.3) and the child asked to name the color of each stimulus.

Figure 3.3

Stroop Test Color List

In condition-3, color words printed in colors different from the word (e.g., *red* printed in blue ink) were listed, and the child was asked to name the color rather than read the word. (Figure 3.4). In each task, the child was given 45 s to read or name as many items as possible. (The time was set up by multi timer mobile app).In each condition, the child was instructed to read or name from top to bottom. They were asked to correct the mistakes which they made and move on to the next.

Figure 3.4

Stroop Test color word List

The Rational of the test is it tests cognitive performance and provides valuable brain damage and cognition diagnostic information. It evaluates the ability to inhibit cognitive interference that occurs when the stimulus element processing influences the simultaneous processing of another feature of the same stimulus (Stroop, 1935).

Analysis of Stroop test score includes baseline scores which includes Word Score (WS), Color Score (CS), Color-Word Score (CWS) and interference score which includes CWS-CS.

3.6.1. 2 Wisconsin Card Sort Test. WCST (WCST–Revised and Expanded; Heaton et al., 1993) uses three dimensions (color, shape, and number) to classify a series of cards which is shown in figure 3.5. Four key cards were placed in front of the child. Each of them had a different shape (triangle, star, cross, or circle), different numbers of shapes

(one, two, three, or four), and various colors (red, green, yellow, or blue). The children were asked if they could see the three ways in which the cards are different, which appeared to make the distinction more salient to the child (rather than being told how they differ by the experimenter). The child was instructed to pick up the first card and match it to one of the key cards by color, shape, or number. If the child matched the card by the correct sorting criteria (in the first instance, color), the experimenter said "that's right," and the child should continue sorting the following cards by the same dimension. If the matching dimension was incorrect, the experimenter responded, "that's wrong," and the child should match the next card by a different dimension, in an attempt to identify the correct one. When the child had maintained the exact sorting dimension for ten consecutive trials, the experimenter changed the matching criteria without explicitly telling the child. It was the child's task to use the feedback given by the experimenter to determine that a previous matching criterion that was correct is now incorrect, and that a different matching criterion needs to be used. This procedure was continued until the child completed six category changes or ran out of cards (total = 64 trials).

Figure 3.5

WCST Material

The rational of the test it evaluates the ability to shift from one cognitive set to another. It provides a versatile measure of neuropsychological functioning, assessing abstract thinking, CF, executive function, and impairment.

The WCST scores for analysis are Total Number Correct(TNC), Total Number of errors(TNE), Perseverative Responses(PR), Perseverative Errors (PE), Non-Perseverative Errors(NPE), Conceptual level Responses,(CLR), Number Categories Completed (NCC), Trials to Complete First Category(TCFC),Failure To Maintain Set(FTMS) ,Learning to Learn(LTL).

Statistical Analysis

The obtained Stroop test and WCST parameters were tabulated and subjected to statistical analysis using Statistical Package for the Social Sciences (SPSS) software package (version 21.0). Shapiro Wilk's test was used to test the normality. As the obtained data was non-normalized, non-parametric test was performed. Descriptive statistics was performed to calculate mean, Standard deviation and median. Mann-Whitney U test was done to calculate across group comparison.

Chapter 4

Results

The present study aimed to investigate CF in high school children with and without LD through Stroop test & WCST scores. The study also aimed to compare the performance of the Stroop test and WCST for TDC and children with LD in high school children. A total of twenty-six participants participated in the study. The participants were divided into two groups (Group I and Group II). Group I (Clinical group) consisted of 13 children with LD from 8^{th} to 10^{th} standard. Group II (Control group) consisted of 13 TDC from 8^{th} to 10^{th} standard.

The objectives of the current study were as follows:

- To compare Stroop test scores between children with LD and TDC.
- To compare WCST scores between children with LD and TDC.

The data obtained from both the groups, i.e., TDC and LD, were subjected to statistical analysis for the Stroop test and WCST scores. The mean value of each score of the Stroop test and WCST was computed. The data was subjected to Shapiro-Wilk's test of normality testing and one-way MANOVA was done for the scores, which were normally distributed. Non – Parametric tests were carried out for the scores not normally distributed. ($p<0.05$). The data was analyzed using the following statistical procedures:

- Test of normality

- Descriptive statistics was carried out to obtain the mean, median, and Standard deviation (SD) of Stroop and WCST scores for participants with and without LD.
- One way MANOVA and Mann Whitney U-test were carried out to check for the significant effect of the group on scores of Stroop test and WCST.

The results of the study are explained under the following headings:

4.1. Stroop test scores

4.1.1. Mean and SD scores of Stroop test scores in LD and TDC

4.1.2. Comparison of Stroop test scores between LD and TDC

4.2. WCST scores

4.2.1. Mean and SD scores of WCST scores in LD and TDC

4.2.2. Comparison of WCST scores between LD and TDC

4.1. Stroop test scores

4.1.1. Mean and SD scores of Stroop test scores

The Descriptive statistics analysis was performed to obtain the Mean, Median and Standard Deviation (SD) values for the Stroop test scores in children with LD (Group I) and TDC (Group II). Table 4. 1 shows the Mean, Median and SD values of Stroop test Scores for LD and TDC group.

Table 4. 1

Mean, Median and SD value of Stroop test Scores for LD and TDC group.

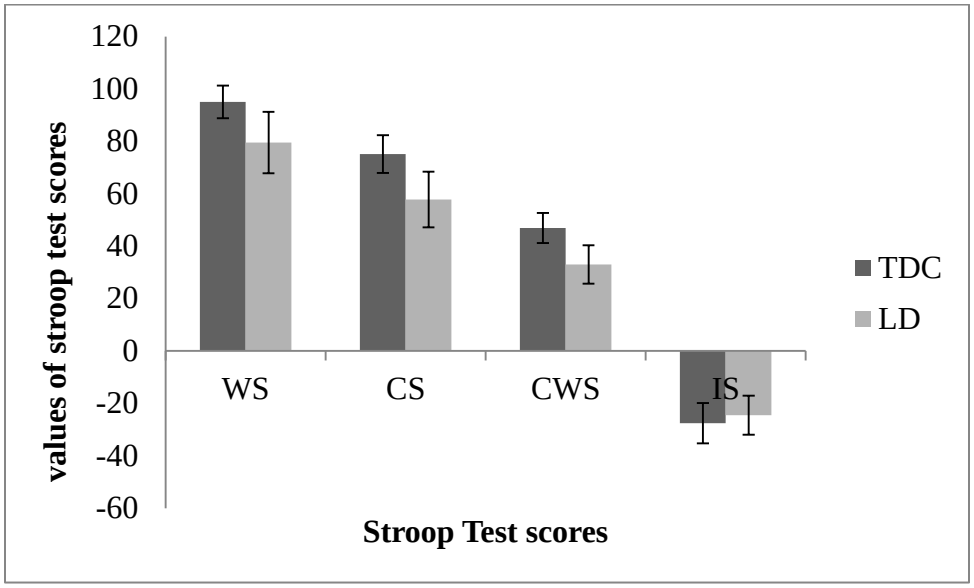
Stroop Scores	**LD (Group-I)**				**TDC (Group-II)**			
	N	Mean	SD	Median	N	Mean	SD	Median
WS	13	79.53	11.74	78.00	13	95.00	6.24	98.00
CS	13	57.76	10.61	58.00	13	75.07	7.20	75.00
CWS	13	33.00	7.28	34.00	13	46.92	5.72	45.00
IS	13	-24.53	7.45	-26.00	13	-27.53	7.68	-26.00

Note: *WS-Word Score, CS - Color Score, CWS – Color – Word Score, IS - Interference Score*

The analysis of the results in table 4.1 revealed that the Stroop test Scores were higher in TDC when compared to the LD group. As indicated by Table 4.1 in TDC, higher mean score were obtained for WS (Mean=95.00, SD=6.24), followed by CS (Mean=75.07, SD=7.20), C-WS (Mean= 46.92, SD=5.72) and least for Interference Score (Mean=-27.53, SD=7.68) [Figure 4.1]

Figure 4.1

Mean values of Stroop test scores.



Note: *WS - Word Score, CS - Color Score, CWS – Color Word- Score, IS - Interference Score*

4.1.2. Comparison of Stroop test scores between LD and TDC

Mann-Whitney U test were done to compare between TDC and LD. Table - 4.2 showed the Z and p values of Stroop test Scores.

Table 4. 2

Comparison of Stroop test scores between LD and TDC using Mann-Whitney U test

Stroop Scores	Z-values	p-values
WS	-3.13	0.00*
IS	-0.59	0.55

Note:**Significant difference (p≤0.05) in Stroop scores between LD and TDC; WS - Word Score, IS - Interference Score.*

The analysis of the result table 4.2 revealed that there was a significant difference in WS (/Z/=-3.138, p<0.05). And there was no significant difference in Interference score. (/Z/=.595, p>0.05).

One way- MANOVA was done to compare between TDC and LD. Table: 4.3 Depicts F and /p/ value of Stroop scores

Table 4.3

Comparison of Stoop test scores between LD and TDC using MANOVA test

Stroop Scores	**F-values**	**p-values**
CS	23.65	0.00*
CWS	29.39	0.00*

Note: **significant difference (p≤0.005) in Stroop test scores between LD and TD; CS - Color Score, CWS – Color – Word Score*

The analysis of the result table 4.3 revealed that there was a significant difference in CS (F=23.658; P=.000) and CWS (F=29.391; P=.000).

Multivariate test of one -way MANOVA was done to compare the Stroop test scores across the two groups. The analysis revealed that there was highly significant difference across the two groups, Wilks' Lambda= 0.414, F (1, 2) =16.299, p=0.000.

With the findings mentioned above, the null hypothesis states that there is a significant difference in Stroop scores between the children with LD and TDC

4.2. WCST scores

4.2.1. Mean and SD scores of WCST scores in LD and TDC

Descriptive statistics showed the Mean, Median and Standard Deviation (SD) for the WCST scores obtained for both the group (Children with LD and TDC). Table 4. 4 shows the Mean, Median and SD values of WCST test Scores for LD and TDC group.

Table 4.4

Mean, Median, SD of Wisconsin Card Test

Scores	LD (Group-I)				TDC (Group-II)			
	N	Mean	SD	Median	N	Mean	SD	Median
TNC	13	37.15	7.85	36.00	13	44.69	8.07	42.00
TNE	13	26.84	7.85	28.00	13	19.30	8.27	22.00
PR	13	17.30	6.15	17.00	13	11.92	5.70	11.00
PE	13	17.92	9.36	21.00	13	12.00	7.42	11.00
NPE	13	8.92	3.20	8.00	13	7.46	3.09	7.00
CLR	13	27.38	10.40	23.00	13	35.84	12.99	32.00
NCC	13	3.30	0.85	3.00	13	4.00	0.91	4.00
TCFC	13	13.84	5.16	12.00	13	12.61	2.98	11.00
FMS	13	1.69	0.85	2.00	13	1.38	0.96	1.00

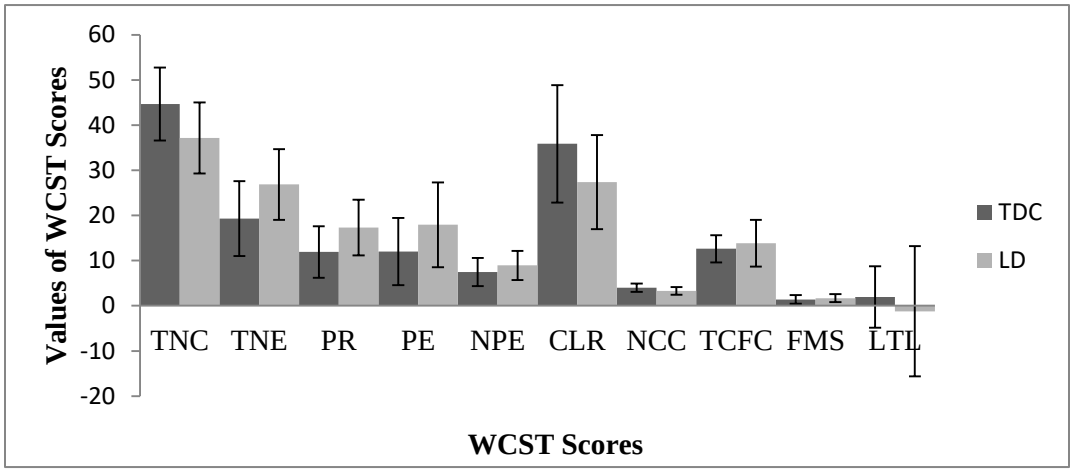
LTL	13	-1.22	14.41	0.00	13	1.92	6.80	1.22

Note: *TNC - Total Number correct; TNE - Total Number of Errors; PR–Perseverative Responses; PE-Perseverative Errors; NPE-Non- Perseverative Errors; CLR-Conceptual Level Responses ; NCC-Number of Categories Completed; TCFC-Trials to Complete First Category; FMS-Failure to Maintain Set, LTL-Learning To Learn*

The analysis of the results in table 4.4 revealed that the WCST test Scores were higher in TDC when compared to the LD group. As indicated by Table 4.5 in TDC, higher mean score were obtained for TNC (Mean=44.69, SD= 8.07), CL R(Mean =35.84, SD=12.99), NCC(Mean=4.00, SD=0.91), LTL(Mean=1.92, SD=6.80) and least for TNE (Mean= 19.30, SD=8.27) , P R (Mean= 11.92, SD= 5.70), P E(Mean= 12.00 , SD= 7.42),N P E(Mean=7.46,SD= 3.09) ,TCFC (Mean=12.61, SD= 2.98), FMS(Mean=1.38, SD= 0 .96) [Figure 4.2]

Figure4.2

Mean values of WCST Scores



Note: *TNC - Total Number correct; TNE - Total Number of Errors; PR – Perseverative Responses; PE - Perseverative Errors; NPE - Non- Perseverative Errors; CLR - Conceptual Level Response; NCC – Numberof Categories Completed; TCFC - Trials to Complete First Category; FMS -Failure to Maintain Set.*

4.2.2. Comparison of WCST scores between LD and TDC

One way -MANOVA was done to compare between TDC and LD Table - 4.5 showed the F and p values of WCST Scores.

Table 4. 5

Comparison of WCST scores between LD and TDC using MANOVA test

WCST Score	F Value	p Value
TNC	5.82	0.02*
TNE	5.68	0.02*
PR	5.34	0.03*
PE	3.19	0.08
CLR	3.35	0.07
FMS	0 .74	0.39

Note: **significant difference (p≤0.005) in WCST scores between LD and TDC; TNC - Total Number correct; TNE - Total Number of Errors; PR - Perseverative Responses; PE - Perseverative Errors; NPE - Non- Perseverative Errors; CLR - Conceptual Level Response; FMS - Failure to Maintain Set.*

The analysis of the result table 4.6 revealed that there was a significant difference in TNC ($F=5.823$, $p<0.05$), TNE ($F=5.681$, $p<0.05$) .PR ($F=5.348$, $p<0.05$) and there was a no significant difference in PE, CLR and FMS between TDC and LD Group.

Mann-Whitney U test was done to compare between normal and learning Disabilities. Table -4.6 shows the Z and p values of WCST Scores4

Table 4.6

Comparison of WCST scores between LD and TDC using Mann- Whitney U test

WCST Score	Z value	p Value
NPE	-1.37	0.16
NCC	-1.79	0.07
TCFC	-0.44	0.65
LTL	-0.64	0.52

Note: *NPE - Non- Perseverative Errors; NCC - Number Categories Completed; TCFC - Trials to Complete First Category*

The analysis of the result table 4.6 reveals that there was no significant difference in Non NPE, NCC, TCFC, and LTL.

Multivariate test of one -way MANOVA was done to compare the WCST test scores across the two groups. The analysis revealed that there was highly significant difference across the two groups, Wilks' Lambda= 0.491, F (1, 2) =3.284, p=0.022.

With the findings mentioned above, the null hypothesis states that there is a significant difference in WCST scores between the children with LD and TDC.

Chapter 5

Discussion

The current study aimed to investigate CF in high school children with and without Learning Disability through Stroop test & WCST scores. The study also aimed to compare the performance of the Stroop test and WCST for TDC and children with LD in high school children. A total of twenty-six participants participated in the study, of which thirteen were present in the clinical and control group.

The objectives of the study were as follows:

- To compare Stroop test scores between TDC and children with LD.
- To compare WCST scores between TDC and children with L D.

The findings of the study are explained under the following headings:

5.1. Stroop test scores for children with LD and TDC

5.2. WCST scores for children with LD and TDC

5.1. Stroop test scores in children with LD and TDC

The Stroop test scores analyzed in the present study included WS, CS, C-WS, and IS. The present study's findings indicated a statistically significant difference observed for WS, CS, and C-WS between children with LD and TDC. Hence, the mean WS was higher for children with TDC when compared to LD, which is in consensus with majority of the studies. (Everatt et al. 1997; Golden et al. 2002; Reiter, et al. 2005). It suggests that Word color reading depends on reading automaticity, Reading dominance, selective attention, and CF.

The Mean Color sore was high in TDC compared to children with LD, which is consensus with most studies. (Everett et al. 1997; Golden, et al. 2002; Reiter et al. 2005; Proulx, &Elmasry, 2015). It suggests that better readers would typically concentrate more selectively than poor readers on a suitable collection of responsive names.

The mean color-WS was high in TDC compared to children with LD, which is consensus with the majority of the studies (Kelly, Best, & Kirk, 1989; Everatt et al. 1997; Golden et al. 2002; Reiter et al. 2005; Proulx &Elmasry, 2015). This is attributed to poor cognitive control in stopping the need to read the word instead of stating the color. For example, Everatt et al. (1997) noted that people with dyslexia are incapable of stopping word processing before interference. It also suggests that the children with LD do not hold careful attention to the color of the ink and inhibit responses to the color word itself.

There was no statistically significant difference in the interference score. However, the mean of interference score was low in TDC compared to children with LD as would be expected. The current study is supported by the following studies (Kelly, Best, & Kirk, 1989; Everatt et al. 1997; Reiter et al. 2005; Proulx, &Elmasry, 2015). Stroop interference could be due to reduced cognitive control among children with LD, resulting in difficulty stopping the need to read the word instead of stating the color. As a consequence of impaired executive functions, several researchers attribute Stroop interference observed in dyslexic groups (Altemeier, Abbott & Berninger, 2008; Varvara et al., 2014). Executive functions apply to a set of cognitive abilities such as mentally playing with ideas, planning before acting, avoiding temptations (self-control), and controlling interference (selective attention and cognitive inhibition) (Diamond, 2013). Dyslexic and normal readers both have difficulties stopping word processing.

Automatic readers, however, can better monitor their supporter response than dyslexic individuals (Helland&Asbjørnsen, 2000). Everatt et al. (1997), for example, observed that people with dyslexia is incapable of stopping word processing before the point of interference.

With the findings mentioned above, the null hypothesis is found to be proved

5.2. WCST scores for children with LD and TDC

The WCST test scores were analyzed in the present study which included TNC, TNE, PR, PE, NPE, CLR, NCC, TCFC, FMS, and LTL. The present study's findings indicated a statistically significant difference observed for TNE, PR and TNC. Hence, the mean TNC was higher for children with TDC. The mean of a TNE& PR was high for children with LD, which is in consensus with majority of the studies (Menghini et al. 2010; Cruz-Rodrigues &Barbosa, 2014; Barbosa, & Rodrigues, 2019). It indicates that shifting and inhibiting skills, CF may be affected in children with LD. (Barbosa & Rodrigues, 2019).

Statistically, no significant difference was observed for P E, N-P E, CLR, NCC, TCFC, FMS, and LTL. However, the mean PE and NPE were high in children with LD compared to TDC, which is in consensus with majority of the studies. (Kelly, Best & Kirk, 1989; Cruz-Rodrigues, & Barbosa, 2014; Barbosa & Rodrigues, 2019). It suggests that phonological WM problems may also be responsible for the increased number of persevering mistakes in children with LD. Even though the WCST is commonly used as a measure of shifting, it is found to be a complex task which requires the ability to maintain the current category of memory till the completion of the task. Such deficits affect the

continuity of an ongoing memory category and the influence of the examiner's feedback. This led the child to commit more such errors. Even though some authors incorporated WCST in children with LD due to their nonverbal nature, this test also involves test for verbal abilities, like phonological memory.

However, the mean NCC and CLR was high in TDC compared to children with LD. (Kelly, Best, &Kirk,. 1989; Menghini et al. .2010; Cruz-Rodrigues & Barbosa, .2014; Barbosa & Rodrigues, 2019). It suggests that, may be, CF is poor in children with LD because the NCC, CLR, are the primary flexibility outcomes.

However, the mean of FMS and TCFC were high in TDC compared to children with LD. (Bull, &Scerif, 2001, Cruz- Rodrigues, Barbosa, .2014, Barbosa, and Rodrigues 2019). FMS in children with LD indicates that, maybe the struggle by individuals with dyslexia to continue a set is the result of a deficit in the initial attention/perception stage alone. It also indicates the slow speed of processing in children with LD. TCFC in children with LD show the poor conceptual ability.

However, the mean of LTL was high in TDC when compared to children with LD. In most of the studies, the score of LTL is not included. LTL has shown an average improvement in intellectual output, across consecutive WCST categories.

With the findings mentioned above, the null hypothesis is found to be proved

Chapter 6

Summary and Conclusion

The present study aimed to investigate CF in high school children with and without LD through Stroop test & WCST scores. The study also aimed to compare the scores of the Stroop test and WCST for TDC and children with LD in high school children. In the present study, a total of twenty-six (26) students from 8th to 10th standards were included in the study. Group I consisted of 13 children with LD, group II consisted of 13 TDC. In Stroop test WS, CS and C-WS showed a significant difference between the groups.

Similarly, in WCST NCC, TE, and PR showed significant difference within the groups. However, in overall companion significant difference was found between the groups both in Stroop test and WCST. The poor performance of Children with LD in the Stroop test may be due to poor reading automaticity, inhibition, selective attention, and CF. WCST scores were found to be affected in children with LD. It suggests that there was a deficit in set-shifting, phonological WM and CF. Hence the overall findings of Stroop, WCST tests suggest that may be a deficit in frontal lobe function in children with LD.

Implication of the study

- The study will help to understand the nature of CF in children with and without learning disabilities between 8th to 10th standard students.
- The deficits in CF were observed in children with LD. Then the findings can be utilized to target or develop suitable remediation strategies and tutorials for the affected pupils in the clinic, home, and school settings.

Limitation of the study and the future directions

- The present study was employed on a small sample size, and future studies are required to generalize the findings of the present study to a larger sample.
- The selection criteria for children with LD did not include the types of LD, like dyscalculia and dysgraphia.
- These types could have influenced the variation seen in the findings for the present study, especially in children with Learning disabilities. This current study was not included the age, gender-matched criteria.

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APPENDIX- A

Social Demographical Data-Sheet

Name:

Age:

Gender:

Class:

School Name:

The medium of instruction:

Syllabus:

Family history: Nuclear or Joint

Medical history:

Educational status of the Father:

Education Status of the Mother:

Educational Status of the guardian:

Sibling History:

APPENDIX - B

All India Institute of Speech and Hearing, Manasagangothri,

Mysore, 570006

I Ms.Sivaranjani. P, IIM.Sc. SLP fellow, As am doing research as a part of my dissertation on “Cognitive flexibility in high school children with and without learning disability.During the course of research I have to do two test (Stroop test and Wisconsin card sort test). Performance of this test will be kept confidential. There are no risks or discomfort involved during the study. The participant in the study is voluntary and there is no compulsion.

Informed consent

I have been informed about the study and understand its purpose and participation in it. I give my consent for my participation as a subject or withdrawn my concern at any time. I give my consent my participation tin this study.

I, _____ , the undersigned give my consent for participation in the study.

(AGREE/DISAGREE)

Signature of the participant Signature of the investigator

(Name and address) (Name and Designation)