VERBAL SHORT TERM MEMORY AND PHONOLOGICAL PROCESSING IN CHILDREN WITH LEARNING DISABILITY

Deepika
Register No. 13DCL001

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ALL INDIA INSTITUTE OF SPEECH AND HEARING

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MYSORE-570 006

May, 2014

CERTIFICATE

This is to certify that this project work entitled "Verbal Short Term Memory and Phonological Processing in Children With Learning Disability" is a bonafide work submitted in part fulfilment for the degree of Post Graduate Diploma in Clinical Linguistics (Speech-Language Pathology) of the student (Registration No. 13DCL001). This has been carried out under the guidance of the faculty of this institute and has not been submitted earlier to any of the University for any award of any other Diploma or Degree.

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DECLARATION

This is to certify that this dissertation entitled "Verbal Short Term Memory and Phonological Processing in Children With Learning Disability" is the result of my own study under the guidance of Dr. Jayashree. C. Shanbal, Reader in Language Pathology, Department of Speech -Language Pathology, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier in other University for the award of any Diploma or Degree.

Mysore

May, 2014.

Register No.: 13DCL001

DEDICATED TO

OM SAI RAM

AND

MY PARENTS

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First of all I want to say thanks to om sai ram my inner inspiration who is always shown light in the path.

I would like to thank Dr. Savithri, Director, AIISH, Mysore, for permitting me to carry out this independent project.

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CHAPTER 1: Introduction

Children with Learning disability (LD) are often found to have deficits in memory which is reflected in their performance of academic skills. These deficits are found to be evident in their verbal short-term memory (VSTM), either in the form of phonological memory. These children also tend to show a related deficit in phonological processing. These evidences seem to form the basis for a causal role of memory in reading performance Share, Jorm, Maclean, and Matthews (1984) and phonological skills studied in kindergarten children. Evidence for a causal role of memory in reading performance comes from a small number of prediction studies that found memory capacity in kindergarten to be significantly related to later success at learning to read.

Various models have been reported to explore on these deficits in children with Learning disability/reading disability. Baddeley (1986, 1990) explains that the phonological loop is the component of working memory specialized for short-term maintenance of verbally-coded material or VSTM. The loop consists of two parts: a phonological store that holds speech-based information and a subvocal rehearsal mechanism/articulatory control process that is based on inner speech. According to Baddeley, the store retains phonological representations of information that decay over time if not rehearsed. The articulatory control process refreshes the memory trace by means of subvocal rehearsal. When examining the phonological loop in RD, the literature has been discordant.

Few researchers have found poor readers have reduced VSTM spans and absent phonological similarity effects, concluding the phonological store is abolished in RD

(Liberman et al., 1977; Mann et al., 1980). Besides poor phonological coding and a store that functions with reduced effectiveness, two alternate sources of the VSTM impairment in RD have been proposed: slow articulation rate and reduced long-term memory (LTM) representations. McDougall and Hulme (1994) suggested that articulation rate provides a measure of the rate of processing within the phonological loop . Long-term memory also may play a role in VSTM span in the population at large by providing phonological representations of words that can be used to aid retrieval (Hulme, Maughan, & Brown, 1991). Although Hulme et al. (1991) suggested that the contribution LTM makes to VSTM is in terms of providing phonological representations that can be used to aid retrieval, their study provides evidence that the LTM contribution also may be semantic in nature. They required English-speaking controls to remember novel Italian words, and the participants performed poorly. In contrast, when they taught the participants the meaning of the words they performed much better. Other researchers have found that VSTM does make a unique contribution to reading ability beyond that of phonological awareness (Cormier & Dea, 1997; Gathercole, Willis, & Baddeley, 1991; Hansen & Bowey, 1994; Tractenberg, 2002).

In the above context it is relevant to study the impact of verbal short term memory and phonological processing in reading of children with Learning disability in the Indian context where children are exposed to English as a second language. It may also be interesting to know how well the working memory model Baddeley (1975, 1990) fits into understanding learning deficits in Indian children. The aim of the present study was to study the verbal short-term memory and phonological processing skills in children with Learning disability (LD).

The aim of the present study was to study the verbal short-term memory and phonological processing skills in children with Learning disability (LD). The objectives of the study included:

- To study the verbal short-term memory and phonological processing skills in typically developing children.
- To compare the performance of children with LD and typically developing children on the reading word and repetition task.

CHAPTER 2: Review of Literature

Learning disabilities is characterized by difficulties in single-word decoding, resulting in failure to acquire reading proficiency (Stanovich, 1986; Vellutino (1979). According to Shaywitz et al. (1990) initial signs and diagnosis usually occurs during childhood, with 5%–10% of school-age children affected, dyslexia may have long-term educational, economic, and social repercussions. Berninger (1994) opined that diagnosis is complicated by the educational experience and the lack of a standard protocol regarding which measures should be used for diagnosis. Many measures have been proposed, to understand the component processes that are involved

There are main two components on the basis of which diagnosis has been made Orthographic coding—This is refer to ability to code written words which takes place in the short-term memory in order to represent them in long-term memory . Phonological coding—This is refer to the, the ability to code spoken words into short-term memory, operate components sounds, and reproduce words, without the aid of meaning cues (Berninger et al., 1994)

Reading process in the learning disability has always been a main focus area in psycholinguistic research and found implications by various researchers including those in the field of speech-langauge pathology.. There now exists a number of research studies reporting an association between reading disability and short term memory limitations. In this context the present study reviewed various theories and models that have been proposed in order to understand working memory performance in children with Learning disability.

2.1 Role of memory in the reading process

There have been various models and theories proposed to study the reading process in children and adults. The most relevant one for the present study was found to be the Baddele's working memory model (Baddely & Hitch, 1974). Baddeley's working memory model (Baddeley & Hitch, 1974) was used in various studies in order to understand the reading process in childrenwith LD. According to Baddeley and Hitch 1974, divided the working memory process into three parts -phonological loop (stores verbal and acoustic information), visuospatial sketchpad (stores visual information) , and central executive.

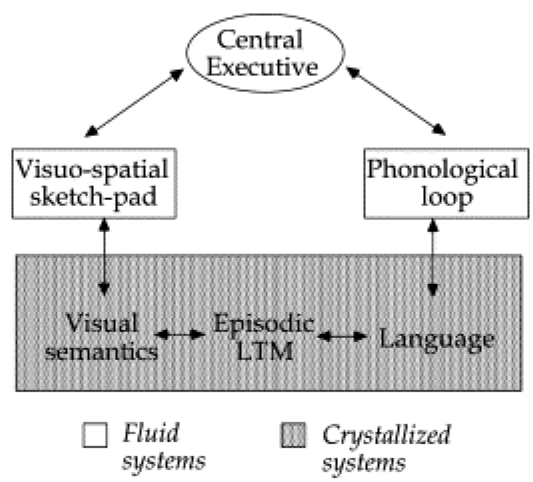

Figure 2.1. Baddeley's Working memory model (Baddeley & Hitch, 1974)

The phonological loop: According to Baddely and Hitch (1974), it is mainly divided into two components, a temporary storage system which stores memory traces over a few seconds, during which the information will get decayed, till that time refreshed by the second component. Subvocal rehearsal system function is not only to maintain that stored information but that not only maintained information within the store, but also do the function of storing visual information within the store, provided the items can be named. This subsystem of working memory combines the spatial, visual, and possibly kinesthetic information into one single unit representation which can be temporarily stored and manipulated.

Visual sketchpad: The visual sketchpad clearly is of less role in the language disorders than is the phonological loop. But system will be involved in reading process, where it may be involved in maintaining a representation of the information and its layout that will remain stable and facilitate tasks such as moving the eye . Its function is to move eye from the end of one line to the beginning of the next.

The central executive: It is responsible for the attentional control of working memory. It relies closely, but not completely, on the frontal lobes (Stuss & Knight., 2002), and can almost certainly be fractionated into a number of executive subprocesses (Baddeley & Shallice, 2002)

The model also discusses the component of 'Episodic buffer'. According to Miller (1956) episodic *buffer* stores information in the form of chunks. Baddeley (2000) believed episodic buffer to have limited capacity system which depends on executive processing. The function of this buffer is to of combine together information from a number of different sources into chunks or episodes later converting to a single multi-faceted code .

In terms of storage, working memory is a temporary storage system that makes stronger our capacity for thinking, it is clearly the case that it should have implications for language processing, and that disorders in working memory may impact on language processes. Such working memory deficits are found to show up in reading of children with Learning disability.

Another aspect to working memory is the short-term memory (STM) and more specifically its contribution to verbal-short term memory (VSTM). Verbal short-term memory typically refers to the ability to retain and immediately repeat verbal material of increasing length: sequences of two to nine digits (digit span), onwards of two to five syllables (nonword repetition), or even sequences of nonwords (nonword span) (Ramus et al., 2003) Deficits in VSTM are often quoted in children with LD. According to Swanson, Cooney and McNamara (2004), STM performance on WM tasks may appear to be more promising in our understanding of the memory processes of children with reading disability. WM measures have been crucial in differentiating typically reading and children with reading disability. WM is defined as a processing resource of limited capacity, involved in the preservation of information while processing the same or other information (Baddeley et al., 1999 & Unsworth et al 2007).

On the other hand in order to understand reading process, visual word recognition models have been proposed to elucidate the process of reading through various routes. One such model is the the Dual Route Cascaded Model proposed Coltheart et al. (1993, 2001). Figure 2.1 shows the DRC model proposed to understand visual word recognition in children. According to this model, the two routes involved are the lexical direct route and the non-lexical indirect route for processing words. The non-lexical route is mainly responsible for the generating the pronunciation of non-word via a set of sub-lexical spelling-sound correspondence rules, these set of rules are mentioned in the GPC module. The lexical route is responsible for processing of meaningful words.

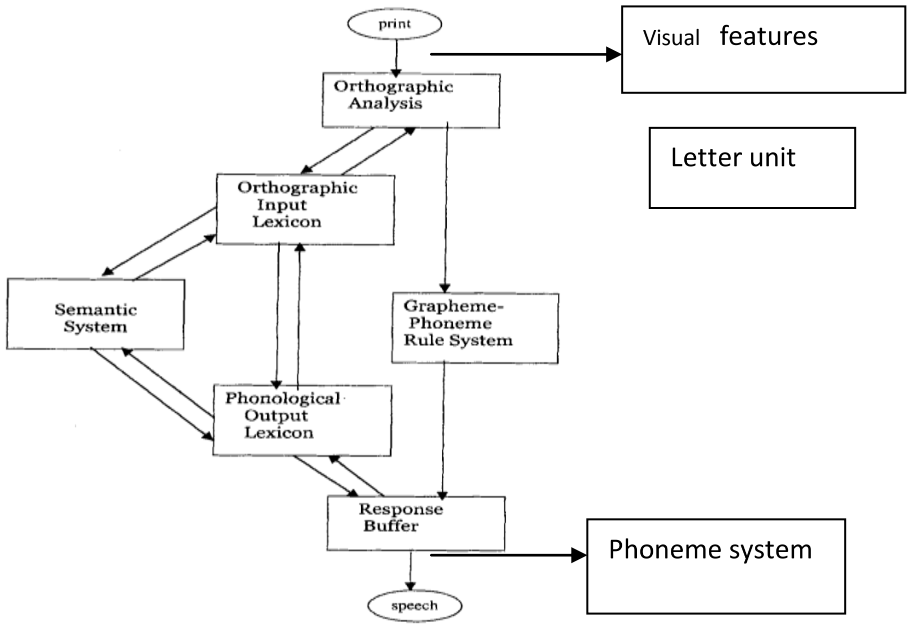

Figure 2.2 Dual-route Cascaded Model (Coltheart et al., 2001)

The information of orthographic lexicon and the phonological lexicon are linked together so that activation in one leads to activation of the other. The output from both these routes activates the phoneme system. At the phoneme system the final pronunciation is produced. Pronunciation occurs when all the phonemes of the letter string have been are activated. According to the Coltheart et al. (2001) DRC model applies to words of length up to eight letters. The non-word letter length effect was opined to be produced as a consequence of serial processing in the GPC module. As GPC processes letters serially, the time to name non-word increases as the length of non-word increases.

On the other hand, a word that is known to the reader i.e., a familiar word, the correct pronunciation is quickly generated by the lexical route. A non-word which cannot be found in the orthographic lexicon and therefore cannot be read by the lexical route so read by the non-lexical route. The set of sub-lexical spelling-sound correspondence rules can also be applied when naming words, the resulting pronunciation will regularize the pronunciation of exception words. An intact system of lexical and non-lexical routes together is capable of pronouncing both words and non-words.

DRC Model by Coltheart et al., (2001) and Connectionist Dual Route Processing (CDP +) model (Perry et al., 2007) explain that every letter string enters the reading system letter-by-letter, starting from the first. Shortly after the serial processing of letters has started, the lexical route (or lexical network) is activated. The lexical route processes letter strings in parallel and is able to map the orthographic input directly to a code in the phonological lexicon that directly activates the pronunciation of whole words. This route considerably speeds up the word-recognition process. It follows from the DRC and CDP +models that the length effect will be larger for pseudowords than for words. A lot of studies indeed found this lexicality by length interaction effect in both naming and lexical decision tasks (Balota et al., 2004; Weekes, 1997).

Various other studies reported that (Martens, 2006; Ziegler et al., 2003; Zoccolotti et al., 2005), children with dyslexia were more sensitive to the number of letters of words and pseudowords. According to them, there is stronger reliance on a letter-by-letter reading strategy and less efficient use or a lack of orthographic knowledge. This hypothesis was also explained as to why the effect is stronger for the younger readers, who have less experience with grapheme-phoneme mappings, and the dyslexic readers, who are typically found to have difficulties mapping graphemes onto phonemes. Children with dyslexia were showed sensitivity to the effects of length, which is considered a marker effect for the use of a serial-reading strategy.

Apart from the significance of non-word reading in understanding phonological processing and its relation to verbal working memory in children with Learning disability, there are also evidences that word frequency effect and word length effect contribute to understanding whether the verbal working memory deficits in children with Learning disability.

2.2 Phonological processing in children with Learning disability

Reed (1989) opined that initial “inadequate phonological representation” could lead to difficulties in becoming aware of phonological structures within spoken language. This insufficient representation might then cause problem in phonemic awareness, the mapping of phonemes to graphemes in word reading, and verbal short term memory because phonological representation result handicap. It might make verbally presented stimuli more difficult to maintain in memory. Brady et al. (1983) began with the specific hypothesis. The hypothesis state that impaired short term memories often result difficulty in the auditory perception . Their result of poor perception of speech by the LD groups supported this hypothesis. Torgesen et al (1990) stated the phonological codes for verbal material such as words ,and letters are incompletely precise in long term memory , which will result both articulation problems and the acoustic coding problems and the acoustic coding problem that have been observed in children with the reading disabilities . The articulation problem it refer to problems in rapid serial naming

Brady et al. (1987) used stimuli as nonsense syllables list .Study reveal that poor readers made more errors than good readers, but for both groups transposition errors accomplish for the majority of errors . Poor readers do less effective use of phonological coding indicate deficit in short-term memory and reduced memory span (Mann et al., 1980; Mark et al., 1977; Olson et al.,1984; Shankweiler, et al., 1979; Siegel & Linder, 1984).Related to this, error analyses has been done for both groups . Both reading groups use phonological coding strategies. But the poor readers are less accurate in using the phonological coding strategies as compared to the good readers . Poor readers are found to have difficulties in phonological processing are confined to nonwords Brady et al. (1983).

Snowling et al. (1986) stated that but the problem repeating words are primarily due to the deficit of formulating a phonological representation. Case et al. (1982) there is a significant relation between encoding processes and memory span. Phonological difficulties in memory, in speech perception, and in speech production have been observed in children with reading difficulties.

2.3 Relation between the working memory and phonological process

Stanovich et al. (1984) and Yopp (1988) stated that the development of phonological awareness may facilitate the ability to use phonological segments in working memory, as opposed to larger articulatory units such as syllables .

Few researchers have found poor readers have reduced VSTM spans and absent phonological similarity effects, concluding the phonological store is abolished in RD (Liberman et al., 1977 & Mann et al., 1980). Besides poor phonological coding and a store that functions with reduced effectiveness, two alternate sources of the VSTM impairment in RD have been proposed: slow articulation rate and reduced long-term memory (LTM) representations. McDougall and Hulme (1994) suggested that articulation rate provides a measure of the rate of processing within the phonological loop. Long-term memory also may play a role in VSTM span in the population at large by providing phonological representations of words that can be used to aid retrieval (Hulme, Maughan, & Brown, 1991).

Although Hulme et al. (1991) suggested that the contribution LTM makes to VSTM is in terms of providing phonological representations that can be used to aid retrieval, their study provides evidence that the LTM contribution also may be semantic in nature. They required English-speaking controls to remember novel Italian words, and the participants performed poorly. In contrast, when they taught the participants the meaning of the words they performed much better. Other researchers have found that VSTM does make a unique contribution to reading ability beyond that of phonological awareness (Cormier & Dea 1997; Gathercole et al., 1991; Hansen & Bowey, 1994; Tractenberg 2002).

2.4 Relation between the nonword repetition and the vocabulary growth

Snowling, Chiat and Hulme (1991) suggested that phonological storage itself is merely a reflection of deeper phonological processing problems based upon the phonological loop model This model is given by Brown and Hulme (1996) . As this model suggest the vocabulary growth will result the improved lexical representation of the segments of the words. It will lead to improvement in the non word repetition. The Brown and Hulme (1996) hypothesis for vocabulary growth showed a reciprocal relationship between vocabulary growth and the capacity to repeat nonwords is assumed.

The model differs from that proposed by Baddeley et al. (1998) in not specifying a role for phonological short-term memory.

A study done by Gathercole (1995) in that she has observed that for any given length of nonword, some sequences appeared to be difficult for the children to read than others, easier one are the words which are getting resembled to the English words . She divided the nonwords into two groups, based on phonotactic frequency measures, but the they were govern the same phonotactic rules and were very closely related. She found that those sequences closer to English (e.g., *stirple*; *blonterstaping*) were easier than less familiar phoneme sequences (e.g., *kipser*; *perplisteronk*). This strongly suggests the influence of existing language habits on current nonword repetition performance. Brown and Hulme (1996) study reveals that unfamiliar sequence showed good correlation with the vocabulary growth as compaired to that of the familiar sequences . The correlation of the familiar sequences with the vocabulary growth was not so significant.

Phonological loop is mainly comprises of two parts parts . One of them is the storage and the other one is articulatory component. Nonword repetition mainly relies on both the components. But articulatory skills mainly depend on the storage system. Storage /Memory do the function of relating the previous learned information with the newly learned information but in the LD this kind correlation does not happen because of the deficit in the storage system, which will indirectly affect the articulatory system which leads to effect on the repetition of the nonword .

Few researchers have found poor readers have reduced VSTM spans and absent phonological similarity effects, concluding the phonological store is abolished in RD (Liberman et al., 1977; Mann et al., 1980). Besides poor phonological coding and a store that functions with reduced effectiveness, two alternate sources of the VSTM impairment in RD have been proposed: slow articulation rate and reduced long-term memory (LTM) representations. McDougall and Hulme (1994) suggested that articulation rate provides a measure of the rate of processing within the phonological loop . Long-term memory also may play a role in VSTM span in the population at large by providing phonological representations of words that can be used to aid retrieval (Hulme, Maughan, & Brown, 1991). Although Hulme et al. (1991) suggested that the contribution LTM makes to VSTM is in terms of providing phonological representations that can be used to aid retrieval, their study provides evidence that the LTM contribution also may be semantic in nature. They required English-speaking controls to remember novel Italian words, and the participants performed poorly. In contrast, when they taught the participants the meaning of the words they performed much better. Other researchers have found that VSTM does make a unique contribution to reading ability beyond that of phonological awareness (Cormier & Dea, 1997; Gathercole, Willis, & Baddeley, 1991; Hansen & Bowey, 1994; Tractenberg, 2002).

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Aim of the study

The aim of the present study was to study the verbal short-term memory and phonological processing skills in children with Learning disability (LD). The objectives of the study included:

- To study the verbal short-term memory and phonological processing skills in typically developing children.
- To compare the performance of children with LD and typically developing children on the reading word and repetition task.

CHAPTER 3: Method

A standard two group comparison design was adopted for the present study.

3.1 Participants

Two groups of participants were considered for the present study- clinical group and the control group. The clinical group included 10 children with Learning disability (LD) in the age range of 9-15 years of age and the control group consisted of 10 age and gender matched typically developing children (TDC). Children with LD were diagnosed by a Speech-Language Pathologist and a Clinical Psychologist. All the children selected had Kannada as their native language background with English as the medium of instruction in schools.

All the children selected had normal or corrected normal vision with average or above average IQ. None of the participants had any marked neurological and medical histories according to the WHO Ten question disability screening checklist (cited in Singhi, Kumar, Malhi & Kumar, 2007). Children with Learning disability were diagnosed by a Speech-Language Pathologist and a Clinical Psychologist.

3.2 Test material

The test stimuli consisted of a total of 45 words. These words included 15 high frequency words, 15 low frequency words and 15 nonwords (Appendix I). The stimuli were prepared based on the Dyslexia Screening Test-Junior (Fawcett & Nicolson, 2004) and the Dyslexia Screening Test- Secondary (Fawcett & Nicolson, 2004) and the text books. Frequency of the words was ascertained through a rating scale given to two experienced Speech-Language Pathologists. The final list of stimuli included a total of 45 words with 15 High frequency (HF) words, 15 Low frequency (LF) words and 15 Non sense (NS) words. Each list of HF, LF and NS words included 8 monosyllabic and 7 bisyllabic words (See Appendix I).

3.3 Procedure

The stimuli were presented through the DMDX software (Forster & Forster, 2003). The participants instructed to read the stimuli. In order to test for VSTM the stimuli was presented by the examiner and the children were instructed to repeat the stimuli presented. The testing session followed a training phase with a different set of stimuli. Each child was tested individually in a quiet room situation. The responses were recorded for accuracy and reaction time measures in milliseconds.

3.4 Scoring and analysis

Each accurate response was scored of ‘1’ and inaccurate response scored ‘0’. The responses were analyzed for both reaction time (in milliseconds) and accuracy measures. The data was subjected to appropriate statistical analyses procedures in order to compare the performance of children with LD and typically developing children on verbal short-term memory tasks.

Statistical analysis was carried out using the software Statistical Package for Social Sciences (SPSS). 17.0. Descriptive statistics was performed to calculate the mean, and standard deviation values.

- The Mann-Whitney test was done to compare the performance between TDC and children with LD across HF, LF and NS words.

- Repeated measures ANOVA was done to compare the performance of TDC across grades for HF, LF and NS words.
- Friedman Test was done to explore the performance of TDC and children with LD across different word lengths with TDC and LD groups being two independent samples.
- The Wilcoxon Signed Rank test was carried out to observe the difference for the performance of TDC and children with LD across word frequencies (such as HF and LF), phonological processing (reading NS words) and word length effects (such as monosyllabic and bisyllabic).

CHAPTER 4: Results

The aim of the present study was to study the verbal short-term memory and phonological processing skills in children with Learning disability (LD). The objectives of the study were also to study the verbal short-term memory and phonological processing skills in typically developing children and to compare the performance of children with LD and typically developing children on the reading word and repetition task.

The stimuli were presented through the DMDX software through which accurate responses and reaction times (in ms) were extracted. The date was analyzed for reaction time and accuracy measures, to compare the performance of TDC and children with LD on three types of words-i.e., High frequency words (HF), low frequency words (LF), and nonsense words (NS). The data was also analyzed to study the word length effects if any, through words of different lengths such as monosyllabic , bisyllabic , trisyllabic and multisyllabic words .

The results of the present study are explained in the following sections:

4.1 Performance of TDC on VSTM and phonological processing for reaction time and accuracy measures.

4.2 Comparison of performance of TDC and children with LD on VSTM and phonological processing for accuracy and reaction time measures.

4.3 Comparison of performance of children with LD and TDC on VSTM based on repetition

4.1 Performance of TDC on phonological processing for reaction time and accuracy measures.

Analysis of results on descriptive statistics for VSTM and phonological processing in TDC children revealed that TDC showed longer reaction time for LF words (Mean=1650.31, SD=373.20) compared to HF words (Mean= 1048.88, SD=161.18). The results also showed that the TDC showed longest reaction time for NS words (Mean=1818.06, SD=293.67) compared to HF and LF words. Table 4.1 shows the mean and SD values for HF, LF and NS words on reaction time measure and accuracy measures.

Table 4.1

Mean and SD values for HF, LF and NS words in the TDC for RT and accuracy measures

Type of words	Reaction time (in ms)		Accuracy	
	Mean	SD	Mean	SD
HF	1048.88	161.18	13.900	1.96
LF	1650.31	373.20	10.500	2.95
NS	1818.06	293.67	10.400	2.67

Note: HF-High frequency, LF-Low frequency, NS-Nonsense

Further results on repeated measures ANOVA revealed that there was a significant difference in the performance of TDC across HF, LF and NS words, $F(2, 18)=33.79$, $p<0.001$. Further a pair-wise analysis revealed that there was a significant difference for HF and LF words; HF and NS words at $p<0.001$ level of significance. However, there was no significant difference observed for LF and NS words. Analysis of results in table 4.1 shows that TDC shows better performance for HF than LF words and the poorest was observed for NS words for TDC (figure 4.1).

Analysis of results on descriptive statistics for VSTM and phonological processing in TDC children in terms of accuracy measures revealed that TDC showed lesser accurate responses for LF words (Mean=4.000, SD=3.3912) and NS words (Mean=, 3.800 SD=4.1473) when compared to HF words (Mean=10.600 , SD=2.5100). Table 4.1 shows the Mean and SD values for accuracy measures for HF, LF and NS words. Further results on repeated measures ANOVA revealed that there was a significant difference in the performance of TDC across HF, LF and NS words, $F(2, 18)=41.38$, $p<0.001$. Further a pairwise analysis revealed that there was a significant difference for HF and LF words; HF and NS words at $p<0.001$ level of significance. However, there was no significant difference observed for LF and NS words. Analysis of results in table 4.1 shows that TDC shows better performance for HF than LF words and the poorest was observed for NS words for TDC (figure 4.1).

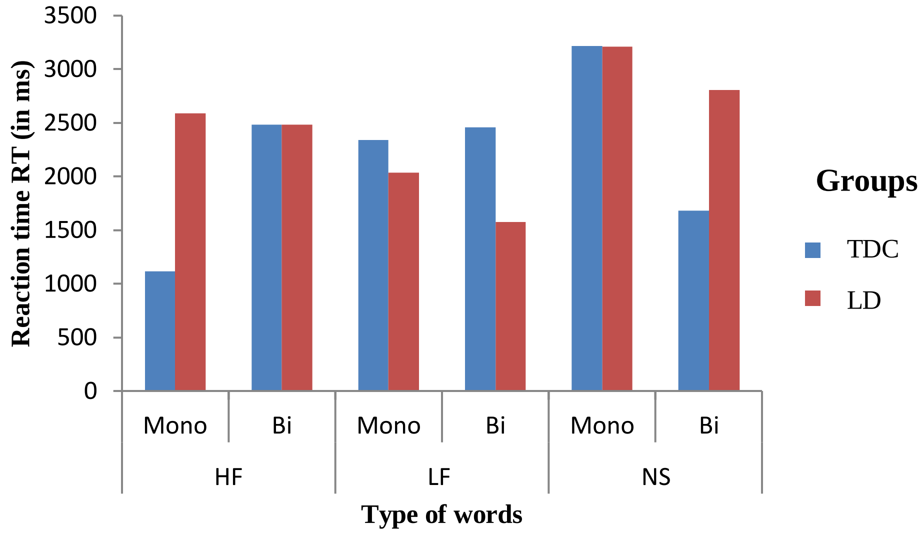

Figure 4.1. Performance of children with LD and TDC on reaction times measures across HF, LF and NS for mono and bisyllabic word lengths

Note: HF-High frequency, LF-Low frequency, NS-Nonsense

4.2 Comparison of performance of children with LD and TDC on phonological processing for reaction time measures and accuracy.

The data was analyzed to compare the performance of children with LD and TDC to explore the VSTM and phonological processing ability along with the effect of word length in reading HF, LF and NS words on reaction time and accuracy measures. Results in table 4.2 shows that children with LD showed longest reaction time for NS words (Mean=3102.33, SD=350.64) followed by LF words (Mean=2857.11, SD=496.69) and then the HF words (Mean=2537.91, SD=457.95). Table 4.2 shows mean, and SD values for HF, LF and NS words for TDC and children with LD on reaction time measures. The results in table 4.2 indicate that the performance of children with LD was better for high frequency words in comparison to low frequency words and nonsense words. Further, the analysis of results for comparison of the performance of children with LD and TDC for HF, LF and NS words showed that children with LD showed longer reaction times to HF (Mean=2537.91, SD=457.95), LF (Mean=2857.11, SD = 496.69) and NS words (Mean=3102.33, SD=350.64).

Table 4.2

Mean, and SD values for HF, LF and NS words for TDC and children with LD on reaction time measures

Type of words	LD		TDC	
	Mean	SD	Mean	SD
HF	2537.91	457.95	1048.88	161.18
LF	2857.11	496.69	1650.31	373.20
NS	3102.33	350.64	1818.06	293.67

Note: HF-High frequency, LF-Low frequency, NS-Nonsense

Table 4.3 shows Mean, and SD values for HF, LF and NS words for TDC and children with LD on reaction time measures. The data was also analyzed to compare the performance of children with LD and TDC on HF, LF and NS words for different word length (monosyllabic and bisyllabic). Analysis of results on descriptive statistics revealed that for HF words children with LD showed longer reaction times to both monosyllabic (Mean= 2591.02, SD=439.83) and bisyllabic word lengths (Mean=2480.42, SD= 613.58) when compared to TDC (Mono-Mean=1116.28, SD=179.66; Bisyllabic-Mean=2480.42, SD 613.587). Results on Mann Whitney test revealed that there was a significant difference in the performance of children with LD and TDC for HF monosyllabic word length, $|z| = -3.06$, $p<0.001$. Significant difference was also observed for HF bisyllabic word length, |z| =-3.062, $p<0.001$ for performance of children with LD and TDC for HF words.

Table 4.3

Mean, and SD values for HF, LF and NS words in the TDC between lengths on reaction time measures

Type of words		Reaction time (in ms)			
		TDC		LD	
		M	SD	M	SD
HF	Mono	1116.28	179.66	2591.02	439.83
	Bi	2480.42	613.587	2480.42	613.58
LF	Mono	2343.430	1312.89	2034.91	1089.033
	Bi	2457.34	603.0184	1575.72	298.25
NS	Mono	3215.6	337.68	3211.13	447.15
	Bi	1679.75	370.86	2805.16	1117.35

Note: HF-High frequency, LF-Low frequency, NS-Nonsense

The data was analyzed to compare the performance of children with LD and TDC to explore the VSTM and phonological processing ability along with the effect of word length in reading HF, LF and NS words on accuracy measures. Results in table 4.4 shows that children with LD showed lesser accurate responses for LF words (Mean=2.00, SD=0.60) than NS words (Mean=2.50, SD=0.39) and HF words (Mean=4.00, SD=0.39). Table 4.4 shows mean, and SD values for HF, LF and NS words for TDC and children with LD on reaction time measures.

Table 4.4

Mean, and SD values for HF, LF and NS words for TDC and children with LD on accuracy measures

Type of words	LD		TDC	
	Mean	SD	Mean	SD
HF	4.00	0 .39	10.50	2.95
LF	2.00	0.60	13.90	1.96
NS	2.51	0 .39	10.50	2.35

Note: HF-High frequency, LF-Low frequency, NS-Nonsense

The results in table 4.4 indicate that the performance of children with LD was better for high frequency words in comparison to low frequency words and nonsense words. Further, the analysis of results for comparison of the performance of children with LD and TDC for HF, LF and NS words showed that children with LD showed lesser accurate responses to HF (Mean=10.50, SD=2.95), LF (Mean=13.90, SD =1.96) and NS words (Mean=8.50, SD=2.35) in TDC.

Table 4.5

Mean and SD values for HF, LF and NS words in the TDC between lengths on accuracy measures

Type of words		**Accuracy**			
		TDC		LD	
		M	SD	M	SD
HF	Mono	10.00	1.24	7.750	0.50
	Bi	3.20	0.91	2.600	0 .54
LF	Mono	2.50	3.00	1.77	2.33
	Bi	3.20	2.77	5.80	2.34
NS	Mono	2.70	0.67	1.5	1.00
	Bi	4.20	1.67	2.25	1.89

Note: HF-High frequency, LF-Low frequency, NS-Nonsense

Analysis of results on descriptive statistics for accuracy measure revealed that for HF words children with LD showed lesser accuracy scores for both monosyllabic word (Mean=7.75, SD=2.5) and bisyllabic word lengths (Mean=2.6, SD=0.54) when compared to TDC (Mono-Mean=10.0, SD=1.24; Bisyllabic-Mean=3.2, SD = 0.91). Results on Mann Whitney test revealed that there was a significant difference in the performance of children with LD and TDC for monosyllabic word length, IzI =-1.703, $p<0.001$. Significant difference was also observed for HF bisyllabic word length, IzI =-1.296, $p<0.001$ for performance of children with LD and TDC for HF words.

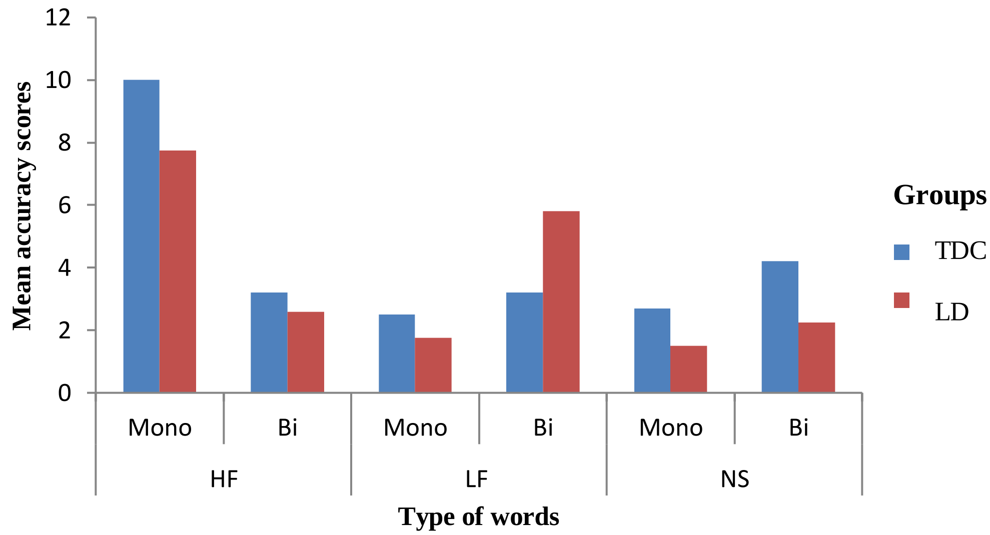

Figure 4.2. Performance of children with LD and TDC on accuracy measures across HF, LF and NS for mono and bisyllabic word lengths

Note: HF-High frequency, LF-Low frequency, NS-Nonsense

Analysis of results on descriptive statistics revealed that for LF words children with LD showed lesser accuracy to both monosyllabic word (Mean= 1.7, SD=2.3) and bisyllabic word lengths (Mean=5.8, SD=2.34), when compared to TDC (Mono-

Mean=2.50, SD=3.0); Bisyllabic-Mean=5.8, SD = 2.34) (Figure 4.2). Results on Mann Whitney test revealed that there was a significant difference in the performance of children with LD and TDC for monosyllabic word length, |z| = -.491, p>0.001. There was also a significant difference observed for HF bisyllabic word length, |z| =-1.553, p<0.001 for performance of children with LD and TDC for HF words.

Analysis of results on descriptive statistics revealed that for NS words children with LD showed lesser accuracy to both monosyllabic word (Mean=1.5, SD=1.0) and bisyllabic word lengths (Mean=2.2, SD=1.89) when compared to TDC (Mono-Mean=2.7, SD=.67 ; Bisyllabic-Mean=4.2, SD =1.61). Results on Mann Whitney test revealed that there was a significant difference in the performance of children with LD and TDC for monosyllabic word length, IzI = -2.092, p<0.001. There was also a significant difference observed for HF bisyllabic word length, IzI =.036, p<0.001 for performance of children with LD and TDC for HF words.

4.3 Comparison of performance of children with LD and TDC on VSTM based on repetition

In order to assess VSTM, verbal repetition task was used. The stimuli for this task consisted of HF, LF and NS words of monosyllabic and bisyllabic word lengths. Descritpve statistics was used to extract the mean percentage and SD values. Table 4.6 shows mean scores (in %) and SD values for performance of children with LD and TDC across HF, LF and NS words for different word lengths.

Table 4.6

Mean scores (in %) and SD values for performance of children with LD and TDC across HF, LF and NS words for different word lengths

Stimuli		Mean scores (in %)			
		LD		TDC	
		Mean	SD	Mean	SD
HF	Monosyllabic	53.36	35.61	65.62	32.31
	Bisyllabic	50.26	40.12	68.55	55.63
LF	Monosyllabic	32.61	24.61	54.63	42.31
	Bisyllabic	26.65	22.31	53.03	31.03
NS	Monosyllabic	20.92	18.34	44.71	33.23
	Bisyllabic	10.61	8.32	40.11	20.01

Note: HF-High frequency, LF-Low frequency, NS-Nonsense

Analysis of results as in table 4.6 for performance of children with LD shows that on descriptive statistics mean percentage responses for verbal repetition task was greater for monosyllabic HF words children in both children with LD (Mean=53.36, SD=35.61) and TDC (Mean=65.62, SD=32.41). Fewer repetitions were observed for children with LD than TDC. Results on Mann Whitney test revealed that there was a significant difference in the performance of children with LD and TDC for monosyllabic word length, IzI =-2.73, p<0.001. For bisyllabic HF words children with LD showed poorer repetitions than monosyllable words (Table 4.6). Children with LD (Mean=32.61, SD=24.61) performed poorer than the TDC children (Mean=54.63, SD=42.31) for LF monosyllable words and bisyllabic words. A significant difference was found on Mann Whitney test between TDC and LD for LF words, IzI =-1.71, p<0.001. For the performance on NS, the results indicated that children with LD performed the poorest in comparison to HF and LF words. They also performed poorly than the TDC 9table 4.6). A significant difference was found for monosyllabic (Mean=20.92, SD=18.34 and bisyllabic (Mean=10.61, SD=8.32) word lengths for NS words in children with LD. A significant difference was observed in the performance of children with LD, IzI =-1.13, $p<0.001$.

The results indicated that children with LD showed fewer repetitions for NS words in comparison HF and LF words. This was found to be poorer than the TDC for all the words. In terms of word lengths, children with LD showed fewer repetitions for bisyllabic words than monosyllabic words. Also children with LD showed fewer repetitions than typically developing children.

CHAPTER 5: Discussion

The results of the present study indicated that on reading HF, LF and NS words, TDC showed better performance on HF words than LF words and NS words on reaction time and accuracy measures.

These findings indicate that children tend to take lesser time to process HF words which they are familiar with than LF and NS words. The results also showed TDC took longest time to process the NS words amongst three sets of stimuli i.e., HF, LF and NS words. The performance of TDC on HF and LF was indicative a significant frequency effect which means that children performed better for HF words which are familiar than LF words which are less familiar to children. The poorer performance in terms of longest reaction time for NS words is indicative of the longer route that is adopted for processing nonwords or nonsense words as suggested by Coltheart et al., (2001) in the Dual-route Cascaded Model (See Figure 2.1). According to this model processing of nonwords require a different indirect route called the non-lexical route or the phonological route which helps processing of words not through the semantic route but through segmentation of nonsense words into segments. When a child attempts to read a word, after visual analysis the target word is searched in the *orthographic input lexicon* of the direct route or the lexical route. If the target word does not exist in the lexicon then the word is processed through the *indirect route* or the *phonological route.* In this whole process, longer time is taken to process the nonsense word in comparison to a word which is highly familiar or frequently occurring. Literature suggests that processing may be very similar for low frequency words and nonsense words as children may not be familiar or less familiar with a LF word and hence the word may not be available in their lexicon.

The findings of the present study can also be explained in terms of the process of encoding, storing and retrieval as explained by Glanzer and Adams (1985). They state that previous experience with that information play a major role in the accuracy and latency for reading. Previous experience with the word is also called as the word frequency effect. According to the McClelland and Chappell (1998) word frequency effect also helps in the recognizing the low frequency words by preserving the special feature of the low frequency words. But high frequency words are more likely to be recognized early. According to the Reder and Nhouyvanisvong (2000) source of activation confusion model of dual process model of memory HF word are established with the greater conceptual strength as compared to the LF words. High frequency words have better and stronger association with in terms of the conceptual links to the concept node. Hence, children are able to process HF words with greater accuracy and lesser reaction times.

The findings of the study also indicated that the performance of children with LD was poorer when compared to TDC on both reaction time and accuracy measures while reading HF, LF and NS words. The findings indicated that children with LD took longer reaction time for HF, LF as well as NS words. Children with LD showed longest reaction time to NS words when compared to HF and LF words (Table 4.2). The results also indicated that children with LD showed longer reaction time to LF words when compared to HF words. These findings indicate the effect of frequency of words on a reading task which was found to be present and the performance was found to be poorer than TDC.

Poorer performance on NS words than words (HF and LF words) indicate the stronger lexicality effect that is commonly found in children with dyslexia. The lexicality effect refers to the finding that words are generally read faster and more accurate than comparable pseudo-words or nonsense words. Children with LD in the present study were found to show this effect (Marinus & de Jong, 2008; Martens & de Jong, 2006; Rack et al., 1992; Ziegler et al., 2003; Zoccolotti et al., 1999). The difficulty that children with dyslexia experience in the reading of pseudowords or nonwords has been typically interpreted as a marker of a phonological processing deficit (Rack et al., 1992).

The results of the present study also indicated the difference in the performance of children with LD and TDC for HF, LF and NS words in word length (monosyllabic and bisyllabic). The results indicated that children with LD showed greater length effects for nonsense words than HF words and LF words when compared to TDC. There was no significant difference found between the LF words and NS words in terms of reaction time measures for monosyllabic and bisyllabic words. This finding indicates that children with LD could be sensitive to word length effects especially for nonsense words. Various studies have found that children with dyslexia respond slower to longer nonwords than shorter ones (Martens & de Jong, 2006; Ziegler et al., 2003; Zoccolotti et al., 2005). This word length effect could be explained due to impairment in applying lexical reading strategies (Coltheart et al., 2001) or lacking in the use of orthographic knowledge while processing the reading in a parallel manner.

Children with LD could be using an effortful letter-by-letter decoding strategy (Zoccolottiet al., 2005) unlike typically developing children. Similar findings were found for length effects in both children and adults readers on lexical decision tasks (Balota et al., 2004; Martens & de Jong, 2006). It is often assumed that length effects reflect the serial processing of words and pseudowords (Zoccolotti et al., 2005). Serial processing is one of the core assumptions of the Dual Route Cascaded (DRC) model (Coltheart et al., 2001) and is also incorporated in the Connectionist Dual Route Processing (CDP+) model (Perry et al.,2007). It follows from these models that the length effect will be larger for pseudowords than for words.

Whereas the DRC and CDP+ postulate that the length effect results from the serial processing of the letters of the stimuli some connectionist models (Seidenberg & McClelland, 1989) assume that the effect of word length is a mere consequence of neighbourhood effects. However, the present study did not attempt to study the neighbourhood effects. Children with dyslexia or LD are typically found to have greater difficulties in reading nonwords as they are typically found to show problems mapping graphemes on to phonemes. This is indicative of a phonological processing deficit in dyslexia.

On the other hand phonological processing as a metaphonological skill has been considered as an indicator of verbal short-term memory (VSTM). Various tasks have been used to assess VSTM through nonsense word reading or nonsense word repetition, etc. In the present study NS word reading was carried out for monosyllabic words and bisyllabic words. As suggested a significant difference in the word length within LD group and between LD and TDC group is indicative of a poor VSTM. This could be inferred from a poorer performance on RT and accuracy measures by children with LD than TDC and a greater effect for bisyllable NS than monosyllable NS. This suggests that children with LD who may be deficient in storing units in their memory (phonological memory) may find it more difficult to decode and read nonsense words (Perfetti, 1977; Lesgold, 1979).

These findings were also indicated on the quantitative and qualitative analysis of the data when children with LD showed greater problems on repetition of LF words and NS words than HF words. HF words which are familiar may have been repeated by the children with LD as they have heard those words before and it becomes more or less an automatic task for them to repeat a word which was already learnt. Whereas, since the LF words and NS words are not heard before and hence have to be recalled as units (phonemic) in a serial manner and then repeated unit by unit. Also, children with LD were found to have more difficulties than TDC while repeating the bisyllabic words than monosyllabic words especially for LF words and NS words.

The findings of the present study seem to support the research which suggests that the deficit in VSTM in children with dyslexia could be a result of difficulty encoding material by its sound (called “phonetic coding” and “phonological STM” for the purposes of this study; Kibby, in press; Kibby & Cohen, 2008; Wagner, Torgesen, & Rashotte, 1994). Poor phonological processing could probably considered being the ‘core’ deficit in dyslexia (Liberman & Shankweiler, 1991; Rack, Snowling, & Olson, 1992; Stanovich, 1988; Wagner et al., 1994), and phonological STM is one component of phonological processing.

Summary and Conclusion

The aim of the present study was to study the verbal short-term memory and phonological processing skills in children with Learning disability (LD). The objectives of the study were also to study the verbal short-term memory and phonological processing skills in typically developing children and to compare the performance of children with LD and typically developing children on the reading word and verbal repetition task.

Literature suggests that reading words is influenced by the frequency of words and also dependent on the phonological abilities. In this context, the present study incorporated reading words of high frequency (HF), low frequency (LF) and reading nonwords to study the phonological processing abilities in children. According to Van Ordan (1987 The most common technique used for assessing phonological process involve presenting pronounceable nonsense words and measuring the reaction time for that and the latency of the response .

Nonsense word exhibit regularity means because these words are unfamiliar and person will not able to recognize it soon. Since the nonwords are unfamiliar and cannot be recognize easily but they need some kind of unfamiliar spoken response to be recognized /tep / for /tip/ so that subject can employ the phonological rule of the regular word to the nonsyllabic word. Therefore the performance on the nonword reading task provides great measure. Further to study the verbal short-term memory these stimuli with different word lengths were asked to repeat. The stimuli were presented through the DMDX software through which accurate responses and reaction times (in ms) were extracted. The date was analyzed for reaction time and accuracy measures, to compare the performance of TDC and children with LD on three types of words-i.e., High frequency words (HF), low frequency words (LF), and nonsense words (NS). The data was also analyzed to study the word length effects if any, through words of different lengths such as monosyllabic and bisyllabic words .

The performance of TDC on HF and LF was indicative a significant frequency effect which means that children performed better for HF words which are familiar than LF words which are less familiar to children. The poorer performance in terms of longest reaction time for NS words is indicative of the longer route that is adopted for processing nonwords or nonsense words as suggested by Coltheart et al., (2001) in the Dual-route Cascaded Model.

The findings of the study also indicated that the performance of children with LD was poorer when compared to TDC on both reaction time and accuracy measures while reading HF, LF and NS words. Poorer performance on NS words than words (HF and LF words) indicate the stronger lexicality effect that is commonly found in children with dyslexia, indicative phonological processing deficit (Rack et al., 1992).

The results of the present study for VSTM also indicated the difference in the performance of children with LD and TDC for HF, LF and NS words in word length (monosyllabic and bisyllabic) on a repetition task. The findings of the present study seem to support the research which suggests that the deficit in VSTM in children with dyslexia could be a result of difficulty encoding material by its sound.

The present study had few limitations in terms of the small sample sizes in both TDC and LD groups. A larger sample size would help in generalizing the findings. Also a larger sample size in each group would help in understanding any developmental lag if any in children with DL in comparison to TDC. In terms of implications, the findings of the study implicate the significance of incorporating different word lengths in assessments and intervention of children with LD which could give us an idea especially when there is a deficit in the VSTM in children with LD. The present study does support to a certain extent that both VSTM and phonological processing deficits may be contributing to reading difficulties in children with Learning disability.

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Appendix I

Test stimuli

Sl. No.	Stimulus	Type of word	Word length
1.	Dog	HF	Monosyllable
2.	Age	HF	Monosyllable
3.	Laugh	HF	Monosyllable
4.	Book	HF	Monosyllable
5.	Bus	HF	Monosyllable
6.	School	HF	Monosyllable
7.	Home	HF	Monosyllable
8.	Like	HF	Monosyllable
9.	Doctor	HF	Bisyllable
10.	Singer	HF	Bisyllable
11.	Hunter	HF	Bisyllable
12.	Cattle	HF	Bisyllable
13.	Brinjal	HF	Bisyllable
14.	Jacket	HF	Bisyllable
15.	Handle	HF	Bisyllable
16.	Bring	LF	Monosyllable
17.	News	LF	Monosyllable
18.	Tongue	LF	Monosyllable
19.	Work	LF	Monosyllable
20.	Strain	LF	Monosyllable
21.	Spring	LF	Monosyllable
22.	Annoyed	LF	Monosyllable
23.	Thrill	LF	Monosyllable
24.	Curtail	LF	Bisyllable
25.	Debate	LF	Bisyllable
26.	Wishful	LF	Bisyllable
27.	Final	LF	Bisyllable
28.	Battle	LF	Bisyllable
29.	Commission	LF	Bisyllable
30.	Culture	LF	Bisyllable
31.	Kring	NS	Monosyllable
32.	Lews	NS	Monosyllable
33.	Jongue	NS	Monosyllable
34.	Tork	NS	Monosyllable
35.	Srain	NS	Monosyllable
36.	Sring	NS	Monosyllable
37.	Unnoyed	NS	Monosyllable
38.	Khrill	NS	Monosyllable
39.	Burtail	NS	Bisyllable
40.	Lebate	NS	Bisyllable
41.	Nishful	NS	Bisyllable
42.	Vinal	NS	Bisyllable
43.	Pattle	NS	Bisyllable
44.	Tommission	NS	Bisyllable
45.	Julture	NS	Bisyllable