SENTENCE PROCESSING IN CHILDREN WITH AND WITHOUT SLI (SPECIFIC LANGUAGE IMPAIRMENT)

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(Speech-Language Pathology)

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ALL INDIA INSTITUTE OF SPEECH AND HEARING

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April, 2018

CERTIFICATE

This is to certify that this dissertation entitled **"Sentence processing in children with and without SLI (Specific Language Impairment)"** is a bonafide work submitted in part fulfillment for degree of Master of Science (Speech-Language Pathology) of the student Registration Number: 16SLP016. 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.

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April, 2018

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CERTIFICATE

This is to certify that this dissertation entitled **"Sentence processing in children with and without SLI (Specific Language Impairment)"** has been prepared under my supervision and guidance. It is also being certified that this dissertation has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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DECLARATION

This is to certify that this dissertation entitled **"Sentence processing in children with and without SLI (Specific Language Impairment)"** is the result of my own study under the guidance of Dr.R.Rajasudhakar, Reader in Speech Sciences, Department of Speech Language Sciences, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysore **Registration No.: 16SLP016**

April, 2018

I dedicate my dissertation to SLI RESEARCH….

Acknowledgement

A thousand questions…. Flying feathers…. Small dreams…. Amongst this, there comes the responsibility as a daughter, as a sister and as a student…

- **By a graduate girl's life**

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CHAPTER I

Introduction

Language is one of the many abilities that are unique to humankind. Typically have low scores on standardized tests of language ability developing (TD) children appear to acquire language without much effort due to their innate abilities for language learning. Children, who have difficulty to acquire &/or learn language, despite adequate non-verbal abilities are classified as children with Specific Language Impairment (SLI). The term specific language impairment (SLI) refers to a developmental language disorder in the absence of any obvious neurological, intellectual, and sensory motor impairment (Leonard, 2014).

Children with SLI are a heterogeneous group, exhibiting different combinations of deficiencies in various aspects of language comprehension and production. In general, a language test score of 1.25 SD or lower with a non-verbal IQ performance of 85 or higher, indicates condition of children being 'at risk' for SLI. Affected children have significant problem in syntactical domain of language, whereas semantics and pragmatics are comparatively spared (Leonard, 1998). Grammatical judgement is one of the most effective tasks used to get information about the syntactic skills in children (Correa, 2004).

According to Tiwari et al. (2017), the linguistic profile of SLI includes the following:

- Delayed emergence of first word
- Extended period of lexical development

- Marked deficits in language production than comprehension, but comprehension being below their age-level (Leonard, 2014).
- Typical SLI group has morpho-syntactic errors (Bishop, 2004).

The syntax deficits include use of shorter, simpler and limited structural variations with omission of functional words (Rice & Wexler, 1996). Grammatical morphology related to verbs is affected. Poor comprehension of grammatical morphemes has been reported.

The deficit in syntax domain among the SLI population is addressed by the Procedural Deficit Hypothesis (PDH), given by Ullman and Pierpont (2005). According to the hypothesis, children with SLI have deficits in procedural system, which is responsible for morpho-syntactic abilities. Further, they also exhibit motor sequencing problems as the procedural system in SLI children governs both grammar and sequence learning. However, declarative system is generally spared, leading to fairly intact semantics. Procedural Deficit Hypothesis (PDH) that supports syntactic deficits in children with SLI is explored with respect to the linguistic dependency of morpho-syntactic units. A major finding in sentence processing is that, when the distance between dependencies increases, such as in a noun-verb dependency condition, the processing difficulties also increase. (Chomsky, 1965; Just & Carpenter, 1992; Gibson, 2000; Lewis & Vasishth, 2005); this effect is referred to as the locality effect.

According to Van der Lely (2005), in terms of domain-specific cognitive perspectives of SLI, there are two major views which tend to reason out the

sentence processing deficits in SLI. The first view is mainly to do with the "Domain – general perspective of SLI", which states that there is a general slow processing which leads to difficulty in processing sounds with rapid acoustic transitions and/ or phonemes with low phonetic salience. This in turn affects the tense and number agreements while processing and comprehending the sentences. The later view is on the "Domain-specific perspective of SLI", according to which there should be a specialized system to allow children to notice subtle grammatical distinctions that are necessary for fluent language. Empirical data from the SLI investigations, especially from that of G-SLI (grammatical type) suggest that developmental deficits in grammar, are the best accounted for by the hypothesis that the brain consists of domain-specific systems. The author had stated that deficits of each of the three components of language (phonology, morphology, syntax) can all exist together and might all dissociate.

Sentence analysis or processing is generally based on the dependency relations, than based on phrase structure. The concept of dependency relations stem from traditional grammar of languages. Linguists mostly state that dependency relations involve binary relationship between two linguistic units, mostly the governor and the dependent. (Mel'čuk, 2003; Nivre, 2006; Hudson, 2007);

According to Hsu and Bishop (2010), children with SLI show deficit in sequential learning, across all modalities. Vasishth and Drenhaus (2011) and Levy and Keller (2013) had opined that locality effects (long distance agreement deficits) may come into play during high working memory load

conditions; anti-locality effects (distant agreement relations might not play a role) may be present when the load on working memory is low.

According to Tiwari et al. (2017), there are different accounts put forth by authors in order to explain the probable underlying deficits, to explain the processing deficits in Children with SLI (CwSLI); this majorly includes the *perceptual deficit account (states that due to lack of the ability towards perceptual saliency in the input, processing deifects are manifested), normal distribution account(which states that CwSLI fall on the left end of normal distribution due to delayed language development) and linguistic accounts(which suggest morpho-syntax to be the core deficit for processing difficulties among CwSLI)*. In terms of the linguistic accounts, it is opined that CwSLI have certain linguistic blindness arising from genetic predisposition, which had lead to the inability to develop implicit grammatical markers. This inability hinders in processing of the linguistic information.

Need for the study

Literature on Children with SLI (CwSLI) documented a clear deficit in sentence processing abilities. Children with SLI generally are slow in processing information (Sininger, Klatzky, & Kirchner, 1989); (Kail, 1994) and may not show deficits in accuracy at least when the sentences are shorter. But, it is not clear, if this is due to their general slower processing speed or it is the time lapse to use their declarative memory to compensate for their procedural sentence processing deficits. It is necessary to load them with another task and see if children with SLI still perform accurately. If they do perform well,

it can be inferred that they are generally slower and if not, they are using declarative compensation.

Aim of the present study

The aim of the present study is to explore the processing of simple and complex sentences in children with and without SLI.

Objectives

- To compare between children with Specific Language Impairment (CwSLI) and typically developing (TD) children on processing simple short sentences (with one dependency) in single task paradigm.
- To compare between CwSLI and TD children on processing complex short sentences (with two dependencies) in single task paradigm.
- To compare between CwSLI and TD children on processing simple long sentences (with one dependency) in dual task paradigm.
- To compare between CwSLI and TD children on processing complex long sentences (with two dependencies) in dual task paradigm.
- To determine the effect of gender on sentence processing between CwSLI and TD children.
- To compare between CwSLI and TD children on sentence processing in terms of age and gender-matched condition.
- To compare between CwSLI and TD children on processing short and long sentences in both single and dual tasks.

- To compare between CwSLI and TD children in terms of sentence processing in single and dual tasks.

Hypotheses

1. There will be no significant difference between children with and without SLI, on processing simple short sentences (with one dependency) in single task.

2. There will be no significant difference between children with and without SLI, on processing complex short sentences (with two dependencies) in single task.

3. There will be no significant difference between children with and without SLI, on processing simple long sentences (with one dependency) in dual task.

4. There will be no significant difference between children with and without SLI, on processing complex long sentences (with two dependencies) in dual task.

5. There will be no effect of gender in the sentence processing within children with and without SLI.

6. There will be no significant difference between children with and without SLI, when compared in terms of age and gender-matched condition.

7. There will be no significant difference between children with and without SLI, in processing short and long sentences in both single and dual tasks.

8. There will be no significant difference between children with and without SLI, in processing sentences in single and dual tasks.

CHAPTER II

Review of Literature

Sentence processing in typically developing children

Sentence processing involves the study of representations that humans form, as and when they comprehend a sentence or an utterance and the mechanisms that underlie the processes. The processes include recognition of words, determining the semantic and syntactic relations among them in a sentence level, and interpreting the sentence, in terms of the relevant linguistic and non-linguistic content (Tenenhaus, 2006). Adams (1990) opined that children with good receptive language skills were capable of using word order cues to process or comprehend the sentences correctly. While exploring the psycholinguistic viewpoints, it is often assumed that an individual's implicit knowledge of lexical semantics, specifically the knowledge of verbs play a vital role; thereby paving the way rapid real-time sentence interpretations. Many theories have been put forth which assumes that recognition of a verb includes rapid activation of associated semantic and syntactic details related with each argument (Mauner & Koenig, 2000). Studies on sentence processing had shown that Typically Developing (TD) children construct representations at multiple levels, which aids in their processing. According to Trueswell et al.(1999), similar to adults, children make hypotheses about the syntactic-semantic connections between phrases, as they unfold. Such predictions are made possible because of the information that is present early in the sentence (Choi & Trueswell, 2010).

Sentence processing in SLI

Studies that were published in language abilities of children with SLI, has shown that the major hallmark of the disorder is the significant deficit in syntax, in particular the inflectional morphology (Loeb & Leonard, 1991). Children with SLI were reported to have poor morphological awareness when compared to age-matched peers (Smith-Lock, 1995). Most of the studies have concentrated on English language speakers, though there are few cross-linguistic studies. In Italian language, wherein verb morphology is very important, it was found that children with SLI, had no difficulty in verb inflection when compared with their peers, who were matched for their Mean Length of Utterance (MLU) and they focus on deficits in learning agreement morphology (Leonard et al.,1987; Leonard,1988; Bortolini, Caselli & Leonard,1996; Cipriani et al.,1998).

Joanisse and Seidenberg (1998) reviewed the previous studies in order to determine whether Specific Language Impairment involves a deficit in grammar or processing. They had suggested that the SLI population does have some amount of knowledge regarding the necessary grammatical principles, but factors such as the limitation of working memory are known to interfere with the ability to use the knowledge in sentences.; hampering the processing of sentences. Apart from working memory perspective, studies suggest that problems with phonological processing can result in deficits of morpho-syntactic skills (Rispens and Been, 2007). This can in turn affects the sentence processing ability among children with SLI.

Sentence processing is majorly based on the dependency relations or agreements in the sentences. Dependencies are usually studied with the manipulation of morphological rules in the sentences. There are two hypotheses in the literature which talk about the use of inflectional morphemes in SLI. One is the *process account*, which states that children with SLI have a limited processing capacity which in turn impacts their use of inflectional morphology (Leonard, 1988). The other is the *agreement-deficit account / agreement-deficit hypothesis*, which states that children with SLI may have selective impairments with some formal features of language, especially features that do not have a semantic interpretation, like Subject-Verb agreement are more difficult for SLI children (Clahsen et al., 1997). Children with SLI have more errors on Subject-Verb agreement than children with dyslexia and typically developing children (Rispens and Been, 2007). Children with SLI have poor sequence learning abilities (Plante et al., 2002; Tomblin et al., 2007; Hedenius et al., 2011; Lum et al., 2012). It is speculated that the above two hypotheses may not hold true for all languages due to their inherent differences in language structure.

Montgomery (2000) examined influence of the verbal working memory in sentence comprehension among Children with Specific Language Impairment (CwSLI). The study included twelve CwSLI with a mean age of 8.6 years, twelve chronologically age-matched (CA) children with a mean age of 8.7 years and twelve children who were matched for receptive vocabulary with a mean age of 6.8 years. The SLI group's receptive and expressive score were lesser than 1 standard deviation below the mean, when assessed with the Clinical

Evaluation of Language Fundamentals – Revised (CELF-R) and they performed at least 1 SD below the mean on Test of Reception of Grammar (TROG). The other two groups performed either at or above – 1 level from the mean, on same language measures. There were two main tasks in the experiment – Task for Verbal Working Memory (VWM) and Task for Comprehension of non-redundant and redundant sentences. The first task (VWM) included a stimuli of 25 words (without any rhyming words), taken from 5 semantic categories, namely, animals, plant-things, transportation, clothing and body parts. All these words were uttered and recorded from a native male English speaker.

A total of 5 word lists were created (3-word lists, 4-word lists, 5-word lists, 6-word lists and 7-word lists), with each list including words with at least 2 semantic category. Under three processing load conditions, namely no load, single load and dual load conditions, all the children were presented the five word lists. No-load condition involved the children to recall as many words as possible after the presentation of stimuli. Single-load condition involved recall of the stimuli words, in the order of their increasing physical size; Example: Stimuli- Head, Coat, Thumb, Nut, Cow and the response should be – Nut, Thumb, Head, Coat and Cow. Dual-load condition involved word recall with the previous size processing (in single-load condition) and also included recall of words that go together semantically (semantic categorization). In the second task, two sets of 20 sentences, which consisted of a set of linguistically redundant (long) sentences and linguistically non-redundant (short) sentences were created. The redundant set consisted of 4 sentence types - (1) sentences containing double marking of number (e.g., “Point to the picture of the three

cats"); (2) semantically reversible sentences with a single embedded subject relative clause (e.g., "The girl who is smiling is pushing the boy"); (3) semantically reversible sentences with a double embedded subject and object relative clause (e.g., "The little boy who is standing is hitting the little girl who is sitting"); and (4) active sentences with adjectival/adverbial material modifying the subject and/or object noun (e.g., "The dirty little boy climbed the big, tall tree"). All these sentences were recorded by a native male speaker, without any prosodic variations. 40 sentences were presented to the subjects via headphones at a comfortable listening level. Subjects were shown with an array of 4 pictures, during the sentence presentation. They were asked to point to the corresponding picture after hearing each sentence and the responses were scored as correct or incorrect.

Before experimental testing, a pretest was done to check the familiarity of different grammatical parts of speech which were present in the sentences of the experiment. The results indicated that the children with SLI performed in similar lines to that of the CA peers in both no-load and single-load conditions, but poor performance was noted on dual-load condition. In all the three conditions, children with SLI and receptive language-matched peers performed similarly.

In the second task, CwSLI comprehended fewer redundant than non-redundant sentences. The CA and VM children, showed no effect of sentence type. The authors also stated that CwSLI have less functional Verbal Working Memory (VWM) capacity, because of which they find it harder to manage the processing resources, according to the task demands.

The above study has focused on the Working Memory (WM) capacity limitations among CwSLI, according to the task demands. The authors could have determined the performance of CwSLI in "on-line" processing of spoken language to check whether CwSLI were better in managing the WM resources during immediate/real-time processing of inputs; instead of concluding the results based on off-line processing. Such investigation could have given better insights as to how CwSLI manage their cognitive resources in language processing, thereby helping in designing a sensitive assessment and rehabilitation procedures.

Marton and Schwartz (2003) examined to determine the relationship between language comprehension and working memory in children with specific language impairment (SLI), majorly focusing on the central executive component and the interaction with the phonological loop (Baddeley, 1986) in complex working memory tasks. The authors studied the effect of sentence length and syntactic complexity on working memory performance. Two groups of children (thirteen Children with SLI and thirteen typically developing (TD) children) in the age range of 7-10 years participated in the study and all were native speakers of English. The SLI group had a language total of at least 1.5 standard deviation below the mean score of that age, in a standardized language assessment using Clinical Evaluation of Language Fundamentals-Revised version. Both the groups included 5 girls and 8 boys. There were three tasks, namely, Nonword repetition (NR), Nonword Discrimination (ND) and List Recall task (LR). The stimuli for the nonword repetition were 24 nonwords, which included eight two-syllable nonwords, eight three-syllable nonwords and

eight four-syllable nonwords. Five listeners participated in the study, made sure that the stimuli words had no meaningful syllables. For the nonword discrimination task, the twenty four nonword pairs of the ND task were mostly minimal pairs. The minimal pairs differed in stress pattern. Number of correct answers was noted for both identical as well as different nonword pairs. Both NR and ND task provided a baseline regarding the child's performance in phonological working memory.

In the Modified Listening (ML) Task 1 and 2 (ML 1 and ML 2), the stimuli consisted of 90 sentences (30 short syntactically simple sentences, 30 short complex short sentences, and 30 long complex sentences) with a question assigned for each sentence. Short sentences consisted of 10 or lesser syllables and long sentences consisted of at least 15 syllables. Syntactically complex sentences consisted of embedded clauses and relative clauses. In ML1 task, the stimuli consisted of 45 sentences that were unrelated, including 15 short simple, 15 short complex, and 15 long complex sentences, with each sentence ending with a non-word. The first part of the ML2 task was identical to the ML1 task, with one addition. ML2 task was identical to ML1 task, except an additional task of answering question regarding the content of the sentence. In the List Recall task, all children were instructed to listen to sets of sentences (five sentences in each set) and recall the sentence-final words after the fifth sentence. The words were real words, and they had been controlled for their phonological features. They were similar in frequency and in word length measured by syllables. The test was constructed with 45 unrelated sentences containing three sets each of 5 syntactically simple, 5 syntactically complex

short and 5 syntactically complex long sentences. Each of the children were tested separately in a two 60-minute sessions. The stimuli for the study were audio recorded by a female speaker and presented via headphones. The children's responses were recorded from a portable tape recorder and were evaluated as correct or incorrect. While analyzing the nonword repetition task, responses were considered as incorrect if it consisted of addition, deletion and substitution of segments, incorrect stress pattern, changed segment order and cluster simplification.

In list recall task, children were scored for each correct recall of stimuli items, irrespective of position or order of recall. The results revealed that CwSLI performed significantly poor than TD children. The two groups did not have any significant difference in Nonword discrimination Task. There was significant group difference between children with SLI and TD children in nonword repetition. The TD children repeated the nonwords in the ML2 task with greater accuracy than children with SLI. As, the sentence complexity increased, the accuracy was compromised. Both the groups exhibited a word-length effect as the number of syllables in the nonwords increased. In the LR task, the children with SLI performed more poorly than the TD children in terms of final word recall within each of the sentence type. TD children recalled more items from initial and final parts than the medial part. In contrast, there was no significant difference in recall across word positions in the children with SLI. Overall, CwSLI performed poorly on NR, ND and LR tasks. This study could have determined the individual differences within the groups, which would have revealed more about interaction within cognitive processes

that are related to the functioning of central executive component. Such findings would have given a better picture of heterogeneity present within the groups, which would help in further classifying the experimental group, based on domain-specific groupings or impairments.

Evans et al. (2009) did a study on statistical learning among Children with Specific Language Impairment (CwSLI). They aimed to find whether CwSLI can implicitly acquire the probabilities of adjacent sequences of sound and also if such an ability is related to the degree of exposure to the sound sequences. They also aimed to find if this implicit capacity is related to vocabulary and if it is domain general or specific phenomena. The study included two groups (CwSLI and normal language controls) in the age range of 6.5-14.4 years. Total of 113 children participated in the study (35 CwSLI and 78 typically developing peers). All the children in the study had a non-verbal Intelligence Quotient of 85 or more. Clinical Evaluation of Language Fundamentals – Third edition (CELF-3) was administered among all children. The criteria for CwSLI were that their composite expressive language scores should be at or below 1.5 SD below the Mean for that age. Each child listened to twenty-one minutes of a language, which had lots of transitional probabilities within words than between words. In the second experiment, children in the age of 8-10.11 years from both the groups were made to listen to the same language for forty-two minute period. The language used in the experiment consisted of 12 CV syllables made of seven consonants and vowels together (/b/, /p/, /d/, /t/, /u/, /I / and /a/), The CV pairs were combined into six trisyllabic words. The experimenter combined three hundred tokens consisting of each of the six words in a random sequence

and constructed in such a way that the transitional probabilities between syllables within the words were higher than across word boundaries. It resulted in four thousand five hundred and thirty six syllables. The stimuli also included six non-word foils, which were created from the syllable inventory of the language. All the stimuli items were synthesized using MacInTalk Speech synthesizer, ensuring that it had no acoustic boundaries and prosodic cues with equivalent co-articulation. Female monotone voice speaking at two hundred and sixteen syllables per minute was used as the output option in synthesized speech. The stimuli were set to a thirty six trial two-alternative forced choice test; wherein half of the items had word as the first member of the pair and the remaining had non-word as the first member. The stimuli set were synthesized and recorded. The children were asked to focus on a computer-based coloring task, while the recorded stimuli were played at the background. At the end of the recorded stimuli, children were asked to do a forced choice paradigm. There were presented with pairs of tri-syllables (one word and non-word) and were asked to choose the sound in each pair that sounded more like they had heard during the coloring activity.

Prior to testing, children were given practice trials with word-non-word pairs derived from English (eg: com-pu-ter vs pu-ter-com). Results revealed that after twenty-one minutes of listening, CwSLI had a chance performance and the TD group had above chance performance in accuracy. In the second experiment, after the forty-two minute listening task, CwSLI performed greater than chance level and the TD group performed significantly higher. The authors concluded that poor implicit learning underlie aspects of language impairment in CwSLI.

Increased exposure aids in their ability to track and learn the transitional probabilities but relatively unsuccessful at differentiating newly learned targets from other, as their phonological representation is more holistic than specific. The study could have shed light on implicit learning that happens across the motor, auditory and visual modalities, in order to more precisely characterize the challenges faced by CwSLI. Also, the study could have included a natural language stimuli (eg: native language; in this study-English), in order to ease out the cognitive taxing of learning an entire new language and then undergoing the subsequent testing.

Leclercq et al. (2013) studied the impact of dual task, in terms of sentence comprehension among Children with Specific Language Impairment (CwSLI). The aim of the study was to test if poor sentence comprehension among CwSLI is due to a deficit in allocation of attention. The investigation included 3 groups of native French children – 15 CwSLI (12 boys and 3 girls) with mean age of 11. 3 years, 15 age-matched controls (6 boys 9 girls) with mean age of 11. 3 years and 15 grammar-matched controls (8 boys and 7 girls) with mean age of 7.11 years. The participants were from low- or middle class socioeconomic status. Parental interview ensured that no children had a history of neurological or psychiatric or associated sensory impairments. Children with SLI were diagnosed as SLI prior to the study, by a certified speech language pathologist. The authors also made sure that the SLI group meets the Leonard's criteria for SLI.

There were 3 tasks, namely, Sentence comprehension task, Serial-Choice Reaction Time Task and Working memory tasks. In the sentence

comprehension task, the stimuli consisted of 120 sentences with division of short/long sentences and high/low lexical frequency words. The short sentences consisted of 7 words and 9 syllables- example- “La madame voit le garçon qui glisse.” (“The woman sees the boy who is gliding.”) and long sentences consisted of 15 words and 17 syllables – example - “Ce soir la belle dame noire appelle la petite fille qui lit dans le pré.” (“This evening, the beautiful Black woman calls the little girl who is reading in the meadow.”). The high and low lexical frequency words were taken from Novlex French Data base.

There were 30 sentences under each of the four types and all of them were uttered by a native Female speaker and recorded. Red, green or blue stimuli appeared on the centre of the computer screen for about 200 ms and the participants were instructed to press any of the corresponding keys on the keyboard, having the same colored dot. There were two 3-minute practice trails in the training time frame and in addition in the trial trials, the ISI was set to the 90th percentile of the member's response times (RTs) gathered amid the last moment of the primary practice time frame. The task was displayed as a game and children were instructed to get a thief who showed up in a red, green, or blue square on screen. To catch the thief, children needed to press on the key of the same color in the keyboard. A dual task was there, wherein there was a time of 10 seconds before the sentence presentation, amid which the Choice Reaction Time (CRT) task was performed alone. Participants were required to proceed with the CRT task while they listened to the sentence. At the point when the sentence was done, four pictures showed up on the screen, among which the children needed to pick the one that precisely portrayed the sentence they heard.

In working memory tasks, a dual task paradigm, participants were presented with the lists of digits had to recall the lists during a period of 2 minutes. They also had to use a pen and mark a chain of boxes as fast as possible, simultaneously. The total number of boxes crossed within the time of 2 minutes was calculated. The sentence comprehension task was presented using E-Prime software (Schneider, Eschmann, & Zuccolotto, 2002) in four different sessions.

During the first and second sessions, children performed the sentence comprehension task and the working memory tasks. During the third session, the children completed two 3-minute practice trials with the serial CRT task, along with the dual-task condition. The children completed a 1-minute practice trial with the serial CRT task (with ISI adapted to RTs) in the fourth session.

Generally, the performances observed in the SLI and the grammar-matched control (GC) groups were rather similar. Performance in these groups was globally lower than that observed in the age-matched control (AC) group, in terms of response accuracy and response times. In sentence comprehension task, all the children responded more accurately and quickly to short than long sentences. The SLI group did not significantly differ from the grammar-matched group, but both the groups performed significantly poorer than the age-matched controls. It was also noted that all the children responded more accurately and more quickly to sentences containing high than low frequency words. All the children's RTs were slower under the dual-task condition and SLI group and grammar-matched group showed slower RTs in dual task condition, than under single task condition. The lexicality/frequency of words had an effect only in single task condition than in dual task condition, with performance for low

frequency vocabulary being even better in the dual task condition. In the serial choice reaction time (serial CRT) task, the SLI group was significantly slower than their age-matched controls, but not when compared to grammar-matched controls. Performance in the serial CRT was more accurate in isolation condition than when performed in dual task condition. In working memory tasks, the control groups did not differ significantly from each other. In the single-task condition, the groups did not differ significantly in terms of the digits repeated accurately but there was a difference in the number of boxes that were crossed. The age-matched performed significantly better than the SLI group and the grammar-matched group, and the SLI group performed significantly better than the grammar-matched group. In dual task condition, the accuracy was reduced in all the three groups with age-matched performing better than the other two groups. The authors concluded that children with SLI have deficits in the capacity of allocating their attention, when compared to their chronological age-matched peers. This deficit in turn affects the sentence processing skills among children with SLI.

In the above study, the stimuli consisted of sentences that were long with more redundant information, which did not result in a significant larger cognitive load on storage of semantic processes, because it did not increase the number of needed semantic chunks that is necessary to be maintained in Short-Term Memory. Hence, designing a stimuli with short and long sentences including adjacent and non-adjacent agreements within them would have certainly provided information about the sentence processing abilities, and especially would have been useful to find if the CwSLI were affected in non-adjacent

agreement conditions, which would have shed light on limitation in attentional allocation capacity (as they may not be able to track the long distant agreements due to working memory constraints). Such a stimuli would have strengthened their aim of the study.

According to Purdy et al. (2014), tense and agreement limitations in CwSLI, is a deficit in appreciating the structural dependencies, which occur in sentences. The study included 12 children with a mean age of 9.7 years, who had a history of Specific Language Impairment (SLI) and 12 age-matched typically developing (TD) children with a mean age of 9.7 years. No children were under any medication that could affect brain function during their participation in the study. The stimuli consisted of 60 grammatical local-agreement sentences (eg: Every night they talk on the phone), 60 local-agreement error sentences (eg: Every night they talks on the phone), 60 grammatical long distance finiteness sentences (eg: He makes the quiet boy talk a little louder) and 60 long distance finiteness errors (eg: He makes the quiet boy talks a little louder), accounting for a total of 240 sentences (master list). Two different sentences lists were created from this list, with 30 of the sentence with each of the four types of experimental sentences, placed in each list. No list had grammatical and ungrammatical version of the same sentence. 16 filler sentences were added to each of the list, resulting in 136 sentences per list. The 136 sentences were randomized for each participant in such a way that, part of the children in each group listened to one list, with the remaining children listening to the other list. Thus, each child listened to set of 30 sentences under 4 types and the 16 filler

sentences. All the sentences were spoken by an adult female speaker and recorded.

With respect to the procedure of the study, all the children were fitted with an EEG cap and seated in a dimly lit sound attenuation booth, approximately 4 feet from the computer monitor. Each child completed two practice blocks, containing grammatical and ungrammatical sentences, different from that of experimental stimuli. The children were instructed to listen to the sentences and when prompted by a question on screen, to press one of the buttons on the response box, to indicate a good sentence, or the other button if the sentence contains a mistake. Event Related Potential measures – Anterior negativity and P600 were recorded. After completion of practice blocks, 6 experimental blocks were presented; each block lasted for 3 minutes. After each block, the children were allowed to play board game of their choice; the testing session lasted for 1 hour including the game breaks. The authors analysed the children's accuracy, by employing a measure A'. A' is defined as the proportion of hits and false alarms. A value of 1.00 indicates complete adult grammar accuracy and if A' is 0.50, it is either acceptance of all sentences as grammatical or chance level performance on both grammatical and ungrammatical sentences. The results revealed that the local sentences elicited expected anterior negativity and P600 in both the groups. For the long sentences, the potentials were delayed with reduced amplitude and duration in the SLI group. Hence, this study concluded that there is a decreased sensitivity to long-distance dependencies in children with history of SLI. There were two possibilities that the authors could put forth, which are as follows:

1. Children with history of SLI might have no longer retained information in the matrix clause by the time the Subject-Verb proposition in the second clause was processed.
2. Children might have successfully retained the relevant information but simply had incomplete knowledge of how first part constrained the other part.

The above study had put forth the two major viewpoints about processing limitations among CwSLI. But the authors did not account for these differences in limitations, by correlating with a set of parameters, as in, if processing limitation is due to the effect of stimuli (local/long sentences) or due to working memory capacity, which has constrained the processing. Though, there is interaction among several factors to result in processing deficit, a domain-specific cause could result in the concept about the nature of the deficit.

Hsu et al. (2014) conducted a study among 120 adolescents (60 normal peers and 60 age-matched and non-verbal IQ matched peers) with SLI and normal peers in the age range of 13-15 years. The study aimed at examining the statistical learning in terms of non-adjacent dependencies between the two groups of interest. The authors further aimed to understand the learning processes which are involved in that of non-adjacent dependencies, especially in SLI group.

All the participants were instructed to listen to sequences of non-sense syllables and no prior information about the patterns was given. Post-listening period, the experimenter informed the participants that all the syllable sequences were generated according to a pattern/rule specifying word order. They were asked to press ‘Y’ for grammatical strings and ‘N’ for ungrammatical strings. There were

twelve test items (six grammatical and six ungrammatical). The stimuli consisted of three dependency pairs: axd, bxe and cxf. The middle element "x" was subjected to three variability conditions – low (x=2), mid (x=12) and high (x=24).

The "x" consisted of non word strings with different levels of variability. The stimuli were presented in auditory mode with 144 presentations of each dependency pair accounting for a total of 432 training strings with 6 foils (2 in each dependency pair). The response of each participant was looked upon, in terms of Hits and False alarms. A non-adjacent pair was noted as "learned" if a participant was capable of accepting all the grammatical strings and rejecting the ungrammatical strings (that is, hit rate = 100% and false positive = 0%). Findings revealed that SLI group benefited from low than high variability in learning non-adjacency pairs, that is, their item-specific learning was better with low variability. On the other hand, the normal group performed better in high variability condition.

The authors concluded that the SLI population employs different type of learning strategy, wherein, they tend to memorize the strings (more of route learning) and hence rely on memorized surface properties of speech; they tend to use memorized input chunks as a compensatory strategy for processing sentences. They also opined that population with SLI cannot take advantage of the variability in statistical learning. In the above study, the sequence learning tasks used involved simpler learning of adjacent sequences, whereas, grammatical learning involve relatively complex non-adjacent dependency learning, from the exposure.

Pettenati et al. (2015) studied the extra-linguistic influences on sentence comprehension in children with and without SLI. The study was carried out in Italian language and included 45 children in total, among which the SLI group consisted of 15 children (12 males and 3 females) in the age of 4.1-5.11 years. Another group of 15 children (11 males and 4 females) in the age of 4.1-5.11 years constituted the age-matched typically developing group (TD-A). The rest of the 15 children (9 males and 6 females) in the age range of 3.1-5.1 years were the younger Typically Developing (TD) children and were referred to as the TD-Y group. The TD-Y children were matched to the SLI group, based on their scores on Peabody Picture Vocabulary Test, which was standardized for Italian language. The SLI group satisfied the Leonard's exclusionary criteria for SLI, by scoring significantly lesser than TD-A on Italian version of Test of Receptive Grammar and age-adequate scores on the Leiter International Performance Scale – Revised.

The procedure consisted of adjective screening task and an experimental task. The adjective screening task was done to make sure that all the children comprehended adjectives. A 20-item screening test was carried out. Each item contained a request (eg: "Mostrami il cane giallo" – "Show me the yellow dog") to point to one of the two pictures shown on computer display. All groups averaged to over 90% accuracy on the test items, with no observed group differences. The experimental task consisted of 3 sets of ten items that was administered in a counterbalanced order. Among them, one set consisted of simple reversible SVO sentences (eg: "Il coniglio insegue il gatto" – "The bunny chases the cat"), wherein the children had to point towards one of the two

pictures displayed on the computer; the other picture depicted the opposite relation (eg:A cat chasing a bunny). This set of items was predicted to have higher accuracy and was referred to as “low-demand” items.

The second set consisted of 10 similar reversible SVO sentences, but with a post-nominal adjective which was used to modify the subject noun. A different post-nominal adjective was also present in the sentences, which functioned to modify the object noun (eg: “Il topo bello copre l’uccello allegro”- “The nice mouse covers the happy bird”). All the adjectives were included to add length to the sentences, compared to the ones used in low-demand condition. This set was considered as the “intermediate-demand” items. In this set, the display consisted of contrastive pictures as that of previous task and the children had to point to the correct one.

The remaining 10 items constituted the “high-demand” items. These were the same as “intermediate-demand” items, in terms of the lexical content, length and syntax. But the difference was in two major ways. First, instead of choosing between two pictures, the children were instructed to choose between four pictures. Another difference is that the alternative pictures not only required the children to comprehend the SVO structure, but also to retain each of the adjective along with its respective character (eg: “Il cane giallo lava il maiale bianco” – “The ***yellow dog*** washes the ***white pig***). Each foil depicted different combinations of correct and incorrect subject-object relation (eg: “A white pig washing a yellow dog”).

Accuracy was calculated for the tested items. Results revealed a significant difference with respect to the demand level. The accuracy on high-demand

items was significantly lower than accuracy on intermediate and low-demand items. TD-A children had significantly greater accuracy than children with SLI. The TD-Y children's accuracy was between the scores of the other two groups, but did not significantly differ from either. With the same length, lexical content and syntax of intermediate-demand and high-demand items, there was a significant poor performance with respect to high-demand items, which indicates that the extra-linguistic factors of the number of foils and foil type (combinations of correct and incorrect subject-object relation) play a vital role in the performance accuracy.

From the above study, it can be stated that demands related to the searching and selection of appropriate picture has an important role in child's performance, independent of the linguistic material that is assessed. The study could have considered more number of children to find out the relative effects of each extra-linguistic factor. The authors could have associated the results with working-memory deficits or sequence learning deficits, which could have given information about the causal link and hence could have given a holistic picture of the underlying deficits in the target population.

Leonard (2017) reviewed the reasons which are responsible for the relatively later mastery of tense and agreement morphology in English-speaking children and the extended period of tense and agreement inconsistency in children with SLI. Based on previous studies, the author opined that, it is the children's intake of the input that seems more likely to be the source of the problem (rather than the input itself). That is, though a misinterpretation of complex input may lead to morpho-syntactic errors in the TD children; such errors will

persist for longer period in children with SLI. This is because the latter group will be very slow to resolve the comprehension deficit with this type of input. The author puts forth three major possible reasons for the morpho-syntactic difficulties in children with SLI, which are as follows:

- Misinterpretation of the input;
- Grammatical morphology as a general deficit; and
- Tense/agreement morphology as a particular deficit.

Most of the previous studies reviewed by the author have adopted an input-based approach –"Competing source of input account", in order to account for the tense/agreement deficits in children with SLI. The approach is based on the premise that, if children exhibit a higher degree of tense/agreement morpheme usage they are less influenced by input structures. Studies have also indicated that children with SLI are less accurate than younger typically developing children, on items containing subject-nonfinite verb sequences (eg: The dad sees the girl sleeping). According to the author, the processing deficits observed in children with SLI cannot be clearly delineated as that of syntax issues and tense/agreement morpheme issues. The challenging aspects of the input in English includes the presence of non-finite verbs that are separated in the sentences from preceding matrix verbs or fronted auxiliaries which govern the following non-finite form. Typically developing children have a tendency to learn these combinations, thereby having only a moderate delay in their development of morpho-syntax when compared to children learning other

languages. In case of children with SLI, this delay persists for much longer duration.

From the above study, it is observed that the native language poses different demands in learning, among typically developing children and children with SLI. Thus, the native language and its syntax is a vital factor in studying the language processing deficits, in both typical and atypical processing mechanisms.

SLI in agglutinative language

The studies discussed highlight that the language structural differences contribute to the type and severity of SLI condition suggesting that the processing demands are invariably dependant on language structure. According to Nemeth et al. (2015), based on morphology, languages can be classified into 4 types, namely: *isolated morphology* (few affixes; grammar is based on position of words. Eg: Chinese); *fusional morphology* (rich affixes; word order is important to convey meaning.eg: Italian, Russian, Arabic and English); *agglutinative morphology* (multiple affixes; each affix is distinct and has unique syntactic or semantic function.eg: Dravidian languages, Turkish, Hungarian, Finnish); and *polysynthetic inuit languages* (chains content and function words into long sequences.eg: Siberian and other tribal languages among Eskimo population).

The agglutinative morphology family comprises of Japanese, Korean, Turkish, Hungarian and the Dravidian family.

In Dravidian language family, two case studies in Malayalam and Kannada language, done among children with SLI revealed morpho-syntactic impairments with deficits in the use of tense, plural, negatives, verb agreement and wh-questions (Raman and Amritavalli, 2007; Prema et al, 2010). Unlike in English, the clinical profile of SLI in agglutinative languages comprise of mixed deficits.

With the above premise, Sengottuvel and Rao (2013) studied the sequence learning in Kannada children. The study consisted of twenty three typically developing children in the age of 8-11 years and seventeen children with SLI in the age of 8-13 years. WHO-10 disability questionnaire was used in order to screen the typically developing group. Children with SLI were selected based on Leonard's exclusionary criteria. Both the groups were matched for attentions and vigilance prior to the experimental sequence learning task, using Two Choice Reaction Time (TCRT) task. In the task, either 1 or 2 appears on the screen and the child has to respond by pressing the appropriate buttons present on the keyboard. The experiment of the study had a visuo-motor task, to check for sequence learning, a grammatical judgement/ revision task to check the knowledge of grammar and a picture description task to check the sentence building ability.

Sequence learning was assessed using an adapted serial reaction time task (AD-SRT), which is a visuo-mototr integration task. The child has to trace the location of the picture on the display, by pressing the buttons for appropriate blocks in a game pad. The children were instructed to trace the

picture (dog) as accurate and as quickly as possible. Reaction time and accuracy were measured. Grammatical judgement task involved the children to judge sentences, that were presented orally and the responses were audio recorded. Incorrect judgements were not scored and experimenter moved onto next sentence. For correct judgement, an additional task of revision was needed for children to get maximum score.

In the picture story description task, children were asked to describe a simple story of two dogs fighting for a bone and the responses were recorded. The results of the study revealed that CwSLI were significantly poorer in sequence learning and in judging inflectional and derivational morphemes, when compared to their normal peers.

In a subsequent study, Sengottuvel and Rao (2015) aimed to examine the judgment and revision of inflectional and derivational morphemes of children with Specific Language Impairment (CwSLI). Their investigation included 31 CwSLI and 33 Typically Developing (TD) children in the age range of 8-13 years. For the selection of the SLI group, all the children with learning disability were selected in gross and administered a language test (Linguistic Profile Test) and non-verbal IQ test (Gesell's' drawing test). Diagnosis of SLI was made based on Leonard's exclusionary criteria (1998). The stimuli consisted of 36 Kannada sentences, wherein 18 of them were sentences with inflectional morphemes and the other half had derivational morphemes. 6 out of 18 sentences under each (inflectional and derivational) were incorrect and needed revision from the participants. The sentences were presented and the child's task is to judge the grammaticality and also revise it, in case of incorrect sentences.

A paradigm called Two Choice Judgment Frame (TCJF) was used during re-presentation (if the child failed to revise the sentence or judge it), consisting of two sentences with one sentence having the target morpheme used correctly, and the other with incorrect target morpheme usage. The child had to choose the most appropriate usage of the morpheme.

The presentation of all the sentences was in a random manner, to rule out chance-bias. The scoring ranged from 0 to 4, wherein a score of 0 was given for incorrect judgment, score of 1 for correct judgment, score of 2 for correct judgment but with failure to revise the sentence with clue, score of 3 for correct judgment but also revised the incorrect sentences with the clue; score of 4 was given when the child was able to judge and revise the sentences correctly in the first instance. Results revealed that the younger TD group performed poorer on derivational compared to inflectional judgment task. The difference between inflectional and derivational performance were not significant in older TD children. In general, TD group performed better in inflectional judgment. SLI group performed better on derivational judgment than inflectional judgment. In the revision task, TD group performed the inflectional revisions better than derivational revisions, while the SLI group performed the derivational revisions better than inflectional revisions. Although, the SLI group performed poorer than TD group on derivational revisions, it was not significantly different.

Tiwari, Karanth and Rajashekar (2017) aimed to study the possible profiles of Kannada-speaking Children with Specific Language Impairment (CwSLI), according to the impairments in various components of language such as phonology, morpho-syntax and semantics. In addition to that, the

authors also attempted to determine the influence of complex syntactic manifestation of Kannada in the manifestation of SLI. Three groups, namely CwSLI (15 children with mean age of 9.8 years), age-matched (17 children with mean age of 10.2 years) and language-matched (15 children with mean age of 8.1 years) peers were included in the study. All the children were recruited from the same school and were from similar Socio-Economic Status (Lower middle class-ensured using NIMH Socio-Economic Scale (Venkatesan, 2011)). Each child underwent a detailed linguistic evaluation using Linguistic Profile Test in Kannada (Karanth, 1980), a norm-based test. CwSLI were selected based on Leonard's criteria (1998).

Each child was tested individually in a quiet room in the school premises and were subjected to Linguistic Profile Test (LPT), followed by Spontaneous speech task. Spontaneous speech task (8 minutes duration) involved conversation and picture description (4 minutes each), from which Mean Length of Utterance (MLU) was calculated. Metaphonological test in Kannada (Karanth and Prakash, 1996) was used to assess the phonological awareness in each participant. Non-word repetition task, designed by the authors in Kannada for the current study was used as a task for all the children. The results indicated that CwSLI performed poorer compared to control groups, on most of the language measures. They found that CwSLI produced morpho-syntactic structures on par with the language- match control participants, an observation that is completely different from the published English speaking population. They had observed similar performance between CwSLI and language matched control children, except

on the syllable awareness and non-word repetition tasks (wherein, the SLI group was poorer in performance comparatively). The authors have also put forth five different profiles among the 15 CwSLI, which include – Impaired morpho-syntax, Weak semantics, impaired morpho-syntax and semantics, impaired morpho-syntax and phonology and global deficits in all the three domains, namely, morpho-syntax, phonology and semantics.

Majority of the studies discussed above, suggest that children with SLI have significant deficits in inflectional operations. Thus designing a task, with different distance among dependencies in sentences with inflectional morphemes, would reveal the degree of difficulty based on the distance that in turn would reflect the processing demands in children with SLI (CwSLI). The results of which, can be used as an evidence on the degree and severity of difficulty in inflectional judgement in CwSLI. This can provide inputs on the effect of sentence length and dependencies in a sentence, in terms of nature of sentence processing in SLI children. It can also aid the clinicians to conduct speech and language therapy for such children in a systematic manner with careful selection of targets (sentence type with distance –simple/complex and dependency in mind), which will likely yield in a systematic treatment for better prognosis and also helps to balance the cognitive load of the children during the therapy considerably.

CHAPTER III

METHOD

Sentence processing is an essential aspect of how humans process their languages. It involves how the readers or listeners map recognized words into the meanings of sentences. It requires co-ordination at different levels namely, orthographic, phonological, semantic, thematic and syntactic. Many methods are employed to study sentence processing, among which Serial Reaction Time task and Dual task paradigms are the most used. The present study employs a dual task paradigm to explore the mechanism of processing simple and complex sentences between the two groups, that is, Children with SLI (CwSLI) and typically developing (TD) children.

Design of the study

The study employed two types of designs – the standard group comparison and the comparative group designs in order to compare the performance of CwSLI and TD children.

Participants

Two groups of children participated in the study. Group I included ten children with Specific Language Impairment (CwSLI) and group II consisted of ten typically developing (TD) children, in the age range of 7 and 13 years of age. Children who underwent or are undergoing speech and language therapy (for about 1-3 months duration) at the All India Institute of Speech and Hearing, Mysore, were taken for the Group I. Age and gender matched participants in control group in relation to SLI group was considered.

Inclusion criteria for group I

- 11 children in the age range of 7 – 13 years were considered for the study.
- All of them were native speakers of Kannada language and belonged to middle – upper socio economic status (ensured using NIMH Socio-economic status scale, Venkatesan, 2011).
- The selection of children with Specific Language Impairment (CwSLI) was done based on Leonard's exclusion criteria (1998), which included fulfilling the following criteria:

i. Language abilities – Language test scores of at least -1.25 SD

ii. Non-verbal IQ – 85 or higher

iii. Hearing – Passes screening at conventional levels.

iv. No recent episodes of otitis media with effusion was considered.

v. No evidence of seizure disorder, cerebral palsy, brain lesions; not under medication for control of seizures were included.

vi. No oral structural anomalies and developmentally appropriate oral-motor function were considered.

vii. No symptoms of impaired reciprocal social interaction or restriction of physical activities were considered.

Enrolment details of participants

Group I

All the participants in Group I (CwSLI) in the age range of 7-13 years, who were diagnosed as having Spoken Language Disorder initially, later developed and was diagnosed as Language Learning Disability, by a qualified Speech Language Pathologist were recruited for the study. All were native Kannada speakers. It was made sure that all of them satisfied Leonard's exclusion criteria. The details of the participants are given in the appendix I.

Group II

All the participants in Group II (TD), in the age range of 7-13 years were recruited for the study. All were native Kannada speakers. The participants were selected based on the administration of WHO Ten Questions screen for disability detection (Singhi et al, 2007). The questionnaire was completed through parental and teacher reports and participants were not considered, if they had any history of developmental delay. The details of Group II participants are given in the appendix II.

Stimulus items

Sentence judgement:

A total of 80 Kannada sentences were taken for the experiment. There were two types of tasks, that is, a single task and a dual task. Under each task, there were two sets of sentences, namely short and long, wherein short sentences (Set A) had Mean Length of Utterance (MLU) of 2-3 words and long sentences (Set B) had MLU of 3-4 words. Each set had simple dependency (i.e, only one dependency) and complex dependency (i.e, two dependencies). Set A consisted of 20 short sentences, sub-divided into two sections: short simple dependency type (10 sentences with only one dependency: 5 correct and 5 incorrect) and short complex dependency type (10 sentences with two

dependencies: 5 correct and 5 incorrect). Set B consisted of 20 long sentences, sub-divided into two sections: long simple dependency type (10 sentences with only one dependency: 5 correct and 5 incorrect) and long complex dependency type (10 sentences with two dependencies: 5 correct and 5 incorrect). Table 1 shows an example for both set A (short – simple and complex dependency) and set B (long - simple and complex dependency) sentences used in the present study as stimulus.

Table 1: An example of stimulus for both short and long sentences, representing simple and complex dependencies.

Set A (Short)		Set B (Long)	
Simple dependency	Complex dependency	Simple Dependency	Complex dependency
/avalʊ sʊnða**rɪ**/	/**ɪbrʊ** taŋɪjarʊ sʊnðarava:gɪ**ða:re**/	/avalʊ sʊnðara hʊdʊ**gɪ**/	/avalʊ **oble** sʊnðara hʊdʊ**gɪ**/

Note: List of the stimuli sentences are provided in appendix III**.**

Material preparation and Presentation:

All the 80 sentences were uttered by a native Kannada female speaker and audio recorded, using Computerized Speech Lab (CSL) 4500 model (Kay Pentax, USA) Software in a sound treated room. The stimuli sentences were verified by a linguist along with 5 Speech Language Pathologists (SLPs). The stimuli were presented using

the free downloadable Psychopy software (version 1.83.00), developed by Pierce (2007).

Tasks:

Single task

The experimental task consisted of 40 sentences, which were divided into 20 syntactically correct and 20 incorrect sentences. Each one had Set A and Set B, wherein Set A had short sentences with one and two dependency and Set B had long sentences with one and two dependency. Each child was instructed to judge the sentences as correct or incorrect, which was presented auditorily for about 2500 ms to 4000 ms. The child was instructed to respond by clicking the correct icon (tick mark) if the sentence is correct and to click wrong (cross mark) if the sentence is wrong. These icons were displayed on the screen of the laptop and the children clicked on the appropriate icon, using an external mouse, connected to the laptop. Only after providing a response by clicking on the icon, the child will be able to do the next set of trials in the single task. Figure 1 shows the visual display screen for the children to respond after listening to sentences auditorily.

Figure 1: Response icon/display on the screen for single task.

Dual task

The experiment consisted of an additional task along with the judgement for 40 sentences; wherein there was a simultaneous visual presentation of four abstract shapes for about 4000 ms, along with the sentences, which was presented auditorily between 2500 ms to 4000 ms. The child was instructed to select the odd-one out from the four pictures through mouse click. Soon after clicking the odd-one, the child was asked to respond to the sentence judgement; by clicking the correct icon (tick mark) if the sentence is correct and to click wrong icon (cross mark) if the sentence is wrong. The display of the shapes on the screen stayed for 4000 ms and then it disappeared, even if the child is not going to respond/click (as, the response for the visual stimuli was not of our interest in this task; this is just to increase the cognitive demand). The child was asked to respond to the sentence, after judging it and clicking on the correct icon; only after the click response, the child was able to do the next set of trials with the same nature and sequence of picture and sentence presentation. Figure 2 shows the screen display on monitor to respond for dual task.

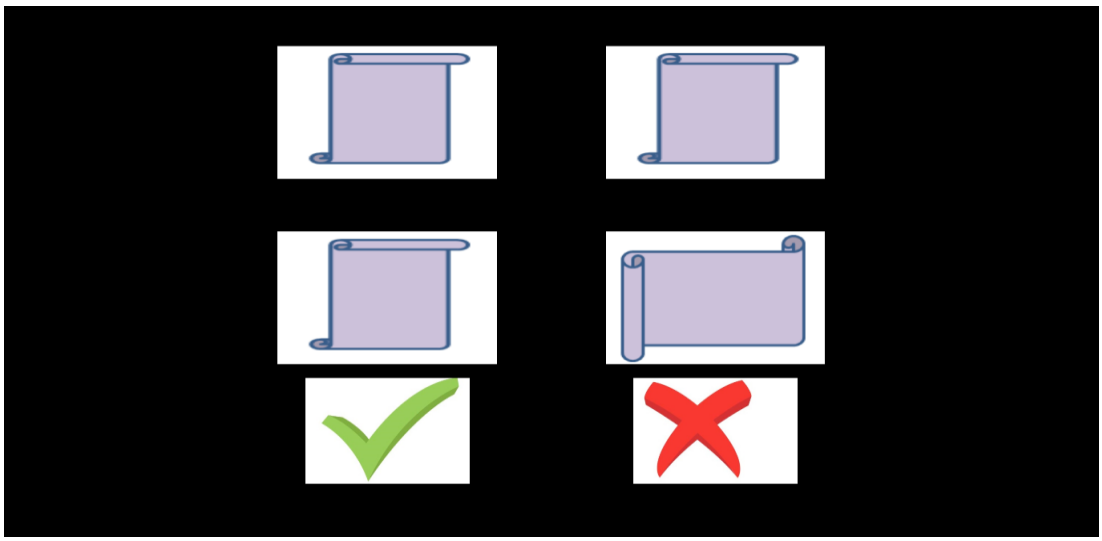

Figure 2: Response icon on screen to respond for dual task.

Procedure

Parents/caregivers were explained about the objectives of the study and both oral and written consent were obtained (before subjecting the children into experiment/study). Testing was done individually for the children. Each participant was seated comfortably in a room, with reduced level of background noise. The distance between the participants and the laptop was adjusted, in such a way that the laptop was placed comfortably at their eye-level. Both the groups were subjected to 3 practice trials in both single and dual tasks, before participating in the actual experiment, for the purpose of familiarizing them with the procedure of task. The sentences were presented in free field (through loudspeakers - Right and Left sides), which was attached to the laptop). Prior to the presentation of each sentence, a "+" symbol served as prime for the upcoming stimuli.

Scoring

The scoring was automatic and the score coding to the software was made in such a way that, each correct response was scored as '1' and each incorrect response was scored as '0'. The performance of both the groups was noted for accuracy, for two sets of sentences in two types of tasks.

Pilot study

A pilot study was carried out on 5 adults (not part of the main study) initially to check for the adequacy of stimulus-presentation related parameters and complexity of the task. It was observed that the adult pilot data resulted in accuracy of equal to or more than 95% accuracy scores, completing the task approximately in 20 minutes. Following this, an another pilot study was tried among 5 normal children in the age

range of 7-13 years (data not included in the main study) to check for complexity of the task, comfort and interest with the response mode, and approximate time gap (break) that the children preferred when moving from single to dual task. It was observed that the accuracy was better (85% and 90%) for older children (the 2 children were 11 and 13 year old, respectively), whereas the other 3 children's accuracy ranged from 79-83.5%, who were about 8 (79%), 9 (81%) and 10 (83.5%) years of age. All the 5 children were able to complete the task in 20-30 minutes of duration.

Majority of the children in the pilot study preferred 5 minutes break time between single and dual task conditions. So, the task was set in such a way that soon after the single task, the laptop display had text instructions for the dual task, which the experimenter would be saying the child verbally. The child can click anywhere on the screen whenever he/she was ready to do the dual task, which lead to the presentation of dual task practice items; followed by dual task experimental items.

Based on the inputs from pilot study, parameters such as stimuli used, order of presentation (randomized), and duration of stimuli, presentation and response modes were noted and these parameters were found to be adequate and thus the same parameters were followed for the main experiment. The "accuracy" of sentence judgement was taken into consideration as measured variable for interpretation of results. In this manner, data was collected for 11 CwSLI (Group I) and 11 TD (Group II) children.

Analysis

The data obtained was analyzed using commercially available SPSS package (Statistical Package for Social Sciences) version 17.0. Both the individual scores (short length– one dependency- single task, short length –two dependency- single task, long length – one dependency – dual task and long length – two dependency – dual task scores) and total scores (short length- single task, long length- single task, short length- dual task, long length- dual task, single task total and dual task total scores) were tabulated and analysed. The data was subjected for the presence of normality, using Shapiro Wilk's test and the findings revealed one significant outlier (from Group I (CwSLI)). Hence, the outlier was removed and then analysed again for normality. The results revealed that all the variables followed normal distribution in both the groups (that is, $p>0.05$), except 2 individual scores which were not following normal distribution among the Group I (CwSLI). Hence, parametric analysis was adopted for the total scores as all the values were significant (that is, $p>0.05$) and non-parametric analysis was chosen for the comparison of individual scores between the groups.

Mann Whitney U test was done to compare the difference in performance between the two groups and to check for the effect of gender in performance in both the groups. One-way ANOVA was carried out to compare the two groups, in terms of total scores for short and long sentences (in single and dual task), and total scores for single and dual tasks. For the purpose of age and gender matched comparison, Wilcoxon's signed rank test was done.

Chapter IV

Results

Total of 22 native Kannada children were considered for the study. 11 children with Specific Language Impairment (CwSLI) were considered as Group I and 11 typically developing (TD) children were considered as Group II. All the 22 children were instructed to do two types of tasks, namely the single task and the dual task, to explore the sentence processing skills between them. The objectives of the study were as follows:

- To compare between children with Specific Language Impairment (CwSLI) and typically developing (TD) children on processing simple short sentences (with one dependency) in single task paradigm.
- To compare between CwSLI and TD children on processing complex short sentences (with two dependencies) in single task paradigm.
- To compare between CwSLI and TD children on processing simple long sentences (with one dependency) in dual task paradigm.
- To compare between CwSLI and TD children on processing complex long sentences (with two dependencies) in dual task paradigm.
- To determine the effect of gender on sentence processing among group I and group II.
- To compare between the two groups in terms of age and gender-matched condition.
- To compare between CwSLI and TD children on processing short and long sentences in both single and dual tasks.

- To compare between CwSLI and TD children on sentence processing, in terms of the performance in single and dual tasks.

The SPSS analysis datasheet was prepared for the statistical analysis, considering the following scores:

- Individual task scores are represented in the following conditions as,

  - Short length- one dependency – single task (Sh1DST)
  - Short length – two dependency – single task (Sh2DST)
  - Long length – one dependency – dual task (Lo1DDT)
  - Long length – two dependency – dual task (Lo2DDT)

- Total scores included the scores in the following conditions namely,

  - Short length – Single task (ShST)
  - Long length – Single task (LoST)
  - Short length – Dual task (ShDT)
  - Long length – Dual task (LoDT)
  - Single task total (STTot)
  - Dual task total (DTTot)

The obtained data was subjected for the presence of normality, using Shapiro Wilks test. The results indicated the presence of a significant outlier (1 participant in Group I (CwSLI)), after which the outlier was removed and again the normality test was done. It was observed that, all the parameters (total scores) followed normal distribution (i.e., $p \geq 0.05$), except two individual parameters (individual scores for Short length – two dependency – single task; Long length – one dependency – dual task) among

Group I participants. Hence, parametric statistical analysis was adopted for the total scores as all the values were significant (i.e., $p \geq 0.05$) and non-parametric analysis was adopted for the individual scores, as two of them were not normally distributed (It was not possible to do non-parametric analysis only for those two conditions, as it would have not resulted in a realistic picture of the individual scores).

The descriptive statistics for the individual scores between the two groups are as follows:

Results of the present study are discussed in the following sub-headings:

1. Comparison between two groups on accuracy scores for individual scores and total scores.
2. Comparison between two groups on processing simple short sentences (with one dependency) in single task paradigm.
3. Comparison between two groups on processing complex short sentences (with two dependencies) in single task paradigm.
4. Comparison between two groups on processing simple long sentences (with one dependency) in dual task paradigm.
5. Comparison between two groups on processing complex long sentences (with two dependencies) in dual task paradigm.
6. Effect of gender in the performance among Group I and Group II.
7. Comparison of the two groups in terms of age and gender-matched condition.
8. Comparison between two groups on processing short and long sentences in both single and dual tasks.
9. Comparison between two groups in terms of the performance in single and dual tasks.

1. Comparison between two groups on accuracy scores for individual scores and total scores.

Table 2: Mean and Standard Deviation of accuracy scores for different individual conditions between groups

Condition	**Group I**		**Group II**	
	Mean (M)	**Standard Deviation (SD)**	**Mean (M)**	**Standard Deviation (SD)**
Sh1DST	6.70	1.25	8.36	1.50
Sh2DST	6.90	0.87	7.81	1.32
Lo1DDT	5.70	1.15	7.45	1.86
Lo2DDT	5.50	1.35	7.18	1.83

[Note: Group I: N =10 and Group II: N = 11 (Mean scores are described on a score of 10)**]**

From table 1, it can be observed that the mean accuracy scores are higher for group II (TD) when compared to group I (CwSLI). In group I, the mean accuracy score is higher for the Sh2DST (Complex short sentences with two dependencies in single task) condition and lower for Lo2DDT (Complex long sentences with two dependencies in dual task) condition. In group II, the mean accuracy score is higher for the Sh1DST (Simple short sentences with one dependency in single task) condition and least for Lo2DDT (Complex long sentences with two dependencies in dual task) condition.

The descriptive statistics for the total scores between the two groups are as follows:

Table 3: Mean and Standard deviation of accuracy scores for total conditions between groups

Condition	**Group I**		**Group II**	
	Mean (M)	**Standard Deviation (SD)**	**Mean (M)**	**Standard Deviation (SD)**
ShST	13.60	1.26	16.18	2.78
LoST	11.50	1.84	15.45	1.91
ShDT	12.00	2.54	14.72	2.86
LoDT	11.20	2.20	14.63	3.23
STTot	25.10	2.76	31.63	4.31
DTTot	23.20	3.96	29.36	5.13

[**Note**: Group I: N =10 and Group II: N = 11. Mean scores are described on a score of 20, except for STTot and DTTot conditions, for which it is described on a score of 40**]**

From table 2, it can be observed that the mean accuracy scores of group II (TD) are higher than that of group I (CwSLI). In group I, the mean accuracy scores are higher for the short sentences when compared to that of long sentences in both single and dual tasks. The mean accuracy score is higher for performance in single task, when compared to that of dual task. Group II also followed a similar trend as like group I. For single task sentence processing, group I participants performed better generally than dual task condition. The same was observed in group II also, that is, accuracy scores are higher in single task than dual task.

2. Comparison between two groups on processing simple short sentences (with one dependency) in single task paradigm.

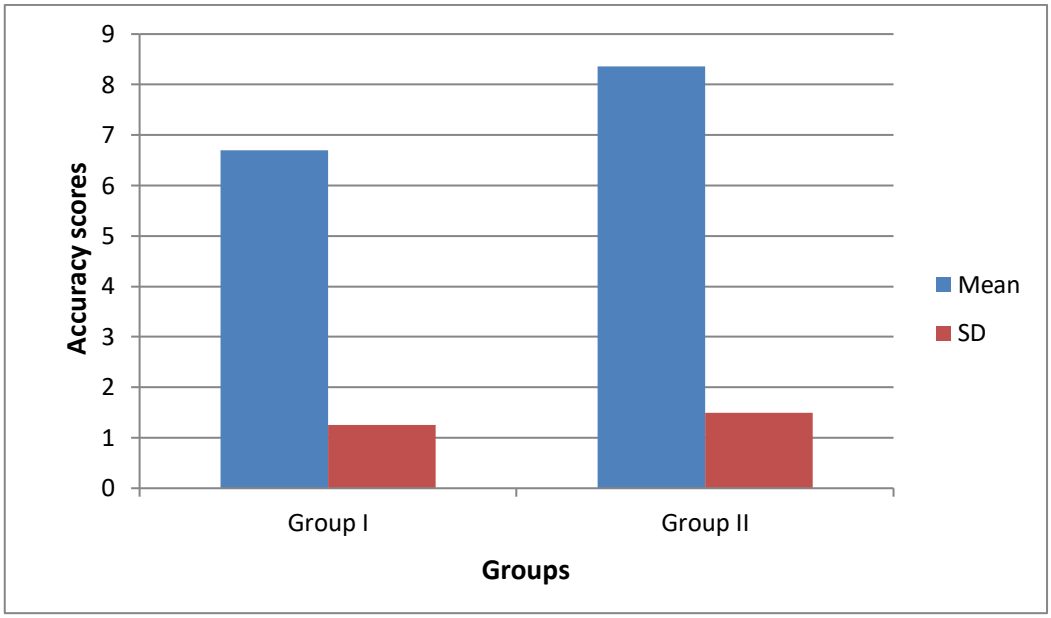

Figure 3: Mean accuracy score on processing short sentences with single dependency in single task paradigm in both groups.

From figure 3, it can be inferred that the mean accuracy scores of group II (TD) was higher than group I (CwSLI) in Sh1DST condition. The value of standard deviation was comparatively more in group II than that of group I.

Mann Whitney U test was done to compare the "Sh1DST" condition between the two groups. The results of Mann-Whitney U test revealed a significant difference between groups ($|Z|$ score = 2.38; $p \leq 0.05$) on processing Simple Short sentences with one dependency in single task. That is, group II had significantly higher accuracy score when compared to group I children.

3. Comparison between two groups on processing complex short sentences (with two dependencies) in single task paradigm.

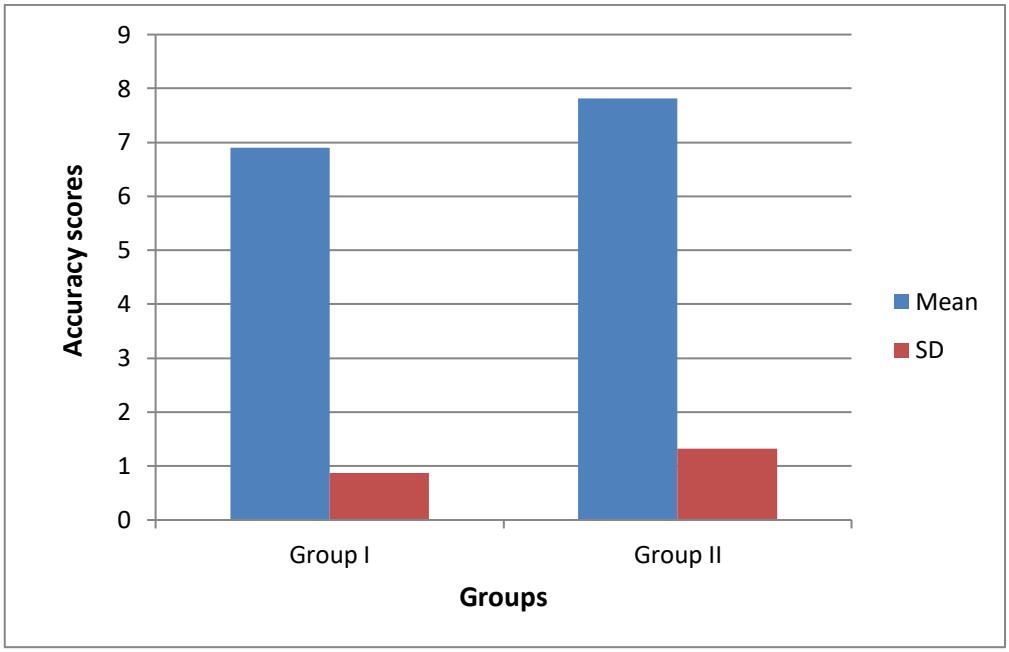

Figure 4: Mean accuracy scores on processing complex short sentences with two dependencies in single task paradigm in both groups.

From figure 4, it can be inferred that the mean accuracy scores of group II (TD) was relatively higher than group I (CwSLI) in Sh2DST condition. The value of standard deviation was comparatively more in group II than that of group I.

Mann Whitney U test was done to compare the "Sh2DST" condition between the two groups. The results of Mann-Whitney U test revealed no significant difference between groups (|Z| score = 1.78; p >0.05) on processing complex short sentences with two dependencies in single task. Unexpected results are obtained as there was a significant difference noticed between Group I and Group II, in the Sh1DST condition. This predicts that the same difference should be observed in Sh2DST also; which is not observed.

4. Comparison between two groups on processing simple long sentences (with one dependency) in dual task paradigm.

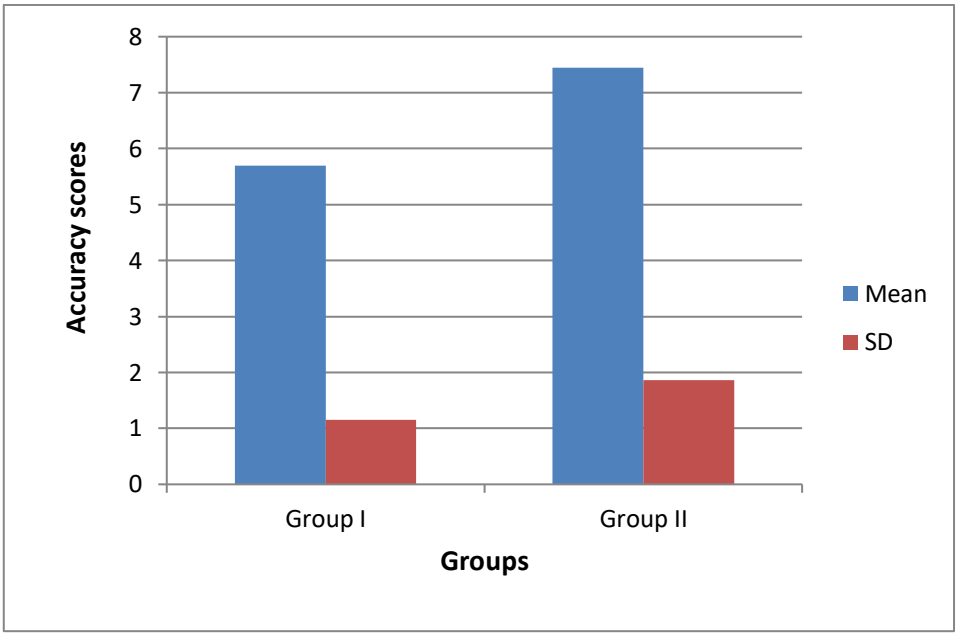

Figure 5: Mean accuracy scores on processing simple long sentences with one dependency in dual task paradigm in both groups.

From figure 5, it can be inferred that the mean accuracy scores of group II (TD) was relatively higher than group I (CwSLI) in Lo1DDT condition. The value of standard deviation was comparatively more in group II than that of group I.

Mann Whitney U test was done to compare the "Lo1DDT" condition between the two groups. The results of Mann-Whitney U test revealed a significant difference between groups ($|Z|$ score = 2.36; $p \leq 0.05$) on processing simple long sentences with one dependency in dual task. That is, group II had significantly higher accuracy score when compared to group I children.

5. Comparison between two groups on processing complex long sentences (with two dependencies) in dual task paradigm.

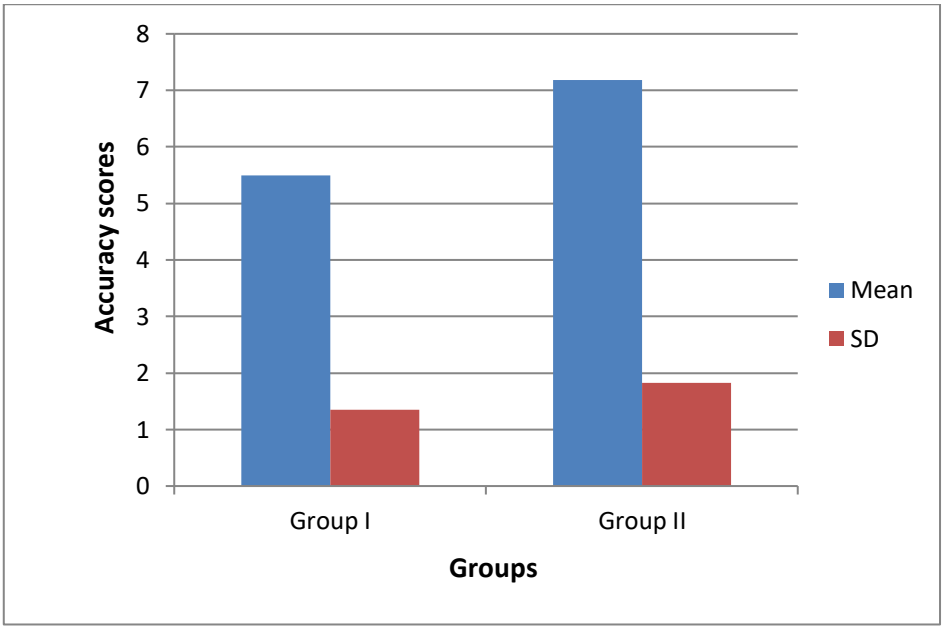

Figure 6: Mean accuracy scores on processing complex long sentences with two dependencies in dual task paradigm in both groups.

From figure 6, it can be inferred that the mean accuracy scores of group II (TD) was relatively higher than group I (CwSLI) in Lo2DDT condition. The value of standard deviation was comparatively more in group II than that of group I.

Mann Whitney U test was done to compare the "Lo2DDT" condition between the two groups. The results of Mann-Whitney U test revealed that group I (CwSLI) performed poorly on processing complex long sentences with two dependencies in dual task paradigm. The difference between the two groups of children showed statistical significance at 0.05 level ((|Z| score = 2.07; $p < 0.05$). That is, group II had significantly higher accuracy score on Lo2DDT task than group I children.

6. Gender effect on sentence processing performance within Group I and Group II.

Table 4: Average mean accuracy score for boys and girls in Group I and Group II.

Condition	**Group I (CwSLI)**		**Group II (TD)**	
	Boys (N=7)	**Girls (N=3)**	**Boys (N=7)**	**Girls (N=3)**
Sh1DST	6.57	7.00	8.71	8.00
Sh2DST	6.71	7.33	8.14	7.66
Lo1DDT	5.71	5.66	8.28	6.66
Lo2DDT	5.71	5.00	7.28	7.66
ShST	13.28	14.33	16.85	15.66
LoST	11.57	11.33	15.57	15.00
ShDT	12.41	11.00	15.57	14.66
LoDT	11.42	10.66	15.57	14.33
STTot	24.85	25.66	32.28	30.66
DTTot	23.85	21.66	31.14	27.66

[Note: Individual scores (Sh1DST, Sh2DST, Lo1DDT and Lo2DDT) are out of 10 and total scores (ShST, LoST, ShDT, LoDT, STTot and DTTot) are on a score of 20**]**

From table 3, it can be observed that in group II (TD), in the individual condition, the average mean accuracy score for boys are relatively higher than that of girls, except in Lo2DDT condition. In total scores, the average mean accuracy score for boys are relatively higher than that of girls. In group I (CwSLI), in the individual condition, the average mean accuracy score for boys are relatively higher than that of girls in Lo1DDT and Lo2DDT conditions. Girls had relatively higher average mean accuracy scores in Sh1DST and Sh2DST conditions. In total scores, boys had comparatively higher average mean accuracy scores in all the conditions except in ShST and STTot conditions, in which girls had higher average mean accuracy scores than boys. Results of Mann Whitney U test revealed that there is no significant difference between boys and girls for all individual and total accuracy scores on all tasks/ conditions ($p>0.05$). The boys in group II consistently got relatively higher accuracy scores on all sentence processing paradigms/ tasks than girls, in general. In group I, in majority of the sentence processing tasks/ paradigms, boys has got relatively higher mean accuracy scores than girls. But with respect to the difference on sentence processing between boys and girls both in group I and group II, there is no statistical significant difference found at 0.05 level.

7. Comparison of two groups in terms of age and gender-matched condition.

Matched pair-wise comparison was done. One of the participant's data from the TD group (group II) was eliminated as there was no counterpart data in group I for this analysis (as that was found to be an outlier and hence, was removed). So, the analysis on sentence processing was proceeded with 10 CwSLI and 10 TD children, whose age

and gender were matched. The descriptive statistics for the matched pair-wise scores is given below;

Table 5: Mean (M) and standard deviation (SD) of accuracy scores for both the groups in age and gender matched condition

Condition	Group I		Group II	
	M	**SD**	**M**	**SD**
Sh1DST	6.70	1.25	8.50	1.50
Sh2DST	6.90	0.87	8.00	1.24
Lo1DDT	5.70	1.15	7.80	1.54
Lo2DDT	5.50	1.35	7.40	1.77
ShST	13.60	1.26	16.50	2.71
LoDT	11.20	2.20	15.20	2.78
STTot	25.10	2.76	31.90	4.45
DTTot	23.20	3.96	30.50	4.83

Wilcoxon's signed rank test was done for matched pair-wise comparison. The results revealed significant difference between the age and gender matched CwSLI and TD children in all the scores (both individual and total), except in Long length-2 dependency-dual task (Lo2DDT) condition, where the p value was 0.06 (i.e., $p>0.05$). In all the other conditions, p value was lesser than 0.05, which resulted in significant differences in accuracy scores between age and gender matched children in both the

groups. That is, children with SLI (group I) had significantly lesser accuracy scores on sentence processing compared to age and gender matched typically developing children (group II).

Table 6: Results of Wilcoxon's signed rank test for age and gender matched comparison in both the groups on individual and total scores

Pairwise comparison for tasks	**|Z|**	**p value**
Sh1DST	2.149	0.03*
Sh2DST	2.013	0.04*
Lo1DDT	2.442	0.01*
Lo2DDT	1.866	0.06
ShST	2.405	0.01*
LoDT	2.376	0.01*
STTot	2.527	0.01*
DTTot	2.603	0.00*

(**Note**: * - indicates statistical significance at 0.05 level)

8. Comparison between two groups on processing short and long sentences in both single and dual tasks.

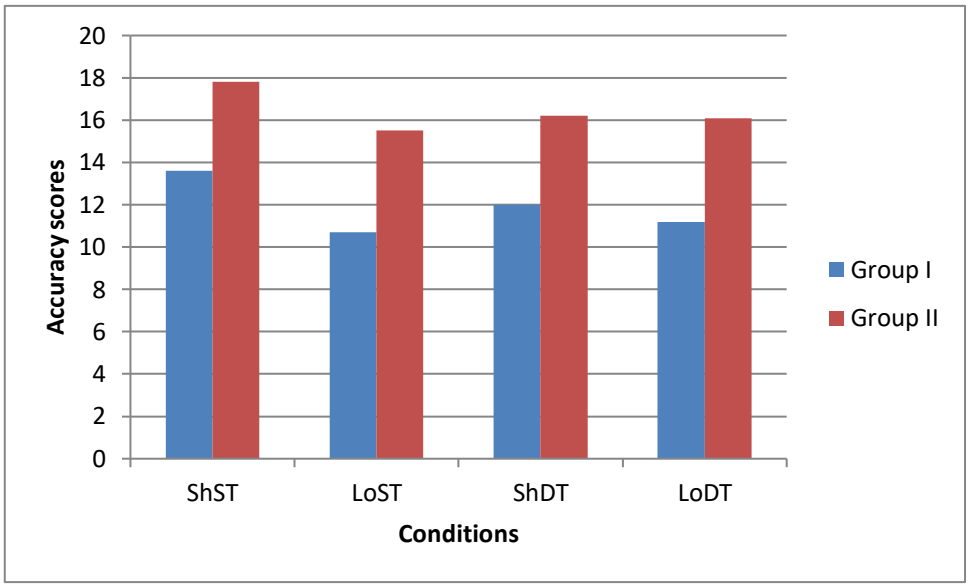

Figure 7: Mean accuracy scores for Group I (CwSLI) and Group II (TD) in short and long sentences in single and dual tasks.

From figure 7, it can be inferred that, in both single and dual task conditions, Group I (CwSLI) performed poorly when compared to Group II (TD). Both the groups performed poorly in long sentences than on short sentences. Also, the accuracy scores had reduced for dual task condition compared to the single task condition.

One-way ANOVA was used to compare the two groups, in terms of the total scores for short and long sentences in both single and dual tasks. That is, the total scores for the conditions – ShST, LoST, ShDT and LoDT were compared. It was found that there is a significant difference noticed between the two groups, among all the four total scores (i.e., $p \leq 0.05$), the details of which are given below:

Table 7: Results of one-way MANOVA for group comparison on short and long sentences in both single and dual tasks

Condition	p value
ShST	0.01*
LoST	0.00*
ShDT	0.03*
LoDT	0.01*

(Note: * indicates significance at 0.05 level)

9. Comparison between two groups in terms of sentence processing in single and dual tasks.

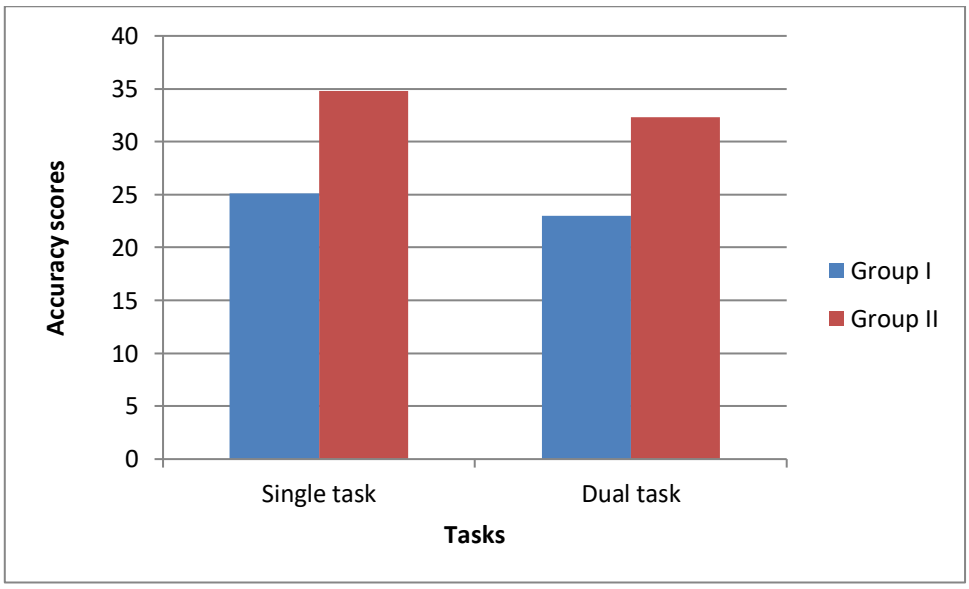

Figure 8: Mean accuracy scores of Group I (CwSLI) and Group II (TD) in single and dual task conditions.

From figure 8, it can be observed that group I (CwSLI) had scored poorly on accuracy scores in processing sentences under single and dual tasks, when compared to group

II (TD). Also, the accuracy decreased for both the groups in the performance of dual task than single task.

One-way ANOVA was done to compare the two groups, in terms of total scores for the single and dual tasks. Table 7 shows the results of one-way ANOVA for task comparison between two groups.

Table 8: Results of one-way ANOVA for single versus dual task comparison between both groups.

Scores	p value
Single Total	0.00*
Dual Total	0.01*

(* indicates significant difference at 0.05 level)

From the above table, it is observed that as $p \leq 0.05$, which indicate that there is a significant difference between CwSLI (group I) and TD children (group II) on sentence processing performance in single and dual tasks. That is, group I got significantly lesser accuracy score on sentence processing in both single as well as dual task paradigm compared to typically developing children (group II).

Chapter V

Discussion

The aim of the present study was to determine the processing of cognitively loaded information, using simple and complex sentences in children with SLI (CwSLI). CwSLI and typically developing (TD) children, in the age range of 7-13 years, were compared in accuracy measure using single and dual tasks.

The results of the present study indicated several points of interest, which are discussed as follows:

First, CwSLI performed poorly in processing the simple short sentences with single dependency in single task. In a previous study done by Montgomery (2000), the author reported that CwSLI comprehended short sentences better than long sentences, while the vocabulary-matched and age-matched children didn't show any superiority in processing one sentence type over the other. There was no significant difference between the three groups in processing short sentences.

With this one can infer that, the sentence length does matter in Indian scenario, as it carries more grammatical details than the English or other languages. Kannada, being an agglutinative language has more preference for the agreement between dependencies and the rich use of morphemes. Such grammatical details, add on to the processing load, making it harder. From the results of the present study, it is observed that even in simple sentences, wherein the dependencies are adjacent to each other, there exist a significant difference in performance between CwSLI and TD children. It can be observed that it is a single task with no cognitive load and the only task for the children is to perform the grammatical judgement. Hence, it can be

inferred that the underlying deficit among CwSLI is not only based on working memory problems, but is majorly to do with the morpho-syntactic domain which is severely impaired. Such a cognitive-linguistic distinction can be inferred from the current results.

In the previous study done by Leclercq et al. (2011), it was noted that CwSLI, grammar-matched and age-matched group, responded more accurately and quickly to short than long sentences. They also reported that CwSLI did not significantly differ from grammar-matched group, but both of the groups performed significantly poorer than the age-matched controls. The present study findings support the findings of Leclercq et al., wherein it can be observed that CwSLI performed significantly poorer than TD children in processing simple short sentences.

The two studies discussed above had been done in English and French language respectively, where the above languages that belong to the fusional morphology type. In fusional morphology, more affixes are used (suffixes are used in Kannada language too) and word order becomes important (not necessary in Kannada). Such intrinsic linguistic differences between these three languages, might account for the results obtained. Kannada belonging to the agglutinative morphology type has shown significant difference between CwSLI and TD in processing simple short sentences; which indicates the morpho-syntactic complexity of the language. Whereas in English, there was no such difference noted and in French, there was a difference; though both of them belong to the same morphology type. When comparing to the previous studies, the results of the current study can be attributed to the linguistic complexity of Kannada and to the methodological differences.

Second, there was no significant difference between children with and without SLI, on processing complex short sentences (with two dependencies) in single task. In the previous study done by Purdy et al. (2013), they reported that CwSLI showed decreased sensitivity to long-distance dependencies, when compared to age-matched TD children. The authors had attributed this to two factors, which state that such a deficit could be as a result of inability to retain the information long enough to track the dependency or agreement; or as a result of how the initial part of the sentence has constrained the second part of it. Hsu et al. (2014), found that CwSLI employ different type of learning strategy for statistical learning, by memorizing the strings on surface properties of speech. CwSLI memorize the input chunks as a compensatory strategy for processing sentences. The authors opined that though CwSLI use a compensatory strategy for learning, it might not be sufficient enough to accommodate the sentence (complex) processing difficulties they face. In the present study, there was no significant difference between the two groups, in processing complex short sentences (with two dependencies) in single task condition. This can be attributed to the linguistic complexity of Kannada as stated previously, which could have constrained the processing approximately to a similar level in both the groups. Hence, TD children also find it difficult to process the complex short sentences (with two dependencies), even in a single task. It is observed that, though working memory is not much constrained in both the groups (task-wise; but they should use working memory to track the dependencies/agreement in the sentence), the linguistic nature of the stimuli plays the key role in the findings of the first two objectives of the current study.

Third, there was a significant difference between children with SLI and typically developing children, on processing simple long sentences (with one dependency) in dual task. That is, children with SLI (Group I) performed poorer in processing the simple long sentences with one dependency in dual task. Leclercq et al. (2011) found that in dual task condition, there was reduced accuracy among CwSLI, age-matched and grammar-matched groups and also the age-matched group performed relatively better than the other two groups. The present study's finding is in line with that of Leclercq et al.'s, with respect to the reduced accuracy in CwSLI in the dual task condition. The present study had used syntactic judgement with finding out the odd-one-out as a dual task, whereas Leclercq et al. had used recall of digits with simultaneous rapid marking of boxes on a sheet. Marton and Schwartz (2003) noted a trend of fewer correct answers as the sentence complexity increases and CwSLI and TD children exhibited a word-length effect in English language. In the present study also, a similar word-length effect can be observed in both the groups in processing simple long sentences (with one dependency) and also CwSLI had relatively more difficulty in dual task.

Fourth, children with SLI (CwSLI) performed significantly poorer in processing complex long sentences (with two dependencies) in dual task. This observation is in accordance with the findings of Purdy et al. (2013) where they reported that there was decreased sensitivity to long-distance (non-adjacent) dependencies in CwSLI. This decreased sensitivity had led to the poor performance of CwSLI in processing complex long sentences (with two dependencies), when compared to the TD children in the current study. In this condition, both the linguistic complexity of the stimuli and the task complexity together might have attributed to the reduced accuracy in both the

groups compared to other comparison conditions; CwSLI were performed poorer comparatively due to their working memory constraints and morpho-syntactic deficits in sentence processing.

Fifth, there is no effect of gender on sentence processing task in CwSLI. The results revealed that there was no gender difference in performance among CwSLI and TD children. This result cannot be generalized as there were only three girls in each group along with seven boys in the groups. As the comparison ratio was not linear (7:3), the results cannot be generalized. None of the previous studies done in the similar lines, had focused on gender differences in sentence processing in CwSLI and TD children. This makes this objective as a future direction to be explored with larger sample/participants.

Sixth, matched pair-wise comparison between the two groups revealed significant difference between the age and gender matched CwSLI and TD children in all the scores (both individual and total), except in Long length-2 dependency-dual task (Lo2DDT) condition, where the p value was not significant. This finding can be attributed to the linguistic complexity of the stimuli and task complexity and supports the findings of Purdy et al. (2013), where they found decreased sensitivity of long-distance (non adjacent) dependency sentences in CwSLI.

Seventh, CwSLI processed both short and long sentences with reduced accuracy at single and dual tasks. Also, short sentences were processed better by CwSLI than long sentences at single and dual tasks. This finding is in consonance with the findings of Montgomery (2000), who reported CwSLI comprehended fewer long sentences as

well as short sentences. Marton and Schwartz (2003) reported that CwSLI and TD children tend to perform less accurate because of the word-length effect as the number of syllables in the nonwords increased in the stimuli. Nonwords have no meaning and they retain only the acceptable syllable combinations according to each language. The current study has sentences which are meaningful, thereby adding semantic weightage to the word-length effect, making it comparatively more complex. Leclercq et al. (2011) also reported that CwSLI, age-matched and grammar-matched children performed more accurately and more quickly to short than long sentences. SLI group did not significantly differ from grammar-matched group, but both the groups performed significantly poorer than their age-matched peers.

Eighth, CwSLI has significantly lesser accuracy scores on processing sentences in single and dual tasks. Also, in single task, CwSLI has processed the sentences relatively better than in dual tasks. The observation is in consonance with study done by Montgomery (2000), which revealed that CwSLI performed poorer than their TD peers, in dual-load condition (dual load involved the children to recall the stimuli words, in order of their increasing physical size and also to recall words that are semantically related). The author attributes the results to the less functional verbal working memory capacity, due to which CwSLI find it difficult to manage the processing resources, according to the task demands. The present study has sentences as the stimuli which would definitely interfere more with the verbal working memory, than words which were used by Montgomery (2000). Leclercq et al. (2011) found that in dual task condition (recall of digits with simultaneous rapid marking of boxes on a sheet), the accuracy was reduced in CwSLI, grammar-matched and age-matched groups; with age-matched group performing better than the other two groups. The

results of the present study support the findings of Leclerq et al. (2011). Pettenati et al. (2015) also found a significant difference for demand level. The accuracy on high-demand items was significantly lower than accuracy on intermediate and low-demand items. Age-matched children had significantly greater accuracy than children with SLI. With the same length, syntax and lexical content of intermediate-demand and high-demand items, there was a significant poor performance associated with high-demand items. Thus, the authors concluded that extra-linguistic factors related to the searching and selection of an appropriate picture has an important role in child's performance, irrespective of the linguistic material that is assessed.

To summarize, children with SLI (CwSLI) performed poorer on sentence processing in both single and dual tasks, where single task is marginally better than dual task. Also, CwSLI has less accurate on processing both short and long sentences. Further, CwSLI process sentences relatively better with single dependency compared to two dependencies. The results of the present study indicated that as the sentence complexity and linguistic complexity increases, the performance of CwSLI considerably reduces. The poorer performance in dual task, signals the declarative compensation that occurs (that is, accuracy reduces as CwSLI use the strategy of declarative compensation for procedural (morpho-syntactic difficulties).

Chapter VI

Summary and Conclusion

Sentence processing is known to have been affected in children with specific language impairment (CwSLI) and there are different proposed accounts which try to find the underpinnings of the same. Linguistic nature and the cognitive aspects such as working memory deficits, procedural learning deficits and the individual profiles in processing have been explained in studies, which support the sentence processing deficits among CwSLI. The review of prior literature did not help in delineating the underlying deficit, being caused due to general slower processing speed or if the CwSLI use this time lapse to use their declarative memory to compensate for their procedural sentence processing deficits.

Hence, the present study aimed to explain the processing of cognitively loaded information, using simple and complex sentences; which could shed light on sentence processing in CwSLI, their ability to perform cognitively loaded task. There were two groups in the study: Group I (CwSLI) and Group II had typically developing (TD) children, in the age range of 7-13 years. Both the groups had 7 boys and 3 girls. CwSLI were selected based on Leonard's exclusionary criteria and TD children were selected based on WHO-Ten disability questionnaire, which screens for any developmental disability in children. The study consisted of single and dual tasks, wherein all the children had to perform grammatical judgement for 80 sentences as a whole. Accuracy was the measured variable for both the tasks. Single task consisted of grammatical judgement for 40 sentences and the dual task consisted of 40 sentences along with an additional task (finding the odd shape from the visual display).

The objectives of the current study were to; compare between children with Specific Language Impairment (CwSLI) and typically developing (TD) children on processing simple short sentences (with one dependency) and complex short sentences (with two dependencies) in single task paradigm; simple long sentences (with one dependency) and complex long sentences (with two dependencies) in dual task paradigm; to compare the two groups in terms of age and gender-matched condition; to compare between the two groups on processing short and long sentences in both single and dual tasks and also to compare between CwSLI and TD children in terms of the performance in single and dual tasks.

The results of the present study revealed that both the CwSLI and TD children perform poorly on long sentences and in dual task condition, with CwSLI performing significantly poor when compared to TD children. With reference to the first objective of the study, which is to compare between the groups on processing simple short sentences (with one dependency), the findings revealed that there is a significant difference between children with and without SLI, on processing simple short sentences (with one dependency) in single task. This finding can be attributed to the morpho-syntactic complexity of Kannada, a Dravidian language and also to the nature of sentence processing deficits among CwSLI compared to that of TD children.

The second objective of the study was to compare between the two groups on processing complex short sentences (with two dependencies) in single task paradigm and the results revealed no significant difference between both the groups. This can be attributed to the linguistic complexity of Kannada as stated previously, which has constrained the processing to approximately a same level in both the groups. The testing of the third objective revealed that there is a significant difference between

children with and without SLI, on processing simple long sentences (with one dependency) in dual task. This can be attributed to the word length effect and dual task (working memory constraints) condition, which had influenced both the groups. Due to less functional working memory capacity and relative inability to deal with morpho-syntax, CwSLI performed poorly when compared to TD children.

The result of the fourth objective of the study revealed that there is a significant difference between children with and without SLI, on processing complex long sentences (with two dependencies) in dual task. This is attributed to the less sensitivity to long distance dependencies in the stimuli among CwSLI as found by Purdy et al. (2013). The current study also looked for gender differences among the two groups and the results revealed that there was no effect of gender among CwSLI and TD children in the accuracy performance of the tasks. The ratio of distribution was 7:3 (males: females), which is non-linear, thereby making the results difficult to conclude on gender effect.

The two groups were also compared, in terms of age and gender-matched condition and the matched pair-wise comparison revealed significant difference between the age and gender matched CwSLI and TD children in all the scores (both individual and total), except in Long length-2 dependency-dual task (Lo2DDT) condition. This finding can be attributed to the linguistic complexity of the stimuli and task complexity. The seventh objective of the study was to compare between CwSLI and TD children on processing short and long sentences in both single and dual tasks, wherein the results revealed that there is a significant difference between the two groups, among all the four total scores (that is, short sentence - single task (ShST), long sentence – single task (LoST), short sentence – dual task (ShDT) and long

sentence – dual task (LoDT)). The accuracy of both the groups reduced in long sentences and CwSLI performed poorly than TD children in short and long sentences, in both single and dual tasks. This finding could be attributed to word length effect and the corresponding working memory constraints for the poor performance in CwSLI.

The final objective of the current study was to compare the performance between CwSLI and TD children in single and dual tasks. The results revealed significant difference between CwSLI and TD children in performance on single and dual tasks, wherein CwSLI performed poorer when compared to the TD children. This finding is in consonance with that of Montgomery (2000), Leclercq et al. (2011) and Pettenati et al. (2015). Comparatively poor performance of CwSLI in dual task, revealed about the declarative compensation that might have happened (as the accuracy had reduced due to the application of declarative compensation strategy; this strategy might have been adapted due to the procedural (morpho-syntatic) deficits and such strategy had in turn resulted in reduced accuracy).

The results of the present study are mainly attributed to the morpho-syntactic complexity of Kannada and working memory constraints among CwSLI. The relatively reduced performed of CwSLI in dual task condition compared to TD children, sheds light upon the fact that CwSLI are unable to manage their cognitive resources with less functional working memory capacity. This in turn makes it difficult for them to use declarative compensation (semantics), in order to overcome their procedural deficits (syntactic deficits). Hence, it can be concluded that CwSLI may not be generally slow in the speed of language processing, but instead, they might try to use this time period for declarative compensation for their procedural deficits. When the task's cognitive demand increases, the time period to do

declarative compensation gets hampered and hence leads to more poor accuracy in language processing.

Implications of the study

The study had provided evidence on the degree and severity of difficulty in inflectional judgement in children with SLI, which can be inferred from the results. CwSLI tend to perform poorer on accuracy measures, in making inflectional judgement. It had also provided inputs on the effect of sentence length and morpho-syntactic complexity, in terms of nature of sentence processing in SLI children. This study could be considered as an aid for the clinicians to conduct speech and language therapy for CwSLI, in a systematic manner with careful selection of targets (sentence type with distance and dependency (simple and complex) in mind), which will likely yield in a systematic treatment for better prognosis and also helps to balance the cognitive load of the children during the therapy considerably. In academic research point of view, this study had contributed to inferring the nature of sentences processing deficit among CwSLI in Indian population (Kannada-speaking children), when compared to their typically developing (TD) peers. It had highlighted the interaction between cognitive aspects such as working memory, procedural memory (helps in learning syntactic probabilities) and linguistic aspects such as morpho-syntactic complexity and sentence length. These findings can help further pave the way for advanced researches which in turn may help develop novel intervention strategies.

Limitations of the study

The current study included a small sample size. The present study did not consider language-matched or grammar-matched control group, which could have resulted in a better picture as to whether if children with SLI (CwSLI) differ from age-matched or from grammar-matched peers.

Future directions

Studies in similar lines to that of the present study should include more number of participants and also check for test-retest reliability in order to validate the accuracy scores. Similar method can be used to study sentence processing difficulties among CwSLI in other Indian languages. Along with accuracy measure, Reaction Time (RT) can be included in documenting the sentence processing speed. Future studies can determine the relationship between memory systems (procedural and declarative) and domain-specific linguistic processes that underlie procedural learning aspects like artificial grammar learning.

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APPENDICES

Appendix I: Enrollment details of Group I participants

S. No	Gender	Chronological Age
1	Male	7 years
2	Male	9 years
3	Male	9 years
4	Male	9 years
5	Female	10 years
6	Female	10 years
7	Male	11 years
8	Male	11 years
9	Male	11 years
10	Male	13 years
11	Female	13 years

All the participants of group I satisfied Leonard's exclusionary criteria.

Appendix II: Enrollment details of Group II participants

S. No	**Gender**	**Chronological Age**
1	Male	7 years
2	Male	9 years
3	Male	9 years
4	Male	9 years
5	Female	10 years
6	Female	10 years
7	Male	11 years
8	Male	11years
9	Male	11 years
10	Male	13 years
11	Female	13 years

Appendix III: Stimulus sentences

Sentences in Single Task

C- Correct sentences F- Filler (incorrect) sentences

S.No	Short length – simple (one) dependency
1C	/ɪve/ /na:jɪgalʊ/
2C	/avarʊ/ /malagʊʈa:re/
3C	/a:ne/ /ʈɪn̂ʊʈ̂a:ɪðe/
4C	/nɛn̂e/ /banðalʊ/
5C	/avanʊ/ /ma:dɪðanʊ/
1F	/ɪve/ /na:jɪ/
2F	/avarʊ/ /malagʊʈa:ne/
3F	/a:ne/ /ʈɪn̂ʊʈ̂a:re/
4F	/nɛn̂e/ /barʊʈa:le/
5F	/avanʊ/ /ma:dɪðalʊ/

S.No	Short length – complex (two) dependency
1C	/na:jɪgalʊ/ /dʒo:ra:gɪ/ /ku:gʊʈ̂ɪve/
2C	/avanʊ/ /obane/ /hogʊʈ̂a:ne/
3C	/avarʊ/ /el̂arʊ/ /ʈɪn̂ʊʈ̂a:re/
4C	/avarʊ/ /ɪbrʊ/ /hʊdʊgɪjarʊ/
5C	/avaɻʊ/ /na:le/ /barʊʈ̂a:le /
1F	/na:jɪ/ /dʒo:ra:gɪ/ /ku:gʊʈ̂ɪve/
2F	/avanʊ/ /ɪbru/ /hogʊʈ̂a:ne/
3F	/avarʊ/ /el̂arʊ/ /ʈɪn̂ʊʈ̂a:ne/
4F	/avanʊ/ /ɪbrʊ/ /hʊdʊgɪjarʊ/
5F	/avaɻʊ/ /nɛn̂e/ /barʊʈ̂a:le /

S.No	Long length – simple (one) dependency
1C	/ɪve/ /ðod̂a/ /na:jɪgalʊ/
2C	/avarʊ/ /ʈʊmba/ /malagʊʈa:re/
3C	/a:ne/ /dʒa:sʈɪ/ /ʈɪn̂ʊʈ̂a:ɪðe/
4C	/nɛn̂e/ /dʒa:nakɪ/ /banðalʊ/
5C	/avanʊ/ /bega:/ /ma:dɪðanʊ/
1F	/ɪve/ /ðod̂a/ /na:jɪ/
2F	/avarʊ/ /ʈʊmba/ /malagʊʈa:ne/
3F	/a:ne/ /dʒa:sʈɪ/ /ʈɪn̂ʊʈ̂a:re/
4F	/nɛn̂e/ /dʒa:nakɪ/ /barʊʈale/
5F	/avanʊ/ /bega:/ /ma:dɪðalʊ/

S.No	Long length – complex (two) dependency
1C	/na:jɪgalʊ/ /ʈʊmba/ /dʒo:ra:gɪ/ /kugʊʈ̂ɪve/
2C	/avanʊ/ /obane/ /ʈʊmba/ /o:ðuʈ̂a:ne/
3C	/avarʊ/ /el̂arʊ/ /a:mele/ /ʈɪn̂ʊʈ̂a:re/
4C	/avarʊ/ /ɪbrʊ/ /ja:va:glʊ/ /nagʊʈa:re/
5C	/avaḷʊ/ /na:le/ /ra:ʈrɪ/ /barʊʈ̂a:le /
1F	/na:jɪ/ /ʈʊmba/ /dʒo:ra:gɪ/ /kugʊʈ̂ɪve/
2F	/avanʊ/ /obane/ /ʈʊmba/ /o:ðʊʈ̂a:re/
3F	/avanʊ/ /el̂arʊ/ /a:mele/ /ʈɪn̂ʊʈ̂a:re/
4F	/avarʊ/ /ɪbrʊ/ /ja:va:glu/ /nagʊʈa:le/
5F	/avaḷʊ/ /nɛn̂e/ /ra:ʈrɪ/ /barʊʈ̂a:le/

Sentences in dual task

S.No	Short length – simple (one) dependency	S.No	Short length – complex (two) dependency
1C	/ɪve/ /bɛk̂ʊgalʊ/	1C	/bɛk̂ʊgalʊ/ /jo:ra:gɪ/ ku:gʊt̪̂ive/
2C	/avarʊ/ /alʊt̪a:re/	2C	/avanʊ/ /obane/ /alʊt̪̂a:ne/
3C	/kʊðʊre/ /t̪ɪn̂ʊt̪̂aɪðe/	3C	/hʊdʊgarʊ/ /el̂arʊ/ /t̪ɪn̂ʊt̪̂a:re/
4C	/nɛn̂e/ /ma:dɪðalʊ/	4C	/avarʊ/ /ɪbrʊ/ /mak̂alʊ/
5C	/avanʊ/ /banðanʊ/	5C	/avaḷʊ/ /na:le/ /ma:dʊt̪a:le /
1F	/ɪve/ /bɛk̂ʊ/	1F	/bɛk̂ʊ/ /dʒo:ra:gɪ/ /ku:gʊt̪̂ɪve/
2F	/avarʊ/ /alʊt̪a:ne/	2F	/avanʊ/ /obarʊ/ /alʊt̪̂a:ne/
3F	/kʊðʊre/ /t̪ɪn̂ʊt̪̂a:re/	3F	/hʊdʊgarʊ/ /el̂arʊ/ /t̪ɪn̂ʊt̪̂a:ne/
4F	/nɛn̂e/ /ma:dʊt̪a:le/	4F	/avanʊ/ /ɪbrʊ/ /mak̂alʊ/
5F	/avanʊ/ /banðalʊ/	5F	/avaḷʊ/ /nɛn̂e/ /ma:dʊt̪a:le/

S.No	Long length – simple (one) dependency
1C	/ɪve/ /ðoda̰/ /bɛk̂ʊgalʊ/
2C	/avarʊ/ /ʈ̪ʊmba/ /alʊʈ̪a:re/
3C	/kʊðʊre/ /dʒa:sʈ̪ɪ/ /ʈ̪ɪn̂ʊʈ̪a̰:ɪðe/
4C	/nɛn̂e/ /dʒa:nakɪ/ /ma:dɪðalʊ/
5C	/avanʊ/ /bega:/ /banðanʊ/
1F	/ɪve/ /doda̰/ /bɛk̂ʊ/
2F	/avarʊ/ /ʈ̪ʊmba/ /alʊʈ̪a̰:ne/
3F	/kʊðʊre/ /dʒa:sʈ̪ɪ/ /ʈ̪ɪn̂ʊʈ̪a̰:re/
4F	/nɛn̂e/ /dʒa:nakɪ/ /ma:dʊʈ̪a̰:le/
5F	/avalʊ/ /bega:/ /banðanʊ/

S.No	Long length – complex (two) dependency
1C	/bɛk̂ʊgalʊ/ /ʈ̪ʊmba/ /dʒo:ra:gɪ/ /kugʊʈ̪ɪve/
2C	/avanʊ/ /obane/ /ʈ̪ʊmba/ /aluʈ̪a̰:ne/
3C	/hʊdʊgarʊ/ /el̂arʊ/ /a:mele/ /ʈ̪ɪn̂ʊʈ̪a̰:re/
4C	/avarʊ/ /ɪbrʊ/ /ja:vaglʊ/ /malagʊʈ̪a̰:re/
5C	/avaɻʊ/ /na:le/ /ra:ʈ̪rɪ/ /ma:dʊʈ̪a:le /
1F	/bɛk̂ʊ/ /ʈ̪ʊmba/ /dʒo:ra:gɪ/ /kugʊʈ̪ɪve/
2F	/avanʊ/ /obane/ /ʈ̪ʊmba/ /alʊʈ̪a̰:re/
3F	/hʊdʊgarʊ/ /el̂arʊ/ /a:mele/ /ʈ̪ɪn̂ʊʈ̪a̰:ne/
4F	/avarʊ/ /ɪbrʊ/ /ja:vaglʊ/ /malaguʈ̪a:le/
5F	/avaɻʊ/ /nɛn̂e/ /ra:ʈ̪rɪ/ /ma:dʊʈ̪a:le/