

**EXPLORING THE RELATIONSHIP BETWEEN LINGUISTIC AND  
READING ABILITIES IN BILINGUAL PERSONS WITH APHASIA**

**A DOCTORAL THESIS**

Submitted to the University of Mysore,  
for the degree of  
**Doctor of Philosophy (PhD) in Speech Language Pathology**

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**APRIL 2025**

## CERTIFICATE

This is to certify that thesis entitled “**Exploring The Relationship Between Linguistic and Reading Abilities in Bilingual Persons with Aphasia**” submitted by Ms. Akshaya S for the degree of Doctor of Philosophy (Speech Language Pathology) to the University of Mysore, was carried out at the All India Institute of Speech and Hearing, Mysuru.

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## CERTIFICATE

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## DECLARATION

I declare that this thesis entitled “**Exploring The Relationship Between Linguistic and Reading Abilities in Bilingual Persons with Aphasia**” submitted herewith for the award of the degree of Doctor of Philosophy (Speech Language Pathology) to the University of Mysore, Mysuru is the result of work carried out by me at the All India Institute of Speech and Hearing, Mysuru, under the guidance of Dr. S.P Goswami, Professor in Speech Pathology, All India Institute of Speech and Hearing, Mysuru. I further declare that the results of this work have not been previously submitted for any other degree.

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## CHAPTER I

### INTRODUCTION

Alexia is an acquired condition leading to impairment in reading aloud and/or comprehending written script. More often alexia is known to occur secondary to brain insult. Thus, it can be well presumed that alexia co-exists with aphasia. Aphasia is an acquired condition with a deficit in language processing secondary to language dominant left hemispheric insult (Kiran & Thompson, 2019). Persons with aphasia (PWAs) typically experience widespread, multimodal language impairments resulting from diverse deficits in auditory comprehension, spoken communication, reading, and writing. However, these impairments may be heterogeneous across PWAs. Most researchers and clinicians believe that aphasia does not result in a breakdown of linguistic aspects alone but causes impairments in processes necessary for comprehending, planning, and expressing in both verbal and written forms of language (Brookshire et al., 2014).

Alexia is known to co-occur in conjunction with aphasia (Cherney, 2004; Hillis, 2002; Riley & Kendall, 2013; Madden et al., 2018). However, the prevalence of aphasia-related alexia, its subtypes, and the factors influencing its occurrence remain unclear. These aspects are central as they may influence aphasia rehabilitation goals. On this note, Brookshire and colleagues (2014) reported evidence that 68% of PWAs exhibit the presence of alexia suggesting that reading impairment always accompanies aphasia. This suggests that there is a strong likelihood of the neural network for the spoken language being affected post-stroke also disrupts the network for reading aloud. The severity of this co-occurring impairment likely depends on the location and extent of the lesion. These distributed language networks are thought to deteriorate gradually rather than completely fail when damaged (Brookshire et al., 2014).

A majority of studies on aphasia and its rehabilitation are directed at apprehending and restoring spoken language impairments with minimal focus on acquired reading impairments (Kelly et al., 2015; Thiel et al., 2015). Additionally, there is increased dependency on written modes of communication, mainly for messaging, emails, and other social media, and PWAs express their desire to enhance their written communication modes (reading and writing). Thus, more research devoted to written language is necessitated (Madden et al., 2018; Thiel et al., 2015).

Most research on alexia in the context of aphasia has predominantly emphasized treatment, often involving single-case designs (Cherney, 2004). Consequently, small sample studies restrict the generalizability of findings regarding the prevalence of alexia in the broader population of PWAs (Brookshire et al., 2014). To effectively plan rehabilitation for PWAs concerning the acquired reading impairment, a much efficient, and thorough assessment is necessary to profile the breakdowns in the array of deficits concerning reading.

### **1.1. Importance of reading assessment in aphasia**

Traditionally, a brief screening of acquired reading impairment is performed along with the profiling of the spoken language deficits on PWAs during routine investigations (e.g., Western Aphasia Battery, Boston Diagnostic Aphasia Examination). This merely serves the identification or presence of reading impairments in the PWAs among the multitude of other spoken language impairments. However, to frame an effective treatment regime for the individual, a comprehensive evaluation is warranted to learn the precise breakdowns at various levels of the reading process. This may include analysis of oral reading tasks at single word level through real word and non-word reading; reading comprehension across single word, sentence, and paragraph levels; visual skills, auditory comprehension, naming, and writing.

Specifically, reading comprehension tasks reflect the individuals' ability to retrieve semantic meaning from script/print. Traditionally, the subtasks of reading comprehension are categorically aligned, starting with single-word level comprehension, followed by sentence level (e.g., comprehending written commands) and paragraph (e.g., responding to questions about a paragraph read). They even include recognition of letters (upper/lower case) and shapes as basic components (Cherney, 2004). There are numerous tests designed for assessing reading comprehension for PWAs but as subtasks in the comprehensive spoken language assessments. Nevertheless, in these reading subtasks in comprehensive aphasia batteries like in the Western Aphasia Battery (WAB) (Kertesz, 2006) or Boston Diagnostic Aphasia Examination (BDAE) (Goodglass & Kaplan, 1983) very scarce information is deciphered with fewer items tested, resulting in inadequate information to apprehend milder reading issues, the type and severity of alexia.

Likewise, oral reading abilities are mostly investigated at single-word levels, in the real word and non-word contexts. This provides insight into specific patterns of reading impairments in conjunction with neuropsychological models (e.g. Dual route Cascaded Model, Connectionist model). Based on the breakdowns in the reading, the connection between semantic and phonological routes is justified (Coltheart et al., 1993). For this purpose, several word lists are developed. These entail regular real words, irregular words, and pronounceable non-words. These are verified for length, complexity, frequency of word usage, degree of imageability/ concreteness, and grammatical class (function word vs. content words) (Karanth, 2003). A thorough analysis of errors in the context of oral reading of these words aids in determination of alexia sub-types (Cherney, 2004).

#### ***1.1.a. Classification of Alexia.***

Conventionally, alexia subtypes are classified based on neuroanatomic disturbances (Cherney, 2004). Very first, Dejerine illustrated two unique alexia syndromes. These were alexia with agraphia and alexia without agraphia (Dejerine., 1891). Later, a third predominant type of alexia was proposed, known as frontal alexia, with lesions localized in the left frontal hemispheric region (Benson & Ardila, 1996). These traditional neuroanatomical distinctions could enhance our understanding of alexias, but they did not entirely account for the irregularities observed in individuals with these alexias, nor could define a clear differentiation of alexia subtypes. Subsequently, researchers proposed neurolinguistic and neuropsychological models to define the alexia syndromes (Marshall & Newcombe, 1973; Shallice, 1995). These were known as peripheral and central alexia.

Peripheral dyslexia accounts for the early, pre-lexical stages of recognizing letters and written word forms, reflecting compromised visual word processing (Shallice et al., 1983). Peripheral dyslexias manifest in three variants: (a) pure alexia, (b) neglect alexia, and (c) attentional alexia. Pure alexia is marked by a letter-by-letter reading approach and a word length effect, wherein as the word gets longer, the time needed to read a word increases substantially. Neglect dyslexia/alexia arises from attentional deficits, typically following damage to the right

hemisphere or sometimes even in bilateral lesions. In attentional alexia, reading is relatively intact for single words but reading is severely impaired when words are presented along with other words and letters (Behrmann et al., 1998).

Shallice and Warrington (1983) proposed a superordinate classification of acquired alexia known as central alexia. Central alexia was proposed as an impairment in reading abilities secondary to a disjunction between the visual input and central linguistic components (meaning and/or speech) (Schattka, 2010). Three types of central alexia are a) surface alexia, b) phonological alexia, and c) deep alexia.

The cardinal feature of surface alexia is the ability to read regular words correctly while mispronouncing irregular words by applying regular spelling rules (known as regularisation) (e.g., "cut"/kUt/ read to match the pronunciation of "put"). Individuals with this kind of alexia read both the regular and the non-words through the application of regular phonological pronunciation of the language with normal fluency and near-normal speed (Marshall et al., 1987; Masterson et al., 1985). Deep alexia is identified with the presence of semantic errors while reading aloud single words. Individuals with deep alexia substitute semantically related words which may not resemble phonologically or orthographically (spelling), for example, "ball" is read as "bat". Interestingly, researchers observed that there is a progression from semantic errors to visual errors (Crisp & Lambon Ralph, 2006). The pattern of evolution of errors continued from visual errors to morphological errors, wherein, the individuals faced difficulty in reading only non-words (Karanth, 2003), termed this condition as phonological alexia. Phonological alexia was conventionally defined as acquired reading impairment marked by an inability to read non-words, even of simpler complexity. Regular word reading is better to a certain extent. Phonological alexia was proposed to be a continuum of deep alexia in recent decades (Crisp & Lambon Ralph, 2011). Most of the clinical features of deep alexia are presented in phonological alexia. Phonological alexia is assumed to be a milder version of deep alexia.

Thus, detailed analysis of oral reading abilities across various contexts like real word, non – word and irregular word reading becomes vital in the routine assessment procedures, because the reading errors serve as the main source to categorize the individual with reading impairment into

specific types of alexia (surface, phonological, and deep). Similar to the assessment of reading comprehension, even oral reading subtasks are included in the aphasia battery, but very few items are included. Hence, this necessitates the need to develop a more comprehensive approach to understand the deviations in reading deficits in individuals with acquired alexia co-occurring with aphasia. Also, the next concern arising would be - "What are the underlying connections entailed with the linguistic aspects in instances of acquired reading impairment, as these types of alexia are central, co-existing with spoken language impairment in PWAs".

### **1.2. Primary System Hypothesis – Linking the spoken language and reading impairment.**

The neuropsychologists conducted experiments to explain the reading deficits in terms of the central cognitive overlay. In this journey, nearly three decades ago they put forth a primary system hypothesis (PSH) model stating that the performance of spoken language and written form is a consequence of interaction between the cognitive systems (Beeson et al., 2022; Patterson & Ralph, 1999). The model demonstrated that reading ability depends on the functioning of concept (semantics), sound processing (phonology), and visual processing (orthographic) (Beeson et al., 2022; Patterson & Ralph, 1999; Plaut, 1996). Later on, the model (PSH) explained the reflection of neural substrates of common linguistics domains examined through the behaviors of individuals. In this line, many seminal works reported the link between reading impairment and the status of central linguistic components (semantics and phonology) (e.g., Beeson et al., 2022; Kümmerer et al., 2013; Tochadse et al., 2018).

In recent times, written language seemed to receive attention, as researchers noticed that a literate adult was actively involved in both spoken form and written language modes. With the increase in the number of individuals pursuing higher education and depending on technology, PWAs express their concerns about improving communication through written modality. Subsequently, the PSH model was proposed to evaluate the relationships between impaired oral reading, semantics and, phonologic in individuals with acquired spoken and reading deficits (Crisp & Lambon Ralph, 2006; Madden et al., 2018). The individual's reading status depended on the individual's primary language system. Thus, the reading profiles were proposed and proved through

the primary systems. The PSH model is based on the connectionist perspective, which proposes that spoken language and word reading rely on the synchronized activation of semantic, phonologic, and orthographic units. Word knowledge is stored as learned patterns of neural activity within the connections among these distributed language components (Madden et al., 2018; Plaut 1996). The primary system, also known as the triangular model, consists of three interconnected pathways: semantics-phonology, phonology-orthography, and orthography-semantics, all triggering language processing. This model operates through a division of labor, enhancing the efficiency of the language system. The activation of specific language units varies based on the task, leading to the association of three core neural systems: visual, semantic, and phonological. Consecutively, the reading patterns were explained based on the impairment or disjunctions in the pathways according to the primary system.

*Normal reading* relies on intact semantic and phonological processing abilities. Phonological alexia is marked by difficulty in reading non-words resulting from significant phonological impairment while maintaining relatively preserved real-word reading. *Deep alexia* is widely regarded as a severe form of phonological alexia (Crisp et al., 2011; Crisp & Lambon Ralph, 2006; Friedman, 1996) and is believed to result from both significant phonological impairment and some degree of semantic impairment. In contrast, *Global alexia* is thought to stem from severe deficits in both semantic and phonological processing, leading to a complete loss of reading ability.

From the aforementioned theories, we may understand that in acquired brain insult conditions, central linguistic aspects and reading both functions in parallel or in association with each other. Apparently, the shared association between linguistic and reading abilities in aphasia has not received much attention. However, gaining deeper insight into this relationship could enhance our understanding of language processing and contribute to more effective aphasia assessment and rehabilitation.

Besides the manifestation of varied reading patterns in different types of alexia, yet there are many aspects contributing to the extent of reading impairment in PWAs. One of the prime factors apart from the pathophysiology of brain insult is the orthographic maps of the individuals'

language, which are deemed crucial.

### **1.3 Importance of Orthographic specific investigations in acquired reading impairment.**

In a diverse country like India, the country is abundant with a wide range of rich scripts and a multitude of languages spoken across the country. It is one of the largest functionally multilingual countries in the world (Annamalai, 2001). Especially, bilingualism is widespread in India, with approximately 450 distinct languages spoken across the country (Ethnologue, 2020). The significance of examining effect of orthographic transparency in reading acquisition and dyslexia is well-supported by empirical evidence discussed further.

Over the past decade, numerous longitudinal studies have demonstrated that the consistency between symbols and sounds in a language can influence both the pattern of reading acquisition (Seymour et al., 2003) and the cognitive skills influencing reading proficiency (Landerl et al., 2019, 2022; Vaessen et al., 2010). Furthermore, reading difficulties are widely influenced by the transparency of the script, prompting research into the specific characteristics of alexia across different orthographies (Landerl et al., 2022). For example, in more transparent orthographies (e.g., Indian scripts, Italian, Arabic), reading difficulties tend to manifest more prominently in reading fluency rather than accuracy, as observed in studies on Italian (Re et al., 2011) and Spanish (Suárez-Coalla & Cuetos, 2015) compared to opaque orthographies. However, most of the experiments on alexia in adults are centered on English speakers, which limits the extension of the findings to languages with less opaque orthographies (Reis et al., 2020). Further, the need for bilingual studies increased with the spurt in bilingualism across the globe. This led to multiple attempts to understand the distinctions in learning to read two languages.

A significant underpinning in bilingual readers is that a bilingual individual must acquire reading skills separately for each of their languages, particularly when the languages utilize distinct orthographic systems (Goral, 2019). The extent to which these mechanisms operate depends largely on the orthographic differences between L1 and L2. When transitioning from a transparent L1 orthography to an opaque L2 orthography, additional neural resources may be required.

Whereas, the reverse transition, that is from opaque to transparent demands less neural adaptation (Goral, 2019; Liu & Cao, 2016; Tan et al., 2003).

With the fundamental understanding of processes occurring in typical bilingual processes to read, researchers have performed seminal works to observe how acquired reading impairment manifests among bilingual individuals. The bilingual-acquired reading impairment studies are briefed in Table 1.1.

Table 1.1

*Studies summarizing orthographic effects in acquired reading impairment.*

<b>Study</b>	<b>Year</b>	<b>Languages known</b>	<b>Profile</b>	<b>Orthography effect</b>
Karant	1981	Telugu, Kannada, Tamil & English	The client was literate in Kannada & English, but a native speaker of Telugu (L1). Kannada is more impaired than English.	Present
Ratnavalli et al.	2000	Kannada, English	The severity of impairment was same in both languages. The pattern was different. Non- reading was poor in Kannada, and real word was poor in English.	Moderate
Beland and Mimouni	2001	Arabic (L1), French (L2)	Deep alexia across both languages. More errors in L1.	Present
Laganaro & Overton	2001	Spanish, English	TBI condition, equal impairment in both languages.	No difference
Karant	2002	Hindi, English, Tamil, Bengali, Kannada	More difficulty in reading Kannada compared to English.	Present
Ohno et. al.	2002	Japanese- English	Japanese is more impaired than English. Kana is more impaired than Kanji.	Present
Beaton and Davies	2007	Welsh & English	Three PWAs with deep alexia. An equal proportion of semantic errors in both languages; Reading better in English compared to Welsh. English was the dominant language.	No difference in L1 & L2 performance.
Weekes e t. al.	2007	Mongolian & Chinese	Out of 8, 3 had difficulty in reading	Present
Senaha & Parente	2012	Portuguese, Japanese	Kanji, Kana – scripts of Japanese. Greater impairment in Kanji than in Portuguese. The pattern of errors varies across all three.	Present

Thus, from the aforementioned studies, it is evident that across the globe multiple attempts were made to comprehend the orthographic-specific effects on reading impairment patterns concerning bilingualism and multilingualism. However, it can dully be noted that the majority of these studies were confined to Western orthographies and very countable investigating acquired reading impairment concerning Indian scripts. In the specific interest of the study, owing to multilingualism and bilingualism prevalent in India, a few pioneers in the field observed and reported the distinctions specific to the Indian cross-linguistic context (Chengappa et al., 2004; Karanth, 1981, 2002; Ratnavalli et al., 2000; Ravi & Chengappa, 2014). These studies were conducted among bilingual and multilingual individuals who knew languages such as Hindi, Kannada, Telugu, and English. All these investigations were on acquired alexia in bilingual/multilingual individuals primarily based on single-case studies, often examining how different types of alexia prevail across various orthographic systems. The authors opined that the variation in the degree of impairment in different languages and varied types of reading errors in each language may be ascribed to distinct linguistic representations in the brain. They emphasized the need for future research to develop explanations based on reading models tailored specifically to explain reading processing in Dravidian languages. Also, they proposed the subsystem hypothesis where each language with its script (alphabetic and semi-syllabic) is a subsystem of a larger and common language/cognitive system (Chengappa et al., 2004; Karanth, 1981, 2002; Ratnavalli et al., 2000; Ravi & Chengappa, 2014).

#### **1.4. Need of the study**

From the developmental dyslexia viewpoint, it is well noted that reading develops after the development of fundamental language skills. These fundamental language skills are phonology, semantics, and syntax which are recognized as key contributors to the development of reading skills (Madden et al., 2018). Thus, spoken language impairment is deemed the fundamental cause of reading difficulties (Hume & Snowling, 2014; Madden et al., 2018). Regardless of the knowledge of inter-relatedness of spoken and reading impairment being well accepted in developmental dyslexia, the evidence for the same in adults with acquired reading impairment is insufficient. To

date, most of the aphasia research and assessment is on spoken language impairment in PWAs. Written language impairment (orthography dependent) is given the least prominence. The majority of PWAs are literate and have a professional background before the stroke episode. Additionally, there is increased dependency on written communication (like messages, social media, etc). In recent scenarios, the PWAs have been showing their interest in improving their reading and writing skills. It gets even more challenging as these deficits along with spoken language further hamper their participation in society. Hence, there is limited literature support for understanding of relationship co-occurring between spoken language impairments and reading deficits in PWAs. Specifically, in PWAs, the relationship between the extent of language components (phonology, semantics, and syntax) being affected and their subsequent effect on reading impairment is warranted to understand the processes involved and aid in aphasia assessment. The individuals' premorbid reading skills with current interests and the need to read dominate the extent of intervention required in these skills. Traditionally, a brief screening of acquired reading impairment is performed along with the profiling of the spoken language deficits in PWAs during routine investigations. This merely serves the identification or presence of reading impairments in the PWA among a multitude of other spoken language impairments. However, to frame an effective treatment regime for the individual, a comprehensive evaluation is warranted to learn the precise breakdowns at various levels of the reading process. For example, if a PWA is identified with phonological alexia through comprehensive assessment, then phonology based treatment approaches may facilitate improving phonological reading deficits. Also, there are many factors to be considered in intervening with acquired reading impairments in PWAs. The expression of written language impairment is largely influenced by the script and orthographic structure of a given language. Western models do not sufficiently explain reading and writing difficulties in Indian languages, which are transparent and alpha-syllabic in nature (Karanth, 2003). Concerning the Indian scripts, one such effective model which would be suitable to explain the reading processing entailed in these scripts is the Primary system hypothesis/ triangular connectionist model (Patterson, 1981). Also, acquired reading impairments may present differently in Kannada and English, depending on factors such as language dominance, proficiency, age of acquisition,

and script complexity. A bilingual PWA with alexia may retain reading ability in one language but not the other, highlighting the need to explore language-specific neural processing and cross-linguistic dissociations. Investigating alexia in bilinguals can provide unique insights into how reading is organized and represented in the brain across different language systems. It offers an opportunity to explore whether shared or independent neural networks support reading in two typologically distinct languages. A deeper understanding of bilingual alexia can inform more inclusive support systems and rehabilitation programs that consider both languages. Hence, the study intends to examine the relationship between linguistic abilities (semantics, phonology and syntax), and reading abilities (oral reading and silent reading comprehension) of Kannada–English bilingual PWAs with an underlying explanation from the Primary System Hypothesis (PSH).

### **1.5 Aim**

To examine the relationship between linguistic abilities and reading abilities in bilingual persons with aphasia across Kannada and English languages.

### **1.6 Primary Objectives of the Study**

1. To examine the relationship between a few aspects of phonology, and semantics (linguistic abilities) with oral reading abilities in bilingual PWAs in Kannada and English, separately.
  - i. Relationship between oral reading tasks with phonology, and semantics in Kannada.
  - ii. Relationship between oral reading tasks with phonology, and semantics in English.
2. To examine the relationship between a few aspects of semantics, phonology, and syntax (linguistics) with silent reading comprehension in bilingual PWAs, in Kannada and English, separately.
  - i. Relationship between semantics, phonology, and syntax with silent reading comprehension in Kannada.
  - ii. Relationship between semantics, phonology, and syntax with silent

reading comprehension in English.

3. To understand the orthography effect (alpha syllabic vs alphabet system) in reading abilities of Kannada and English languages in PWAs.

- i. To compare performance in reading abilities (oral reading and reading comprehension) between Kannada and English languages.
- ii. To compare performance in reading abilities (oral reading and reading comprehension) within Kannada and English languages.

4. To understand cross linguistic variations in linguistic abilities of Kannada and English languages in PWAs.

- i. To compare performance in linguistic abilities (semantics, phonology, and syntax) between Kannada and English languages.
- ii. To compare performance in linguistic abilities (semantics, phonology, and syntax) within Kannada and English languages.

### **1.7. Secondary Objective of the Study**

1. To compare a few aspects of linguistic abilities (semantics, phonology, and syntax) and reading abilities (oral reading and reading comprehension) across and within the type of alexia in Kannada and English languages among bilingual PWAs.

- iii. To compare semantics, phonology, and syntax between alexia sub-groups in Kannada and English languages.
- iv. To compare oral reading and reading comprehension abilities between alexia sub- groups in Kannada and English languages.
- v. To compare semantics, phonology, and syntax within alexia sub-groups in Kannada and English languages.
- vi. To compare oral reading and reading comprehension abilities within alexia sub- groups in Kannada and English reading profiles.

## 1.8. Hypotheses of the Study

1. There is no relationship between a few aspects of phonology and semantics (linguistic abilities) with oral reading abilities in bilingual PWAs in Kannada and English, separately.
  - i. There is no correlation between oral reading tasks with phonology and semantics in Kannada.
  - ii. There is no correlation between oral reading tasks with phonology and semantics in English.
  
2. There is no relationship between a few aspects of semantics, phonology, and syntax (linguistics) with silent reading comprehension in bilingual PWAs, in Kannada and English, separately.
  - i. There is no correlation between semantics, phonology, and syntax with silent reading comprehension in Kannada.
  - ii. There is no correlation between semantics, phonology, and syntax with silent reading comprehension in English.
  
3. There is no orthography effect (alpha syllabic vs alphabet system) on reading abilities of Kannada and English languages in PWAs.
  - i. There is no difference in performance in reading abilities (oral reading and reading comprehension) between Kannada and English languages.
  - ii. There is no difference in performance in reading abilities (oral reading and reading comprehension) within Kannada and English languages.
  
4. There are no cross linguistic variations in linguistic abilities of Kannada and English languages in PWAs.
  - i. There is no difference in performance in linguistic abilities (semantics, phonology, and syntax) between Kannada and English languages.
  - ii. There is no difference in performance in linguistic abilities (semantics, phonology, and syntax) within Kannada and English languages.

*Secondary Objective*

1. There is no difference in a few aspects linguistic (semantics, phonology, and syntax) and reading abilities (oral reading and reading comprehension) across and within the type of alexia in Kannada and English languages among bilingual PWAs.
- iii. There is no difference in performance in semantics, phonology, and syntax between alexia sub-groups in Kannada and English languages.
- iv. There is no difference in performance in oral reading and reading comprehension abilities between alexia sub- groups in Kannada and English languages.
- v. There is no difference in performance in semantics, phonology, and syntax within alexia sub-groups in Kannada and English languages.
- vi. There is no difference in performance in oral reading and reading comprehension abilities within alexia sub- groups in Kannada and English languages.

## CHAPTER II

### REVIEW OF LITERATURE

The importance of examining the comparatively isolated reading deficits secondary to brain lesions during the past two decades has served as a milestone of research on language processing and the brain. This period witnessed growing interests among the researchers who eventually attempted to theorize how the neurotypicals recognize and read aloud the prints. Prior to this period, until the 1970s, the emphasis was predominantly on acquired disorders of comprehension and production. The acquired reading deficits, also known as alexia was studied as a homogenous reading disorder with or without aphasia or agraphia.

The very first attempts to scrutinize and document acquired reading disorders began with the notable observations of Marshall and Newcomb (1973), who published evidence of two unique patterns of acquired reading deficits. In the first type, the patient was unable to read irregular words of English accurately (e.g., “Listen” read as “Liston”). In the second type of error, the patient substituted the target word with a semantically related word that did not resemble phonemically at all (e.g., “Gift” read as “Present”). This significant observation led researchers to think that there is differential processing involved in acquired reading deficits and hoped to continue a thorough analysis of reading disorders, suggesting the evolution of comprehensive models of reading representing its sub-components in the human brain. They also hoped these models could further validate the link between reading and language processing with the evidence of functional overlays of components of the human brain (Marshall & Newcombe, 1973a). Similar to sub-variants of aphasia (in terms of acquired language deficits), the researchers unraveled the sub-variants of acquired reading disorders, such as surface alexia, phonological alexia, deep alexia, and so on.

#### **2.1 Subtypes of Acquired Reading Impairments**

Historically, the traditional classification of alexia was based on the neuroanatomical differences. Alexia with agraphia and alexia without agraphia were the two different alexia syndromes that Dejerine identified more than a century ago (Dejerine J., 1891; Reiff Cherney, 2004).

Wherein, alexia without agraphia was reported to be caused by occipital injury in addition to damage to the corpus callosum's splenium, alexia with agraphia followed left-hemisphere parietal

damage. Frontal alexia is a third major alexia syndrome that has been proposed more recently. Frontal alexia was predicated secondary to an anterior lesion in the left hemisphere (Benson & Ardila, 1996).

While traditional neuroanatomical distinctions have enhanced our understanding of alexias, they do not completely account for the variability observed in patients with these disorders, nor do they allow for clear differentiation of alexia subtypes. As a result, the focus shifted from the anatomical foundations of acquired reading impairments to the neurolinguistic and cognitive processes that underpin them.

In this context, several theoretical models of reading evolved to explain the performance of typical readers and to identify which components of the normal reading system are disrupted in alexia syndromes (Reiff Cherney, 2004). Continuing with the attempts of Marshall and Newcomb (1973), Shallice et al., (1983) extended their study to provide an improved classification of dyslexias. They proposed (a) peripheral dyslexias and (b) central dyslexias.

Peripheral dyslexia accounts for the early, pre-lexical stages of recognizing letters and written word forms, without necessarily impairing central semantic or phonological processes. These difficulties are thought to stem from a deficit in processing the visual features of words, which disrupts the matching of a word to its stored representation or "visual word form" (Shallice et al., 1983). Peripheral dyslexias manifest in three forms: (i) pure alexia, (ii) neglect dyslexia, and (iii) attentional dyslexia.

### ***2.1.1. Pure Alexia***

Pure alexia is marked by a letter-by-letter reading strategy and a pronounced word length effect—where the time taken to read a word increases significantly with each additional letter. This leads to notably slow reading, as longer words require more time to process, often adding several hundred milliseconds per letter (Behrmann et al., 1998). Rather than recognizing words as whole units, individuals with pure alexia must decode each letter in a serial, effortful manner. Research by Dundas, Plaut, and Behrmann (2014) has also shown that pure alexia can extend beyond word processing, producing subtle yet consistent deficits in face recognition. Despite the reading difficulties, other language abilities—such as writing, comprehension, and verbal expression—

typically remain intact, with only mild impairments in naming or word retrieval (Starrfelt & Woodhead, 2021). This condition is most commonly associated with damage to the posterior region of the left hemisphere, particularly the visual word form area (VWFA) within the occipitotemporal cortex, near the fusiform gyrus. This area plays a crucial role in rapid and automatic word recognition (Johnson & Raphail, 2016; Turkeltaub, 2015).

### ***2.1.2 Neglect alexia***

Neglect dyslexia, also known as neglect alexia, stems from attentional deficits, most often following damage to the right hemisphere or, in some cases, bilateral brain lesions. This condition is characterized by difficulty identifying the initial portion of words or letter strings, typically due to visuospatial errors in processing written language. It is frequently associated with neglect syndrome, where the individual fails to attend to stimuli on one side of space. Neurologically, it is most commonly linked to lesions in the right posterior parietal cortex, as well as the superior temporal and inferior frontal gyri (Chechlac et al., 2010; Ptak et al., 2016).

### ***2.1.3 Attentional Alexia***

Attentional dyslexia was first described by Shallice and Warrington (1977) as a reading disorder in which individuals can read single words accurately, but experience significant difficulty when words or letters are presented in the context of other surrounding text. A hallmark of this condition is the occurrence of "letter migration" errors, where letters from adjacent words or lines intrude into the target word (Saffran & Coslett, 1998). These context-dependent mistakes are believed to result from a deficit in the attentional filtering system, which typically functions to reduce interference from nearby visual stimuli (McNeil & Warrington, 1993).

The second superordinate classification of acquired alexia was described as aphasia related to reading impairment by Shallice and Warrington (1983), and they termed it central alexia. Central alexia was presumed to suggest impairment in reading abilities as a disconnection syndrome secondary to a disjunction between the visual input and higher-level linguistic sub-components processing (Schattka, 2010). Subsequently, there is impairment in the mechanisms involved in gaining access to visual word forms to meaning and/or speech production components. With this underpinning, Shallice and Warrington (1983) defined three types of central alexia (i) surface

dyslexia, (ii) deep dyslexia, and (iii) phonological dyslexia. Later in the 1980s, neuropsychologists suggested four types of alexia syndrome which may co-occur in association with aphasia in an individual, reported to have occurred due to differential breakdowns in the typical reading processes. These were categorized as phonological, deep, surface, and semantic alexia (Barry C, 1988; M. Coltheart. & J. C. Marshall, 1983).

#### ***2.1.4 Surface Alexia***

One of the earliest atypical reading patterns identified involved individuals reading irregular words as if they were regular, or substituting them with semantically related words. This specific reading impairment was termed surface alexia by *Marshall and Newcombe (1973a)*. A key characteristic of surface alexia is the accurate reading of regular words, coupled with the regularization of irregular words—for example, reading “*cut*” to rhyme with “*put*.”

Individuals with surface alexia typically read both regular words and nonwords (or pseudowords)—those that conform to the phonological rules of the language—with normal fluency and near-normal speed. As such, surface alexia reflects an over-reliance on sub-lexical, letter-to-sound decoding, indicating a breakdown in whole-word or lexical-level processing. This condition is thought to stem from a failure to access or retrieve the orthographic representations of familiar words.

In addition to difficulties with irregular word reading, individuals with surface alexia may also present with anomia (word-finding difficulties) and, in some cases, broader comprehension deficits (Karanth, 2003). Neurologically, surface alexia is commonly associated with lesions in the left hemisphere, particularly affecting the temporal lobe—including both anterior and posterior regions—with the severity of symptoms depending on the extent of the lesion (Ripamonti et al., 2014).

#### ***2.1.4 Deep Alexia***

As previously mentioned, Marshall and Newcombe (1973) were the first to provide a detailed account of deep alexia, identifying its hallmark feature as the presence of semantic errors during the reading aloud of single words presented in isolation and without time constraints.

Individuals with deep alexia often substitute a target word with a semantically related word that bears no phonological or orthographic similarity—for instance, reading "dog" as "cat."

In the 1980s, the condition was further explored by Coltheart, Patterson, and Marshall (1980, 1987), who characterized deep alexia as involving semantic paralexia—errors in which a word with a similar meaning is substituted for the intended word when reading aloud, such as "talk" being read as "speak." Beyond semantic substitutions, individuals with deep alexia demonstrate severe difficulty reading nonwords, as well as impaired reading of abstract, non-imageable, and function words, often making visual errors—e.g., reading "skate" as "scale." They may also substitute function words (e.g., reading "her" as "she") and make morphological errors, such as adding, omitting, or altering prefixes or suffixes (Coltheart et al., 1980; Coltheart & Marshall, 1983).

A notable pattern observed in deep dyslexia is the graded difficulty across word classes, with nouns being read more accurately than adjectives or adverbs, which in turn are read more accurately than verbs (Coslett & Turkeltaub, 2016).

From a neuroanatomical perspective, deep alexia has been identified as a unique acquired reading disorder resulting from extensive damage to the left hemisphere. In such cases, no component of the left hemisphere appears to support reading, leading researchers to propose that affected individuals may rely on a compensatory reading system in the right hemisphere (Coltheart et al., 1980; Coltheart & Marshall, 1983; Saffran et al., 1980).

Interestingly, research has also documented a developmental progression in the pattern of reading errors. Initially, individuals may exhibit semantic errors, which over time evolve into visual errors, followed by morphological errors. Eventually, reading impairment may become limited to nonwords, a condition referred to as phonological alexia (Karanth, 2003).

### ***2.1.5 Phonological alexia***

Phonological alexia was first described by Beauvois and Derouesne (1979) and is primarily characterized by a marked inability to read non-words, even those of low complexity. Although individuals with phonological alexia are not entirely accurate in reading real words, their performance on regular word reading is significantly better than on non-word reading tasks.

In recent years, phonological alexia has been conceptualized as part of a continuum with deep alexia, rather than a completely distinct condition (Crisp & Lambon Ralph, 2006; Friedman, 1996). Most of the clinical features observed in deep alexia also appear in phonological alexia, with one major exception: semantic paralexias (substituting a word with a semantically related one) are exclusive to deep alexia and are not observed in phonological alexia. This distinction has led researchers to view phonological alexia as a milder form of deep alexia within the same spectrum of acquired dyslexia.

Despite their shared symptoms, deep and phonological alexia are still considered distinct disorders. According to Coltheart (1980), deep alexia likely reflects the activation of a right hemisphere reading system following severe impairment of the left hemisphere, whereas phonological alexia is thought to stem from a partially functioning left hemisphere reading system with mild to moderate damage (Friedman, 1996).

Phonological alexia is believed to result from a selective disruption in the non-lexical reading route, specifically the orthography-to-phonology conversion process, while lexical reading pathways remain relatively intact. This impairment may manifest as difficulty in segmenting a string of letters into recognizable sub-units, assigning appropriate phonemes to these segments, and blending the phonemes into a correct pronunciation (Karanth, 2003).

Following detailed documentation of reading syndromes caused by acquired brain lesions, neurologists and neuropsychologists began exploring theoretical models to explain the cognitive mechanisms underlying reading. In the 19th century, Wernicke and Lichtheim pioneered the depiction of language processing areas in the brain using schematic "box-and-arrow" models, mapping out connections between different functional centers involved in language production and comprehension.

Building on these early frameworks, cognitive psychologists later integrated neurological models with information-processing theories, leading to the development of "computer models of the mind." These became known as neuro-computational models, which represent cognitive and neural processes involved in language and reading through flow charts or schematic diagrams, linking cognitive theory to neuroanatomical structures (Karanth, 2003).

## **2.2. Evolution of Neuro Computational Models of Reading.**

Building upon earlier neuropsychological studies, the approach of utilizing data from cognitive deficits to infer aspects of normal cognition led to the emergence of modern cognitive neuropsychology (Karanth, 2003). As a cognitive neuropsychologist, Coltheart (2000) emphasized that while neuropsychology focuses on the brain, cognitive neuropsychology pertains to the mind. He further elucidated that the human brain functions as an information-processing system, comprising both hardware architecture (neural structures) and functional architecture (cognitive modules and their interconnections). The functional architecture delineates how information is processed through various modules and pathways, and how these components interact during information transmission. Neurocomputational models aim to predict cognitive disorders as selective impairments within this functional architecture. These impairments can manifest as:

- Association of deficits: where multiple cognitive functions are impaired together, suggesting they share a common processing module.

- Dissociation of deficits: where one cognitive function is impaired while another remains intact, indicating that they are supported by separate modules.

- Double dissociation of deficits: where two cognitive functions are each impaired in different individuals, providing stronger evidence for their independence and support by distinct modules (Karanth, 2003).

This foundational framework has led to the development, critique, and refinement of numerous neurocomputational models aimed at explaining both typical and acquired atypical reading processes.

### **2.2.1. The Dual Route Model.**

In their seminal work, Marshall and Newcombe (1973b) identified and described three distinct subtypes of acquired dyslexia: surface dyslexia, deep dyslexia, and visual dyslexia. They explained these dyslexias within the framework of a "dual-route" model of normal reading. According to this model, reading can occur through two primary pathways:

1. Direct Route (Lexical Route): This pathway allows for the direct recognition of words and their meanings, facilitating the pronunciation of familiar words without the need for phonetic decoding.
2. Indirect Route (Non-Lexical Route): In this pathway, readers convert letters into sounds using grapheme-phoneme correspondences (GPC), enabling the pronunciation of unfamiliar or non-word letter strings.

These dual routes enable readers to process words efficiently, either by recognizing them directly or by decoding them phonetically.

In dual-route models, word pronunciations can be generated through two distinct mechanisms:

**Phonological System:** This system converts spelling to sound using grapheme-phoneme correspondences (GPC). It allows individuals to read words with regular pronunciations as well as pronounceable nonsense letter strings.

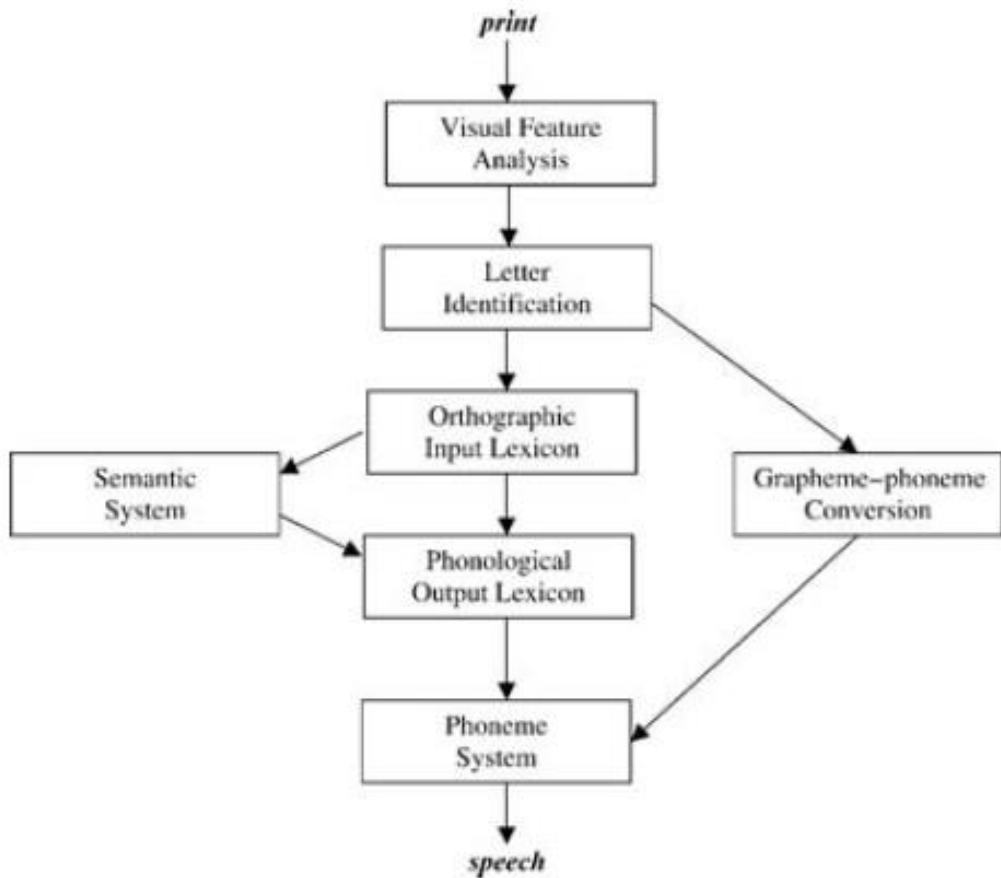
**Semantic System:** This system recognizes words and assigns them meanings. The specific pronunciation of a word can then be directly accessed from its meaning, enabling the reading of exception words that do not follow standard GPC rules.

These mechanisms work together to facilitate fluent reading, with the phonological system handling regular words and non-words, and the semantic system managing irregular or exception words.

The dual-route model has been instrumental in understanding various reading disorders. For instance, surface dyslexia are characterized by difficulty reading irregular words, as individuals rely on the phonological system and apply regular pronunciation rules, leading to errors like reading "colonel" as "Kollonel." Conversely, deep dyslexia involve semantic errors, where a word is substituted with another of similar meaning, such as reading "dog" as "cat." Visual dyslexia pertain to issues with visual processing, leading to errors in recognizing letters or words.

This model has been further developed and refined through computational approaches, such as the Dual-Route Cascaded (DRC) model, which simulates the reading process and has been used to model various dyslexic conditions. These models continue to provide valuable insights into the complexities of reading and the nature of reading disorders

Figure 2.1: Dual Route Model. Note from “Acquired dyslexias and the computational modelling of reading(Coltheart, 2006)”



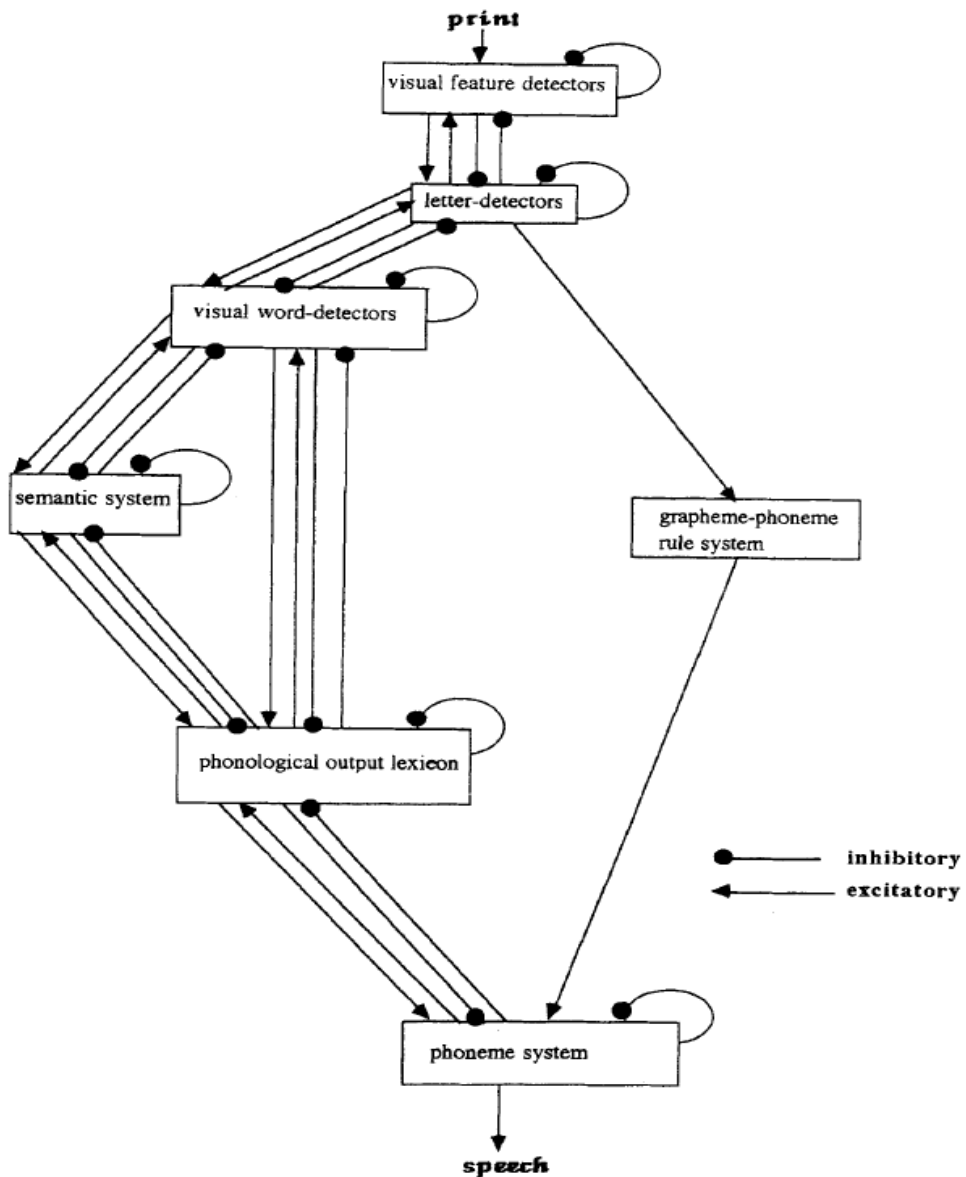
The credibility of functioning of these modules with respect to lesions in the human brain was skeptical to neuropsychologists. With continual critical analysis the neuropsychologists proposed a computational version of DRC model to validate the limitations of the dual route model.

### 2.2.2. Dual Route Cascaded Model.

The DRC model is essentially a computational adaptation of the Dual Route Model, featuring two separate routes (one of which is a lexical sub-route) and components for both orthographic and phonological lexicons proposed by (Coltheart et al., 2001)). In this model, the process begins with a visual analysis of the individual letters' components. Following this, the letter representations (letter names) are activated. The reading processing occurs in cascaded manner. Wherein, any form of activation begins to flow from initial modules and then transferred to the other

modules succeeding. The model holds two routes for transmission from print to verbal output (Figure 2.2). A lexical route, uses *word – specific knowledge*, and a non-lexical Grapheme- to Phoneme Conversion (GPC) route, that uses sub-lexical spelling sound correspondence rule. All the processing occurs parallel in step wise or cascaded manner. However, the processing in GPC route is not parallel, rather serial (Karanth, 2003; Shanbal, 2009). According to Coltheart and his colleagues, this model not only successfully simulates acquired dyslexias but also explains a wide variety of experimental results, including lexical decision tasks, reading aloud, and priming in normal subjects, to a far greater extent than any other model.

*Figure 2.2: Dual Route Cascaded Model. Note from “Models of reading Aloud: Dual Route and Parallel Distributed Processing Approaches (Coltheart et al., 1993)”*



Types of Alexia explained through Dual Route Models: Models of reading must explain the different subtypes of acquired dyslexia. In the dual-route model, surface dyslexics were believed to have damage or disconnection to the semantic route, causing them to read solely through the phonological route (Behrmann & Bub, 1992; McCarthy & Warrington, 1986). In contrast, deep dyslexics were thought to read exclusively via the semantic route due to damage to the phonological route. The errors produced by these patients were seen as a result of the impaired operation of the phonological route, hence they had access only to the semantic route. The third type of dyslexia, visual dyslexia, was believed to involve damage to visual processes that affect both of these routes.

Castles & Coltheart (1993), extended their work to explain the phonological acquired alexia. Phonological dyslexia occurs with a disruption in the sub-lexical pathway. Individuals with this condition struggle to decode unfamiliar words because they rely on decoding processes rather than recognizing words stored in their sight vocabulary.

Shortcomings of Dual Route Model: The dual-route models have offered broad ideas about how their component modules function and interact. Typically, these predictions have been based merely on general concepts of how the different modules would operate and interact in both normal and atypical conditions.

In support of this, (Coltheart, 2006), in his review publication on the models of reading has opined a few shortcomings of this model. Simulating acquired surface alexia and acquired phonological alexia by lesioning the dual-route model is almost very simplistic. Deleting the grapheme-phoneme conversion system would result in 0% non-word reading accuracy while leaving both regular and irregular word reading at 100% accuracy, which represents extreme phonological dyslexia.

On the other hand, appropriately damaging the lexical route after the letter identification stage, such as deleting the orthographic input lexicon would cause 0% irregular word reading accuracy, while leaving non-word reading and regular word reading 100% accurate, which represents extreme surface dyslexia.

Such extreme dissociations are rare, as observed in studies of acquired dyslexia (Coltheart, 2006). Hence, there were two major concerns of the model, first- What happens when there is partial

impairment in irregular or non-word reading, and second - Is 100% dissociation in specific pathways ideally possible in individuals with brain injury? Critics have argued that while these types of predictions may be adequate for capturing the general features of normal and impaired cognitive functioning, however, they become less reliable. Thus, neuropsychologists continued their attempts to explain the reading process in terms of distributed neural networks concerning cognitive skills rather than functional dual-route models.

### ***2.2.3. Connectionist Model- Parallel Distributed Model of Language and Reading.***

Connectionist models, grounded in parallel distributed processing (PDP) and neural network frameworks, offer an alternative to modular dual-route models in explaining cognitive processes involved in reading. Unlike traditional models that treat language and reading processes as separate entities, connectionist models conceptualize them as interconnected systems. This perspective is particularly significant considering that acquired reading disorders often co-occur with language impairments, such as aphasia.

For instance, spoken language models, like those proposed by Dell et al. (1997), typically do not account for orthographic abilities. Conversely, traditional written language models, including dual-route models like those by Coltheart et al. (2001), often overlook the impact of spoken language abilities on reading and spelling. Connectionist models bridge this gap by integrating both spoken and written language processes, providing a more comprehensive understanding of reading and its associated disorders.

These models simulate cognitive processes through networks of interconnected, neuron-like units, where behavior emerges from the interaction of these units. This approach has proven effective in modeling various reading disorders, offering insights into the underlying mechanisms of acquired dyslexia and highlighting the importance of considering both language modalities in understanding reading impairments.

Contrary to the view of distinct spoken and reading systems, a parallel-distributed processing (PDP) connectionist model of single-word processing (Plaut, 1996; Seidenberg & McClelland, 1989) promotes the view that spoken and word reading processing involves synchronized activation of

semantic, phonologic, and orthographic units, with word knowledge existing as a learned pattern of neural activity that resides in the connections between these distributed language units.

The Connectionist Triangle Model of reading, developed by Seidenberg and McClelland (1989), posits that word processing emerges from the simultaneous interaction of semantic, phonological, and orthographic information, forming a learned activation pattern. Unlike traditional models that rely on discrete lexicons or grapheme-phoneme rule systems, this model emphasizes the interconnectedness of these linguistic components. The model comprises three interconnected pathways:

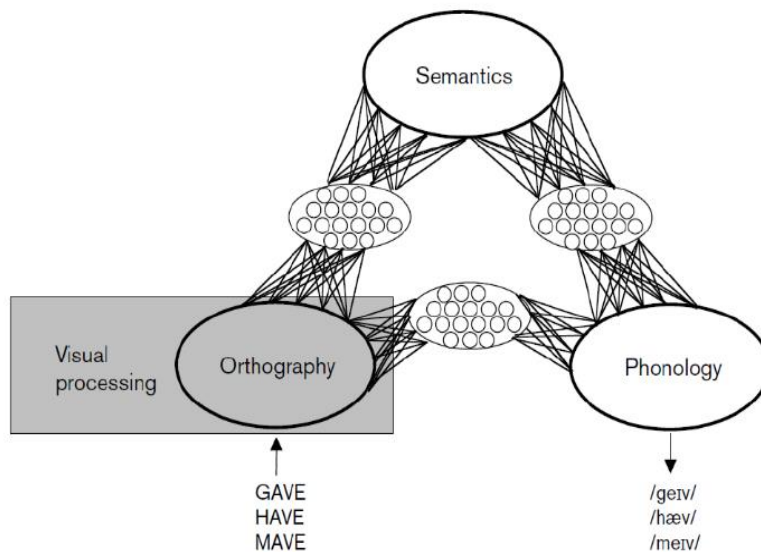
- Orthography to Phonology ( $O \rightarrow P$ ): Direct mapping from visual word forms to their corresponding sounds.
- Orthography to Semantics ( $O \rightarrow S$ ): Mapping from visual word forms to meanings.
- Semantics to Phonology ( $S \rightarrow P$ ): Mapping from meanings to corresponding sounds.

These pathways collectively support language processing, with each contributing differently depending on the nature of the reading task. For instance, when reading irregularly spelled words (e.g., "chef"), the semantic pathway plays a more significant role. In contrast, when reading unfamiliar or non-words (e.g., "kloot"), the phonological pathway becomes more critical. This model operates on a division of labor, where certain linguistic units exert more influence on the final activation pattern based on the specific language task or stimulus. This approach aligns with the understanding that acquired reading disorders often co-occur with language impairments, such as aphasia, highlighting the importance of considering both spoken and written language processes in tandem.

Based on this connectionist version of language processing, the primary systems hypothesis (PSH) emerged and proclaims that three connected primary neural systems (visual, semantic, phonologic; see Figure 2.3) interact to collectively contribute to the reading of all words. Most importantly, it suggests that disruption to one or more of these modality-independent primary systems is responsible for reading impairment (Lambon Ralph & Patterson, 2005; Patterson & Ralph, 1999; Woollams, 2014). The PSH assumes that later-acquired reading abilities develop from and

rely on the same cognitive mechanisms that support earlier-acquired spoken language abilities. Therefore, significant relationships between spoken and reading impairments are expected (Woollams, 2014).

Figure 2.3. Schematic of primary systems/connectionist language framework. Note: From “Selective disorders of reading?” by (Patterson & Ralph, 1999), *Current Opinion in Neurobiology*, 9, p. 235.



2.2.2.a. Reading Patterns Explained through Primary System Hypothesis Model: In the context of the PSH, (Crisp & Lambon Ralph, 2006) depicted the expected relationships between impaired oral reading of content words and semantic and phonologic impairment. As illustrated in Figure 2.4, an individual’s reading ability (or inability) reflects the status of his or her primary language systems.

*Surface alexia* is characterized by difficulty reading irregularly spelled words, coupled with relatively intact reading of regular words—a phenomenon known as the regularity effect. This condition is thought to arise from underlying semantic impairments, which affect the ability to access word meanings directly from their orthographic representations. Consequently, individuals with surface alexia often rely on phonological decoding strategies, leading to over-regularization errors where irregular words are pronounced according to standard spelling-to-sound rules (e.g., pronouncing "pint" as "paint").

This perspective challenges the traditional dual-route model of reading, which posits that surface alexia results from a specific impairment to the lexical reading route. Instead, it suggests that the condition stems from a disruption in the semantic system, affecting the ability to map orthographic forms to their meanings, thereby impairing the reading of irregular words.

*Phonological alexia* is characterized by a significant difficulty in reading nonwords compared to real words—a phenomenon known as the lexicality effect. This condition is believed to result from substantial impairments in phonological processing. Crisp and Lambon Ralph (2006) suggest that this impairment affects both the segmentation and manipulation of sounds, as well as the conversion between graphemes and phonemes.

This perspective contrasts with Coltheart and colleagues' dual-route model, which attributes phonological alexia to damage in the indirect, sublexical reading route and a selectively impaired grapheme-to-phoneme rule system. Individuals with phonological alexia often read familiar words correctly, though performance can be influenced by factors such as word class and imageability. Content words (e.g., "inn," "bee") are typically read more accurately than grammatical function words (e.g., "in," "be"). Similarly, concrete words (e.g., "tart") are read more successfully than abstract words (e.g., "tact").

In contrast, unfamiliar letter strings or nonwords pose significant challenges; patients may produce no response or substitute a real word that is orthographically or phonologically similar. For example, reading the nonword "/dake/" might result in "cake" or "date." These patterns underscore the complex interplay between lexical and sublexical processes in reading and highlight the nuanced nature of reading impairments associated with phonological alexia.

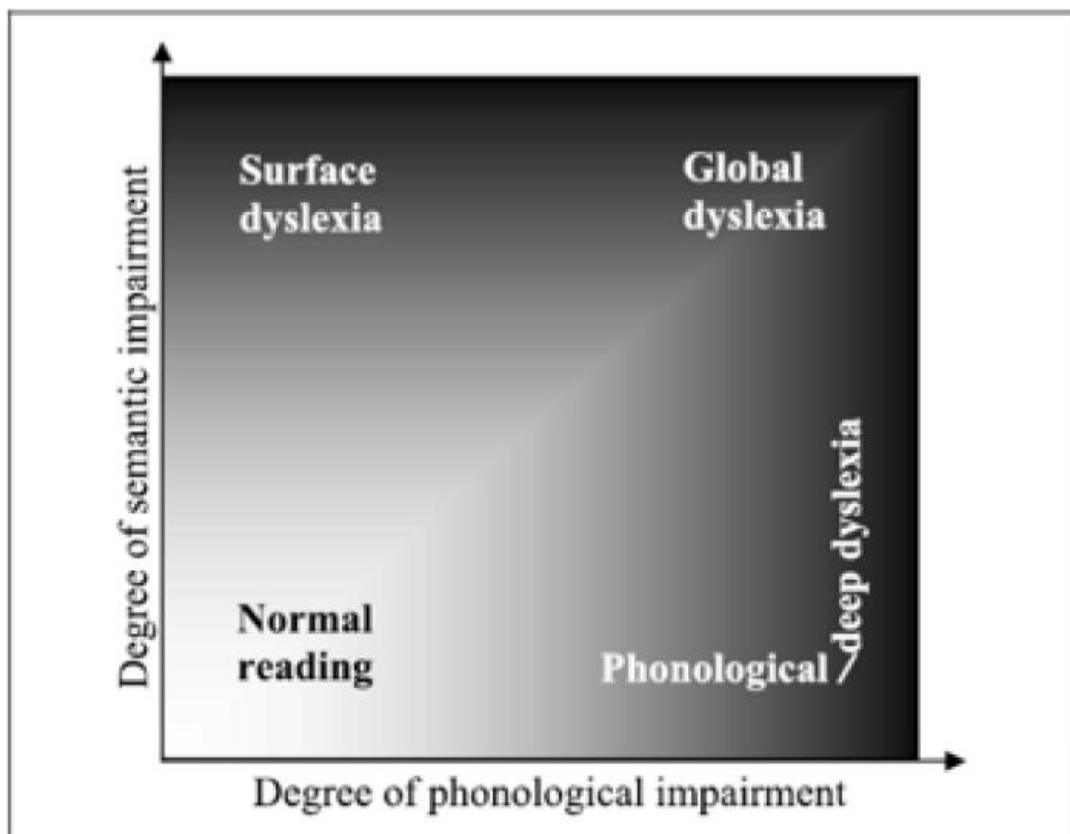
*Deep alexia* is often considered a severe manifestation of phonological alexia, distinguished by significant semantic impairment in addition to profound phonological deficits. This perspective, proposed by Crisp and Lambon Ralph (2006), contrasts with the traditional view that attributes deep alexia to damage in both lexical and sublexical reading routes. The continuum hypothesis suggests that deep alexia represents an extreme form of phonological alexia, with recovery from deep to phonological alexia observed in some cases, indicating shared underlying deficits mediated by common neurological systems.

*Global alexia* is characterized by a complete loss of reading ability, typically associated with severe impairments in both semantic and phonological processing. This condition is thought to result from extensive damage to the neural substrates responsible for reading, leading to a total inability to comprehend written language.

The Primary System Hypothesis (PSH) posits that pure alexia, a form of peripheral alexia, arises from an impaired ability to process visually complex stimuli, rather than from a selective disorder of slow and labored visual analysis of letters. This view suggests that pure alexia results from disruptions in the visual processing pathways that connect written stimuli to the brain's language centers, rather than from deficits in the cognitive processes involved in reading.

*Figure 2.4.*

Proposed relationships between degree of reading impairment (alexia type) and degree of phonological and semantic impairment.



*Note: From “Unlocking the nature of the phonological-deep dyslexia continuum: The keys to reading aloud are in phonology and semantics” by (Crisp & Lambon Ralph, 2006).*

### **Individual's reading abilities reflect their functioning of primary language systems**

<b>Normal Reading</b>	—————>	Intact Semantics and Phonological processing
<b>Surface Alexia</b>	—————>	Intact phonological processing; impaired semantics (characterized by poor irregular)
<b>Deep Alexia</b>	—————>	Severe form of phonological Alexia with mild semantic processing being affected.
<b>Global Alexia</b>	—————>	Severe impairment of both semantic and phonology

Empirical support for the PSH and PDP theory, jointly referred to as the “triangle model/primary systems hypothesis” by Crisp and Lambon Ralph (2006, p. 358), comes not only from acquired alexia but also from behavioral work in developmental dyslexia, as well as neuroimaging findings.

Neuroimaging research demonstrates that reading engages a network of distributed neural regions responsible for various processing aspects. Brunswick (2010) outlines that the functional neuroanatomy of reading encompasses areas associated with visual, semantic, and phonological processing. Orthographic processing relies on neurons in the left posterior occipitotemporal sulcus, also known as the visual word form area (VWFA), which are thought to have evolved from regions initially dedicated to other visual functions (Dehaene et al., 2005). This visual processing interacts with both anterior regions, such as the left inferior frontal cortex, and posterior regions, including the left supramarginal gyrus and anterior inferior parietal cortex, to facilitate skilled reading (Brunswick, 2010; Keulen, 2014).

These findings support the Primary System Hypothesis (PSH), which posits that reading "parasitizes" pre-existing cortical systems, utilizing an interaction between visual and language areas that also serve other cognitive functions (Woollams, 2014).

From the aforementioned theories, we may understand that in acquired brain insult conditions, spoken language and reading both function in parallel or association with each other. Surprisingly, the relationship co-occurring between spoken and reading abilities in aphasia has

received little attention. Now we know the fact that a better understanding of this relationship may enhance our understanding of language processing and improve aphasia rehabilitation.

### **2.3. Alexia in Aphasia.**

Reading difficulties associated with aphasia may align with previously described alexia syndromes; however, no consistent correlation between specific aphasia types and alexia syndromes has been identified. In many instances, alexia in aphasia involves impairments at multiple levels and is referred to as ‘mixed alexia’ or ‘aphasic alexia’. In other cases, such as the previously mentioned non-proficient reader, individuals with aphasia may experience varying degrees of difficulty with the grapheme-to-phoneme conversion process. Aphasic individuals may lose the ability to quickly decode the phonological and visual elements of words, hindering their capacity to read for comprehension (Reiff Cherney, 2004). This explains why many aphasic individuals who can read words and sentences successfully still face delays and comprehension challenges when reading longer texts.

#### ***2.3.1. Reading comprehension in Acquired reading impairment***

Just as oral reading is impaired in acquired alexia secondary to stroke, reading comprehension also shares its role in the deficits, although the severity and pattern of deficit may vary among them. Alike oral reading and reading fluency deficits, reading comprehension is a common feature noted in individuals with aphasia (Kelly et al., 2015). Reading comprehension in individuals with aphasia has been evaluated at the word, sentence, and paragraph levels. However, there is limited understanding of the relationships between these levels and how lexical and syntactic challenges affect every day reading (Webster et al., 2022). Text or discourse comprehension, which involves understanding multiple sentences, requires both lexical recognition and comprehension as well as the processing of sentence syntax. Discourse comprehension entails a complex interplay between linguistic abilities and other cognitive processes, such as working memory, attention, and executive function (Chesneau & Ska, 2015).

Many researchers explored the relationship between single-word and/or sentence comprehension and discourse comprehension in both spoken and written contexts. These studies employed various tasks and typically included small participant samples. In their investigations of

spoken comprehension (Brookshire & Nicholas, 1984; Wegner et al., 1984), no clear connection was found between sentence-level and discourse-level comprehension. Notably, performance on a syntactic comprehension assessment (a shortened version of the Token Test, (SPREEN, 1977) did not significantly correlate with accuracy on different paragraph comprehension tasks. Brookshire and Nicholas (1984) also found no significant correlation between the auditory comprehension subtests of the Boston Diagnostic Aphasia Examination (BDAE, Goodglass & Kaplan, 1983) and correct responses on paragraph comprehension tasks. The BDAE subtests assess comprehension at the word and sentence levels.

Webb & Love (1983) evaluated single-word comprehension (picture-to-word matching), sentence comprehension (error detection), and paragraph comprehension in 35 participants. The assessments of oral reading, letter, and word recognition were also conducted. Sentence comprehension emerged as the most challenging task for participants. Factor analysis identified two factors: general reading ability and silent reading skill, suggesting a connection among the comprehension measures. Additionally, a strong relationship was found between reading ability and the overall severity of language impairment, as measured by the Porch Index of Communicative Ability (PICA, Porch, 1967).

Meteyard et al., (2015) conducted an in-depth study involving four participants, examining their performance across various written tasks, including word, sentence, and discourse comprehension, as well as assessments of working memory and metacognitive abilities. The findings revealed certain dissociations in performance across different linguistic levels. Three out of four participants showed intact word comprehension skills, but they manifested difficulty in written sentence comprehension tasks. They concluded by suggesting a significant relationship between linguistic tasks and reading comprehension across word, sentence, and paragraph levels, and expressed the need to conduct large-scale studies considering the personal feelings about reading tasks among PWAs as well.

Following this, Webster et al., (2022) studied 74 adults with aphasia who reported difficulties in reading. All participants were assessed with the Comprehensive Assessment of Reading in Aphasia (CARA). They analyzed the relationship between reading comprehension of

words, sentences, and paragraphs with their feelings about reading. A significant positive correlation was noted between them and the study concluded by stating the importance of inspecting both reading tasks and agreeing to goals based on their feelings.

Peach (1988) investigated sentence comprehension in individuals with anomic and conduction aphasia using picture-pointing tasks for both auditory and reading comprehension. Their findings showed that both groups demonstrated improved performance on comprehension tasks. Additionally, they observed a moderate correlation between auditory and visual modalities in the anomic group, while a strong correlation was noted in the conduction aphasia group, suggesting a robust relationship between auditory and reading comprehension. Research on reading comprehension in aphasia has also highlighted the impact of contextual factors, such as preceding and following sentence components.

Ravi & Chengappa (2014) explored sentence reading comprehension in Kannada-English bilingual individuals through accuracy and reaction time measures. Twenty adults with aphasia were subjected to sentence judgment tasks with silent reading across three types of sentences. Authors found significant impairment in written sentence comprehension abilities in both Kannada and English languages, however significantly reading comprehension abilities were noted to be better in Kannada compared to English. The deficits in sentence reading comprehension in both languages were attributed to impairment at central linguistic processing caused due to CVA. They stated that sentence comprehension in reading is multifaceted requiring quick and precise access to the lexical system. Which in turn, enhances the activation for retrieval and comprehension of written sentences subserved by semantics, syntactic, and orthographic information. It is believed that the rate of lexical activation and precision of lexical knowledge may affect written sentence comprehension in PWAs (DeDe, 2013; Ravi & Chengappa, 2014).

The co-occurrence of alexia and aphasia is now widely recognized. Although there can be a dissociation between written and spoken language abilities (Howard & Nickels, 2005), a majority of individuals with left hemisphere stroke-induced aphasia present with alexia (Brookshire et al., 2014; Keulen, 2014; Webb & Love, 1983). The next concern arises to what extent reading impairments co-exist in different variants of aphasia.

### ***2.3.2. Acquired reading impairment in different types of aphasia***

In individuals with Broca's aphasia, oral reading is effortful and non-fluent. Reading aloud is poor, with their reading comprehension being similar to auditory comprehension. Most patients with Broca's aphasia have great difficulty (often total failure) in reading aloud. Reading comprehension is considerably better than reading aloud but most persons with Broca's aphasia find reading difficult and avoid it (Benson, as cited in Benson & Ardila, 1996). Sparse and effortful writing is seen with the omission of grammatical elements (agrammatic writing) in them. The written material contains multiple misspellings and the omission of letters. Individual letter formation will be clumsy, oversized, and poor. Because most persons with Broca's aphasia have concomitant hemiplegia, they are required to use their left hand for writing. These persons are better able to copy written material than they can write either on oral command or dictation (Hegde, 2022).

In individuals with transcortical motor aphasia (TMA), reading aloud and reading comprehension are better preserved than either speaking skills or writing skills. In persons with transcortical motor aphasia – type I, both oral reading and reading comprehension are always better than their writing, just as spoken language comprehension is better than expression of spoken language. Reading aloud tends to be slow and difficult to maintain, but reading comprehension is at a normal level except for syntactically complex material (Benson & Ardila, 1996). In persons with transcortical motor aphasia- type II, reading aloud may be near- normal but reading comprehension is usually limited to matching of object to picture.

In persons with global aphasia, reading, and writing deficits are parallel to their severe language deficits. Most persons with Wernicke's aphasia may not recognize sounds associated with written words. They may fail to understand the meaning of printed words. They may not match or recognize the alphabet. They can write easily and effortlessly with well-formed letters. They write neologistically with incorrect combinations or omissions of letters. The written samples contain normal phrase and sentence lengths with word substitutions (paraphasic writing) (Benson & Ardila, 1996). Persons with transcortical sensory aphasia can read aloud normally, with word substitutions. The comprehension of the reading material, however, may be extremely limited or absent. They have relatively preserved oral reading skills.

Persons with conduction aphasia, have difficulty reading aloud. Their oral reading may be filled with paraphasia, and they may simply fail to read short printed material. Nonetheless, they can silently read and comprehend long and complex material as a novel or a scientific book. Persons with anomic aphasia present with normal or near-normal oral reading and writing skills (Hegde, 2022).

Thus, the types of reading impairments are highly variant among different types of aphasia. Identification of impaired components of reading and writing is a crucial factor in remediating these difficulties. The main types of dyslexia noted in aphasia are phonological dyslexia, surface dyslexia, and deep dyslexia. Dyslexia classification in aphasia is arbitrary and is “not informative concerning the nature of damage that underlies the reading disorder” (Hillis & Caramazza, 1992). There is no fixed relationship between dyslexia classification and diagnostic categories of aphasia. Different types of aphasia can have the same reading impairment, and one type of aphasia such as Broca’s aphasia can have different types of reading impairment (Hillis & Caramazza, 1992).

Besides the manifestation of varied reading patterns in different types of aphasia, there are yet many more factors contributing to the extent of reading impairment in persons with aphasia. One of the prime factors apart from the pathophysiology of brain insult is the orthographic maps of the individuals’ language, which is crucial. Especially, in a diverse country like India, the country is abundant with a wide range of rich scripts and a multitude of languages spoken across the country. Hence, investigating acquired reading impairments specific to the orthography of the individual’s native language is the prime need.

#### **2.4. Orthography effects in Acquired Reading Impairment.**

It is known that the spoken language is acquired essentially by all people, literacy skills have to be learned and not everyone learns to read. Learning to read can be a lengthy process, but once mastered, it often becomes a highly automatic skill. In proficient readers, decoding written words occurs remarkably fast within milliseconds. Research has shown that learning to read initially increases activity in certain brain networks, but as reading proficiency improves, activation in

regions like the left temporal-occipital area tends to decrease. This suggests that as reading becomes more efficient, the brain requires less effort to perform the task (Cao, 2016).

Not every language own native writing systems, and those that do, exhibit significant variation in how their orthography maps visual symbols (graphemes) to linguistic elements. These variations manifest in multiple dimensions: the directionality of reading (e.g., left-to-right vs. right-to-left), the size of the phonological unit represented by each grapheme (e.g., phonemes vs. syllables), and the transparency or regularity of the relationship between written and spoken forms.

In languages with transparent orthographies, such as Finnish and Spanish, graphemes consistently correspond to a single phoneme, facilitating straightforward decoding. In contrast, languages like English and French have opaque orthographies, where grapheme-to-phoneme mappings are more complex—individual graphemes may correspond to multiple phonemes, and a single phoneme can be represented by various graphemes or grapheme combinations. While Finnish, Spanish, English, and French employ alphabetic orthographies that map graphemes onto phonemes, Chinese exemplifies a logographic system, where graphemes correspond to syllables or entire words (Madden, 2016). With these variabilities, there is yet another major concern concerning individuals who are bilinguals or descriptors (who have learned two scripts). Multiple studies were performed to understand the distinctions in learning to read two languages.

Bilingual individuals must acquire reading skills separately for each of their languages, particularly when the languages utilize distinct orthographic systems. However, certain aspects of reading in a second language (L2) can transfer from the first language (L1), facilitating the learning process (e.g., Geva & Wiener, 2014). Two primary mechanisms have been proposed to explain how the brain adapts to reading in an L2. According to the *assimilation hypothesis*, the neuronal networks involved in reading L1 are repurposed to process L2. That is, the neuronal networks initially developed for reading in the first language (L1) are adapted or reused to perform a similar function (reading in this instance) in the second language (L2). Rather than forming entirely new networks, the brain modifies existing ones to accommodate the new language. In contrast, the *accommodation hypothesis* suggests that new neural networks are recruited to manage L2 reading (Perfetti et al., 2007).

The extent to which these mechanisms operate depends largely on the orthographic differences between L1 and L2. When transitioning from a transparent L1 orthography to a more opaque L2 orthography, additional neural resources may be required, whereas the reverse transition—from opaque to transparent demands less neural adaptation (Goral, 2019; Liu & Cao, 2016; Tan et al., 2003). While the brain regions activated during L2 reading generally overlap with those engaged during L1 reading, notable differences in activation patterns have been observed, particularly among skilled bicultural readers (Goral, 2019). With the fundamental understanding of processes occurring in typical bilingual processes to read, researchers have performed seminal works to observe how acquired reading impairment manifests among bilingual individuals.

The literature on acquired alexia in bilingual individuals primarily emphasized single-case studies, often examining how different types of alexia manifest across various orthographic systems. A review of this literature highlights two key areas of debate: the first concerns the extent to which the characteristics of a language's orthography influence the nature of the reading impairment, while the second focuses on how differences between orthographies affect the neural networks involved in reading. While most studies offer insights that help clarify the first issue, relatively few directly investigate the neural implications central to the reading.

#### ***2.4.1. Is the reading process in acquired reading impairment determined by the nature of orthography across languages in bilingual individuals?***

Languages with transparent orthographies, characterized by a direct one-to-one correspondence between graphemes and phonemes, predominantly utilize the Grapheme-Phoneme Correspondence (GPC) or non-lexical route for reading. In contrast, languages with opaque orthographies, such as English, which feature complex and irregular grapheme-phoneme relationships, rely more heavily on the direct (lexical or semantic lexical) route from visual form to word meaning, minimizing the use of GPC. This distinction is not absolute; evidence indicates that reading both transparent and opaque orthographies engages brain regions involved in phonological processing. For instance, reading in transparent languages like Spanish tends to activate the left superior temporal gyrus (L-STG) in the dorsal pathway, emphasizing phonological processing.

Conversely, reading opaque languages like English activates regions such as the left inferior frontal gyrus (L-IFG) and left inferior temporal gyrus (L-ITG) in the ventral pathway, highlighting lexical processing. These findings suggest that while reading strategies may differ between transparent and opaque orthographies, there is overlap in the neural mechanisms engaged, reflecting a complex interplay between phonological and lexical processing systems.

In transparent orthographies, where there is a direct and consistent correspondence between graphemes and phonemes, skilled readers often rely on the non-lexical route, utilizing grapheme-to-phoneme conversion (GPC) (Coltheart, 2006). In contrast, opaque orthographies, such as English, with their complex and irregular grapheme-phoneme relationships, tend to favor the lexical route, accessing word meanings directly from visual forms. This divergence suggests that certain alexia subtypes identified in English may be less prevalent in languages with transparent orthographies. For example, deep alexia, characterized by semantic errors and reliance on the lexical route, is less common among readers of transparent languages like Welsh, where the sublexical process is sufficient for reading. Similarly, surface alexia, marked by difficulties with irregular words and dependence on GPC, may be less frequent in languages that depend less on GPC, as this route can lead to frequent errors. However, it's important to note that these distinctions are not absolute, and variations can occur based on individual reading experiences and language-specific factors.

While cross-linguistic (cross-sectional) comparisons can be used to test these predictions, the most effective way to confirm or challenge the assumption that orthographic type influences the manifestation of reading impairments is to study acquired reading deficits in bilingual and biscriptal individuals (Weekes, 2005). Evidence for this comes from observed dissociations in the reading impairments of bilinguals who read both a language with an opaque orthography (e.g., English, French) and one with a transparent orthography (e.g., Indian languages).

Ohno et al., (2002) reported a case of a Japanese-English bilingual man diagnosed with pure alexia (alexia without agraphia) following a left posterior cerebral artery (PCA) stroke, which caused damage to the fusiform gyrus and corpus callosum. Thirty days post-stroke, assessments revealed that, despite intact language and writing abilities, he exhibited severe reading difficulties. He relied on letter-by-letter reading and was unable to read Japanese in either kana (a syllabic script-

Transparent script) or kanji (a logographic script using Chinese characters- Opaque script). Interestingly, his impairment was most pronounced in kana, followed by kanji, with English reading being only mildly affected. The orthographic differences between English and Japanese likely contributed to this variation. Interestingly, they found that kana (the most transparent script) showed the greatest impairment. Additionally, the participant's late acquisition of English (he began learning in late childhood after middle school) may explain the differential impact on his reading abilities between English and Japanese.

The authors (Ohno et al., 2002) also referenced an earlier study by (Lyman et al., 1938), where a bilingual with acquired reading impairment demonstrated less difficulty reading Chinese compared to English. Similarly, Hashimoto & Uno, (2016) documented a case of a Japanese speaker who experienced a left temporal-parietal-occipital infarct, resulting in mild anomia and significant reading difficulties. Despite intact visual perception, the individual struggled with lexical decisions in both kana and kanji, as well as reading high-frequency real words and non-words. Notably, this individual also experienced impaired writing, with greater difficulty in kanji than in kana, highlighting a dissociation between the two orthographic systems.

Senaha & Parente (2012) reported that a Portuguese-Japanese bilingual (triscriptal) speaker, who sustained a traumatic brain injury in the left frontotemporal region, exhibited greater difficulty reading irregular Portuguese words and Japanese kanji compared to regular Portuguese words and Japanese kana. His reading performance aligned with surface alexia in Portuguese, characterized by an overreliance on the non-lexical route, leading the authors to interpret the findings as a selective impairment of the lexical reading route.

A similar pattern was observed by Meguro et al., (2003) in four Japanese-Portuguese individuals with dementia. These individuals consistently showed greater difficulty reading kanji and irregular Portuguese words, while their ability to read kana and regular words remained relatively preserved, further supporting the distinction between lexical and non-lexical reading processes.

The findings from Senaha and Parente (2012), as well as Meguro et al., (2003), support the idea that impaired reading performance following acquired brain injury results from a similar

underlying deficit across all languages, manifesting varied characteristics depending on the orthographic-specific system of each language. Studying an individual who is bilingual and uses three distinct writing systems provides a valuable opportunity to distinguish the effects of the orthographic system of their respective language. Differences in reading impairments between two languages in a bilingual could be influenced by factors such as proficiency, age of acquisition, or linguistic experience. The differences in impairments across two orthographic systems within the same language (e.g., Japanese) can only be attributed to the distinct features of each script (Goral, 2019).

Béland and Mimouni (2001) diagnosed deep alexia in both languages of an Arabic–French bilingual man and observed marked differences in his reading abilities across the two languages. The participant, a Lebanese native speaker of Arabic (L1), began learning French (L2) at the age of four and received formal education in both languages. Arabic is written right to left, with letters that are connected and change shape depending on their position in a word (initial, medial, or final). When written without diacritics—as is common in everyday use—Arabic becomes more opaque due to the presence of numerous homographs. However, the inclusion of diacritics, typically used by beginners or in formal texts, increases its transparency. In contrast, French, an alphabetic language with inconsistent grapheme-to-phoneme correspondence, is considered orthographically opaque.

Following a left-hemisphere cerebrovascular accident affecting the perisylvian region, the participant developed aphasia, apraxia, and alexia, with semantic reading errors present in both languages. Interestingly, he made more errors when reading in Arabic (his L1) than in French (L2). Reading aloud at the letter, syllable, and word levels indicated impairments in both lexical and sublexical processing, though performance was better for closed-class words than open-class words. Semantic errors occurred at similar rates in both forms of Arabic orthography—whether with or without diacritics—and also extended to naming and repetition tasks.

Lexical decision tasks involving cross-language phonological priming showed differential effects between the two languages, which are neither visually nor orthographically similar. No priming effect was observed when Arabic non-words were used as primes and French words as targets. In contrast, a significant priming effect emerged in the reverse condition—French non-word

primes and Arabic word targets. Additionally, the patient frequently made translation errors, often responding with the French equivalent of an Arabic word, although such errors were less common in the opposite direction.

A similar dissociation was observed by Ibrahim (2009) in a native Arabic speaker who began learning Hebrew at the age of nine and eventually became highly proficient in both the spoken and written forms of both languages. Although Arabic and Hebrew share orthographic similarities—such as high opacity and the presence of homographs and variable grapheme shapes when written without diacritics—Arabic is generally considered more complex, featuring a larger set of graphemes that change form depending on their position within a word. After experiencing a cerebral hemorrhage, the patient showed greater difficulty reading Hebrew than Arabic. While this disparity may partly reflect the fact that Hebrew was his second language (L2), the author also attributed it to orthography-specific factors. Due to his alexia, the patient relied on a letter-by-letter reading approach, which proved less efficient in Hebrew than in Arabic.

Karanth (2003) reported on a Hindi–English bilingual individual who developed acquired alexia following a head injury that resulted in a left temporoparietal fracture and hemorrhage. The alexia was classified as central, as it was accompanied by aphasia. The participant was highly proficient in Hindi, his first language (L1), which is written in a transparent syllabic orthography with minimal irregularities. He was also proficient in English, his second language (L2), which has a more opaque orthography. Interestingly, after the injury, he exhibited greater difficulty reading Hindi and opted to undergo therapy in English. His English reading pattern was consistent with deep alexia—marked by semantic errors, an inability to read letter-by-letter, and no clear distinction between regular and irregular word reading. In contrast, his reading in Hindi showed no semantic errors and was more consistent with features of pure alexia.

These findings echoed a similar case reported earlier (Karanth, 1981). The author suggested that reading in Hindi, a language with a highly transparent orthography, more likely depends on the sub-lexical grapheme-to-phoneme conversion (GPC) route and less on the lexical route. Whereas, reading in English relies on both routes. This difference in reliance explains why the reading

impairments manifested differently across the two languages, aligning with predictions about how alexia presents in languages with distinct orthographic systems.

Dissociations in reading errors between the two languages of bilinguals have been documented in various studies across language pairs with varying degrees of orthographic similarity. For example, similar patterns have been observed in Spanish-English bilinguals (Masterson et al., 1985), Turkish-English bilinguals (Raman & Weekes, 2005), and Chinese-Mongolian bilinguals (Weekes, 2005). In the Weekes et al. study, three out of eight bilinguals with Mongolian as their first language (L1) and Chinese as an early-learned L2 demonstrated differential performance on one or more reading tasks. In some cases, Chinese (L2) showed greater impairment than Mongolian (L1), which the authors attributed to the lower proficiency of the second language before the lesion and its greater susceptibility to post-stroke impairment. This observation aligns with Green's model of language inhibition (Green, 2009), which suggests that L2 may be more inhibited after a stroke, leading to greater impairment. However, the differential reading difficulties may also be influenced by the distinct orthographic properties of the two languages, with Mongolian being an alphabetic script and Chinese a logographic (pictographic) one.

In contrast to previously discussed cases showing cross-linguistic dissociations, several case studies have reported bilingual individuals who displayed similar reading impairments across both languages, despite notable differences in orthography—and whose patterns of impairment did not conform to theoretical expectations. For example, Ratnavalli et al. (2000) examined two highly proficient bilinguals in Kannada and English, each diagnosed with a different form of alexia but exhibiting comparable deficits in both languages. The first participant, who had suffered a left occipital infarct extending into the corpus callosum, presented with alexia without agraphia, anomia, and impaired word recognition, although other language functions were preserved. His reading ability was equally compromised in both Kannada and English, with severe letter-by-letter reading evident across both scripts. The second participant was a multilingual speaker of Kannada and English, who also spoke and read Telugu (his first language) and Hindi.

His reading of single words was slow but generally accurate in both Kannada and English, though he exhibited syllable substitution errors in Kannada. Despite similar overall impairments

across the two languages, the specific reading errors differed: in Kannada, errors often resulted in non-words, whereas in English, errors tended to manifest in real words. This suggests that while the severity of the impairment may be similar, the distinct orthographic features of each language influenced the types of errors made.

Two more studies reported no significant orthographic effects on the manifestation of alexia in bilingual individuals with languages of different orthographic transparency. Beaton & Davies, (2007) examined Welsh, a language with highly transparent orthography, and English, known for its opaque orthography, while Laganaro & Overton Venet (2001) investigated Spanish (transparent) and English (opaque).

Beaton and Davies (2007) examined three fluent Welsh–English bilinguals who developed central alexia with aphasia following a left-hemisphere stroke. All three were diagnosed with deep alexia. Based on theoretical predictions, they were expected to produce more semantic reading errors in English than in Welsh, given English's opaque orthography. However, each participant showed a similar rate of semantic errors in both languages. Additionally, two participants read more accurately in English, their dominant language, than in Welsh. Contrary to expectations, the greater reading difficulty typically linked to English's opaque orthography was not observed. These findings suggest that orthographic transparency did not have a significant impact on the nature or severity of their reading impairment.

Laganaro and Overton Venet (2001) described a case involving a Spanish–English bilingual man assessed eight months after sustaining a traumatic brain injury from a gunshot wound to the left temporo-parietal-occipital region. Following surgery, he presented with central alexia, right hemianopia, aphasia, and acalculia. While his language comprehension remained relatively preserved, his expressive language reflected characteristics of conduction aphasia, and a persistent phonological deficit was evident even as his overall language abilities improved. A thorough bilingual reading assessment—including tasks like single-word and non-word reading, visual lexical decision, and narrative reading—revealed similar performance in both Spanish (his first language) and English (his later-learned second language). Non-word reading was more impaired than real-word reading, and no word-length effect was observed, consistent with a diagnosis of phonological

alexia. Reading aloud in both languages was noticeably slow and effortful. These findings challenge the idea that orthographic type alone accounts for how alexia manifests. While some research points to a role for orthographic transparency in acquired reading deficits, others emphasize the influence of factors such as language proficiency (Goral, 2019). Overall, there is insufficient evidence to support a direct, consistent link between orthographic type and specific alexia subtypes.

#### ***2.4.2. Are there differential language representations in instances of selective impairments in bilingual individuals with acquired alexia?***

There are a multitude of studies reporting differential impairment in alexia type across two languages known to the bilingual individual though with orthography-specific characteristics following a single brain lesion. These reports suggest that there are distinct neuronal networks that may underlie different orthographic systems individually for each language. For instance, while readers across all orthographies likely utilize both lexical and sub-lexical reading routes, the reliance on grapheme-phoneme correspondence (GPC) may vary between languages (e.g., Indian languages versus English). This suggests that reading in diverse orthographies might engage distinct processes linked to different neuronal networks (Goral, 2019). Before examining the evidence supporting this hypothesis, it is worth noting the extensive debate regarding whether the spoken languages of bilingual individuals are processed through overlapping neuronal networks. As highlighted in the literature (e.g., Abutalebi et al., 2001), two primary perspectives have emerged. One view posits that the two languages of bilinguals, particularly when not acquired simultaneously, may be represented and processed by separate or partially distinct neuronal networks. This perspective has been supported by cases of differential impairment and recovery in bilingual individuals with stroke-induced aphasia (e.g., Paradis, 2009).

Alternatively, it has been proposed that the observed differential impairment of two languages in bilingual individuals with aphasia reflects differences in activation and inhibition levels rather than varying degrees of language damage. According to this view, instead of a more severe impairment of one language, an impaired control mechanism accounts for the apparent discrepancies between the two languages (Abutalebi & Green, 2008). While this hypothesis is now more widely accepted, it remains plausible that the system underlying spoken language processing is shared

across both languages in bilinguals. However, written language skills are often learned more formally and rely on distinct cognitive processes. In turn, this might involve unique neuronal networks adapted to meet the specific orthographic demands of each language. Such differences may be more evident in early readers than in skilled readers.

Moreover, irrespective of whether the underlying networks converge to support all reading processes in bilinguals, effective control mechanisms are likely necessary to facilitate efficient and contextually relevant word reading. Only a limited number of studies on acquired reading disorders have directly investigated the question of differential neuronal representation. Among these studies, most report that bilingual individuals with alexia exhibit reading impairments in both languages, even when the degree or nature of impairment varies (Goral, 2019). Importantly, none of the reviewed studies have found cases where reading is impaired in one language but entirely intact in the other.

Several researchers have interpreted their findings as evidence supporting differential underlying representations of the two writing systems. Ohno et al., (2002) suggested that the varying degrees of impairment observed in their participants (L1) Japanese and (L2) English (discussed in Section 2.4.2) could be attributed to differences between or within the hemispheric representation. Specifically, they proposed that the participant's later acquisition of English, beginning in late childhood after middle school, may have contributed to the dissociation. The authors hypothesized that English processing was more localized to the right hemisphere compared to Japanese or that there were intra-hemispheric differences in how the two languages were represented. Similarly, Ibrahim (2009) interpreted findings from an Arabic Hebrew biscriptal reader as evidence of partially distinct representations for L1 and L2 reading processes, which could account for the differential susceptibility to impairment following brain damage.

Numerous studies involving bilingual individuals with high reading proficiency in distinct orthographic systems who later developed alexia offer evidence for shared neural representations across orthographies, as well as a strong connection between spoken and written language processing in the brain. For instance, Weekes et al. (2007) observed orthography-related effects on reading performance in only a subset of tasks and in just three out of eight Mongolian–Chinese bilingual

participants. Among these three, all showed similar impairments across various reading tasks in both languages. One participant had greater difficulty with written word comprehension in Chinese but performed similarly in both languages on other tasks. Another participant struggled more with oral reading in Chinese, though their performance across other tasks was comparable. Weekes and colleagues argued that such patterns can be explained using existing models of reading and by considering orthography-specific features, without requiring the assumption of separate neural systems for different writing systems (Goral, 2019).

Early findings from bilingual individuals with acquired reading disorders due to progressive neurological diseases (e.g., Druks et al., 2012) support similar conclusions. In one case, a participant showed better reading ability in their first language, Hungarian, compared to their second language, English. The researchers attributed this to the influence of language dominance rather than distinct neural systems. Differences in age of acquisition and proficiency levels are also thought to contribute to variability in reading impairments across languages. For example, Beaton and Davies (2007) reported that two of three participants demonstrated stronger reading skills in their dominant language, English, over Welsh. Similarly, in Ibrahim (2009), the participant had greater difficulty reading in their L2, Hebrew. Weekes et al. (2007) also noted that three participants exhibited more pronounced reading difficulties in their second language, Chinese.

In conclusion, despite the predictions mentioned earlier, there is minimal evidence to support the notion that separate neuronal mechanisms underlie reading in different languages or orthographies. This finding aligns with conclusions from recent neuroimaging studies conducted on healthy bicultural readers. Evidence from event-related potential (ERP) investigations and neuroimaging studies involving skilled readers indicate that reading relies on similar processes and overlapping neuronal networks across languages, even in cases involving opaque orthographies (Goral, 2019; Perfetti et al., 2007).

Meta-analyses and reviews of neuroimaging studies on reading across various languages suggest that different writing systems generally engage overlapping brain networks, though with some important distinctions (Perfetti et al., 2007). Liu and Cao (2016), in a meta-analysis, found that early bilinguals showed co-activation in the left fusiform gyrus while reading in both their first and

second languages. This pattern was absent in late bilinguals, indicating that differences in brain activation may reflect neural adaptation based on the age of language acquisition. Similarly, Roux et al. (2004), using intraoperative cortical stimulation in 19 bilingual individuals who spoke different languages, found largely similar cortical representations for reading in both languages. However, they also identified specific stimulation sites where reading was disrupted in only one language, echoing earlier findings of language-specific naming impairments during brain stimulation in bilinguals.

These dissociations may be influenced by orthographic differences; as distinct activation patterns have been associated with the two primary reading routes. For instance, left temporal-occipital networks have been linked to sub-lexical reading, whereas the left fusiform gyrus and left frontal regions are associated with lexical reading (Paulesu et al., 2000). Moreover, transparent orthographies tend to elicit greater activation in temporal-occipital networks, while opaque orthographies show stronger activation in temporal-frontal networks (e.g., (Kumar, 2014; Perfetti et al., 2007). Reading Chinese has consistently been linked to bilateral activation compared to left fusiform gyri (Bolger et al., 2005) and a larger left middle frontal gyrus, unlike languages that use alphabetic writing systems (Perfetti et al., 2007; Tan et al., 2003). Therefore, data from bilingual readers suggest that the underlying networks for reading across various orthographies are largely the same. Similarly, evidence for spoken language suggested that there are distinct neural networks involved in lexical and sub-lexical reading. Conclusions about the underlying representation of two or more orthographic systems in the bicultural brain seem to be a matter of interpretation (Goral, 2019).

Evidence from bilingual and bicultural individuals with acquired alexia suggests that while many researchers note possible orthographic influences on reading impairments, most bilinguals with reading difficulties due to brain lesions show relatively similar impairments across both languages. While orthography-specific features may influence the types of errors individuals with alexia make during reading, leading to potential differences in diagnosing alexia types across languages, the majority of reported cases show more similarities than differences in the reading impairments across languages (Goral, 2019). This aligns with the view that different languages and

their reading systems share a common representation in the brain. Additionally, findings from acquired alexia in bilingual individuals challenge traditional reading models, suggesting they may not fully explain reading processes and impairments across various languages and orthographies (e.g., Béland & Mimouni, 2001).

Thus, across the globe multitude of cross-linguistic studies were conducted with the curiosity to understand the distinctions like processing taking place in bilingual or biscriptal instances. In the specific interest of the study, owing to the Indian population, with multilingualism and bilingualism prevalent in the country, few pioneers in the field observed and reported the distinctions specific to the Indian cross-linguistic context.

#### ***2.4.3. The nature of reading impairment in bilingual individuals of India owing to alpha-syllabary orthography across languages in India.***

The present writing system of India, along with our neighboring countries like Thailand, Sri Lanka, Tibet, Myanmar, and a few regions of the Philippines, and Indonesia are known to have originated from the Brahmi script. These scripts are known by names like “neo syllabary” (Fervier, 1959 cited in Bright, 2000), “semi syllabary” (Diringer, 1968), “alphasyllabary” (Bright, 2000), and “pseudosyllabary” (Lecours, 1996). These terms were proposed as these scripts shared properties of both alphabets and syllabaries.

In specific interest of the study, the study focuses on Dravidian languages, which entail alpha-syllabic orthography. This system is significantly more transparent than English orthography. For instance, in English, the phoneme /ki/ represents different phonemic correspondences in words like *king* and *kite*. In contrast, Dravidian languages like Kannada maintain a clear and consistent phoneme-grapheme correspondence, with distinct representations for /ki/ and /kai/. In English, the phoneme /s/ is represented by different graphemes in words like *truce* and *sauce*. However, Dravidian languages use a single, transparent grapheme that corresponds exclusively to each phoneme (Swamy & Goswami, 2024).

In the same context, Coltheart et al. argued that surface dyslexia cannot occur in languages with regular or transparent orthographies, citing Italian as an example (Coltheart et al., 2001), Dual route model). In the Indian context, extensive research by Karanth (1981, 2003) supports this claim

and agrees demonstrating that surface dyslexia is unlikely in Dravidian languages due to their predominantly transparent orthographies (Coltheart et al., 2001).

In particular, Kannada is a Dravidian language, with a phonetically regular script. The script has a 50-letter alphabet called "Akshara" and involves a large number of regular and irregular rules while forming syllables. Linguistically, syllables can be dissected into onset, nucleus (vowel), and coda components. The primary set of letters called the "aksharamala," consists of a sequence of vowels and consonants in their basic forms. Secondary vowel forms are used in various CV combinations, except for C+/a/ sequences. On the transparency-opaqueness spectrum, Indian writing systems tend to be highly transparent, with letter sounds and names exhibiting near-perfect correspondence (Chengappa et al., 2004).

Karantth documented cases of pure alexia showing differential impairments in Kannada and English (Karantth, 1981). She reported a 57-year-old right-handed male patient, diagnosed with pure alexia, had Telugu as his mother tongue. He was also fluent in Kannada, Tamil, and English. Telugu and Tamil, like Kannada, belong to the Dravidian family of languages spoken in South India. Although Telugu was his native language, he was not literate in it, as his family had settled in Karnataka, where Kannada was the primary language. The patient was a graduate whose schooling was conducted in Kannada, while his college education was in English. In his professional life, he primarily used English, as all transactions were conducted in that language. Interestingly, he found it easier to read English than Kannada from the outset and throughout the stages of his recovery, which is somewhat unexpected. One possible explanation for this relative ease is that, during most of his adult life, he consistently used English more frequently than Kannada for reading and writing. Kannada was the first writing system he learned and the medium of instruction throughout his schooling. These differences were attributed to the unique characteristics of each language system, the patterns of language acquisition, and the distinct neural mechanisms involved in processing different scripts (Karantth 1981, 1998, 2002).

Similarly, Ratnavalli et al. observed that the degree and nature of dyslexia vary between Dravidian languages and English (Ratnavalli et al., 2000). They observed two patients, one with pure alexia and the other with alexia and agraphia following a stroke. Both were assessed in two

languages: English and Kannada (a Dravidian language of South India with a semi-syllabic script). The patient with pure alexia exhibited severe impairment and made perceptual errors when reading English, while the second patient showed mild alexia characterized by visual paraplegia in English reading. In Kannada, both patients primarily made script-related visual errors. Notably, errors in Kannada predominantly resulted in non-words, whereas in English, the errors consistently produced real words. Both patients displayed parallel impairments across the two languages. The authors opined that the variation in the degree of impairment in different languages and varied types of reading errors in each language may be attributed to a differential language representation in the brain. Further, they emphasized the need for future research to develop explanations grounded in reading models tailored specifically to Dravidian languages. Also, they concluded that these findings support the subsystem hypothesis where each language with its script (alphabetic and semi-syllabic) is a subsystem of a larger and common language/cognitive system.

Karanth (2002) documented a case involving a Hindi–English bilingual individual with reading impairments, where Hindi was his first language. Like other Indian scripts, Hindi—written in Devanagari—is phonologically transparent and highly regular, allowing for effective sub-lexical processing. Although the lexical route can be employed for reading, it's often unnecessary, as even complex Hindi words follow consistent phonological patterns, and irregularities are rare. In contrast, English, with its irregular alphabetic system, frequently requires reliance on the lexical route for both reading and writing. The patient in question demonstrated deep dyslexia in English, but exhibited almost no reading skills in Hindi. Since deep dyslexia disrupts sub-lexical processing, this difference in performance across the two languages offers important insights into psycholinguistic theories and the neural basis of reading. Based on this case, the researcher concluded that the transparency or opacity of a script plays a critical role, as transparent and opaque writing systems are processed through distinct neural mechanisms—sub-lexical versus lexical. Therefore, bilingual or biliterate individuals who use both a transparent and an opaque script provide valuable opportunities to explore how the nature of writing systems influences the expression of deep dyslexia.

Chengappa, Bhat, and Padakannaya (2004) made a significant contribution to the field with their study on acquired dyslexia in multilingual and multi-literate individuals in India. They noted

that most evidence for shared patterns of reading deficits across languages stems from studies comparing two alphabetic scripts. However, findings from cross-linguistic research involving both alphabetic and non-alphabetic scripts suggest that reading impairments can vary depending on the script. In their study, they examined two multilingual individuals with aphasia, both of whom showed differing levels of reading impairment across languages. Notably, more errors were observed in English than in more transparent scripts like Kannada and Hindi. This variation was interpreted as a reflection of how specific orthographic characteristics influence the presentation of acquired dyslexia. They concluded that while the neurological underpinnings of dyslexia may be universal, the symptoms and severity are shaped by the orthographic and linguistic properties of each language. The authors stressed the importance of conducting more cross-linguistic and cross-script research to deepen our understanding of these differences.

Considering the complex orthographic features of Kannada and the extent of oral language impairment in individuals with acquired reading difficulties, the study underlines the importance of distinguishing concurrent language processes linked to reading impairments. This approach supports the primary system hypothesis and highlights the need for further investigation into the reading mechanisms of Indian language orthographies (Swamy & Goswami, 2024). Thus, in specific the present study aims to look into the distinctions prevalent in Kannada-English bilingual individuals with alexia post-stroke. If the distinctions are pursued, then the author aims to explain the same with the support of reading models exclusively for Kannada-English bilinguals with the fundamental understanding gained through the aforementioned literature support.

## **CHAPTER III**

### **METHODOLOGY**

The study aimed to explore the relationship between linguistic abilities (semantics, phonology, and syntax) and reading abilities (oral reading and reading comprehension) in Kannada-English bilingual PWAs. The linguistic aspects of the study were addressed through performance in semantics, phonology, and syntax. The reading abilities were addressed through performance in oral reading and reading comprehension tasks. To evaluate the linguistic and reading abilities of bilingual PWAs, a series of specific behavioural tasks were designed in Kannada and English languages. This chapter delineates the details of the study design, participant selection, stimuli, tasks (linguistic and reading), procedure, outcome measures, scoring, and analysis of the data.

#### **3.1 Study Design**

The study entailed single-group within subject and correlation design. Within groups, the analysis involved a comparison between linguistic and reading abilities in bilingual PWAs across Kannada and English languages. In addition, correlational design was followed as the study involved analyzing the relationship between linguistic abilities over reading abilities. For the secondary objective of the study, the sub-grouping of alexia was formed based on the oral reading errors. The linguistic and reading abilities distinctions were compared within and between the types of alexia.

#### **3.2 Sample Size**

G\* power statistical software (Version 3.1) (Faul, Erdfelder, Buchner, & Lang, 2009) was employed to calculate the sample size for the proposed study. A pilot study was conducted and based on the correlation values and mean obtained from the data of the four participants, sample size was estimated for the primary objectives of the study. The Bivariate normal model for correlation was applied with obtain results of pilot study ( $r = 0.707$ ). Further, repeated measure within factors-ANOVA test was applied with  $\eta^2 = 0.33$  and effect size  $f = 0.7$  with obtain results of pilot study. The sample size calculated ranged between 8-13 at the significance level ( $\alpha$ ) of 0.05 and power of the test ( $1 - \beta$ ) at 0.80 considering the two sample size statistical estimate tests. To account for potential dropouts and missing data, additional participants were recruited beyond the initially determined sample size to ensure sufficient statistical power and robustness of the study results. Thus, a total of

20 bilingual PWAs were recruited in the study through purposive sampling methods considering strict inclusion and exclusion criteria.

### **3.3 Ethical Considerations**

The present study protocol was subjected to ethical clearance and was approved under the Ethical Committee for bio-behavioral research involving human subjects at the All India Institute of Speech and Hearing (AIISH), Mysuru, India (Ref No. DOR.9.1/PhD/AS/926/2021-22; dated 08.12.2022, Appendix A). Informed consent as per All India Institute of Speech and Hearing (AIISH) ethical guidelines (Basavaraj & Venkatesan, 2009) was taken from all the participants recruited in the study (Appendix B). The participants and their caregivers were explained the purpose of the examination, the study duration, and the importance of the outcome. All were ensured with safety and confidentiality of their details.

### **3.4 Participants**

A total of twenty Kannada-English bilingual PWAs with alexia post-stroke were recruited through a convenient sampling method. All were native speakers of Kannada (L1) (an Indo – Dravidian language, spoken by natives of Karnataka, a south-western state in India) and had acquired English (L2), during their formal schooling. These participants were recruited from in and around Mysuru district. Most of them belonged to middle socio-economic status (SES) (Kumar, Dudala, & Rao, 2013) (N=10), and few belonged to low SES (N=4) and high economic status (N=6). All the participants enrolled in the study were assessed with the Kannada version of Western Aphasia Battery (WAB-K) (Shyamala, Vijayashree & Ravikumar, 2008) and WAB-English (WAB- E) (Kertesz, 2006) to ascertain the presence of aphasia, type of aphasia, and reading impairments. These PWAs were recruited through strict inclusion and exclusion criteria as mentioned below.

#### **3.4.1 Inclusion Criteria**

- ✓ All PWAs recruited had 6 months post-stroke onset and primarily with infarct in the left hemisphere, confirmed through the medical reports of CT and/or MRI scan (Table 3.1).
- ✓ PWAs who were native speakers of the Kannada language (L1) and acquired English language (L2) as a secondary language during their schooling. Thus, all were sequential bilinguals.

- ✓ PWAs with good auditory comprehension abilities verified through scores  $\geq 5/10$  on the auditory comprehension section of WAB-K were recruited.
- ✓ PWAs who complained of reading difficulties were recruited and the same was confirmed through the administration of the reading domain of WAB- K.
- ✓ PWAs with a minimum education level of 12<sup>th</sup> grade and above in English medium were recruited (Table 3.2).
- ✓ PWAs with good proficiency (speaking, understanding, reading, and writing) in Kannada and English languages in their premorbid phase, were appraised through a modified language proficiency questionnaire (Yathiraj & Amruthvarshini, 2018) (Appendix C) (Table 3.2).
- ✓ PWAs possessing right-handedness pre-morbidly were recruited.

#### **3.4.2 Exclusionary Criteria**

- ✗ PWAs with a history of cognitive impairment confirmed through the Montreal Assessment of Cognition (MOCA) were excluded (scores below 26) (Nasreddine et al., 2005).
- ✗ PWAs with developmental dyslexia or any neurological diagnosis other than left-hemisphere stroke were excluded.
- ✗ PWAs with visual impairment or visual neglect and/or compromised hearing sensitivity were excluded via informal interviews with the PWAs and their caregivers, confirmed through WHO ten questions screening checklist (Singhi, Kumar, Malhi & Kumar, 2007).
- ✗ PWAs with Apraxia of Speech (AOS) were excluded, confirmed via the Apraxia section of WAB-K.

Initially, 45 PWAs were selected for the clinical group, and further on observing the inclusion and exclusion criteria for each PWA, a total of 20 PWAs (15 males and 5 females) were recruited as participants for the study. Among the 25 excluded PWAs, five had low proficiency scores in L2, seven had mild cognitive-linguistic impairment, five PWAs had ceiling scores in the reading section of WAB, and eight PWAs had poor auditory verbal comprehension ( $< 5$  on WAB auditory domain), and AOS. Their average age was 43.5 years (S. D= 15.99; Range= 20-68), and they had an average of 16 years of formal education (S. D= 1.77; Range= 12-18) with an average

20 months post-stroke onset (S. D= 11.39, Range= 6-45) were recruited for the study. Refer to Table 3.1 for the description of demographic details of the participants.

Table 3.1. *Demographic details of Persons of Aphasia (PWAs).*

Patient	Age	Gender	Qualification	Occupation	MPO <sup>1</sup> (in months)	MRI Findings	Aphasia Quotient		Aphasia Type	
							WAB <sup>5</sup> - Kannada	WAB- English	Kannada	English
<b>P1</b>	22	Male	Graduation	Clerical	26	Acute infarct in Basal Ganglia & occlusion in Lt MCA <sup>2</sup>	83	80	Anomic Aphasia	Anomic Aphasia
<b>P2</b>	46	Male	Graduation	Bank employee	45	Acute infarct in Lt MCA <sup>2</sup>	67.7	34.5	Broca's Aphasia	Broca's Aphasia
<b>P3</b>	20	Female	Discontinued graduation	Student	12	Temporo partial haemorrhagic infarct	59.1	66.5	Transcortical Sensory Aphasia	Transcortical Sensory Aphasia
<b>P4</b>	32	Male	Post-graduation	Business	10	Acute non haemorrhagic CVA <sup>3</sup> Lt Basal Ganglia	80.5	79.1	Anomic Aphasia	Anomic Aphasia
<b>P5</b>	34	Male	Graduation	IT Engineer	17	Acute CVA <sup>3</sup> in Rt MCA <sup>2</sup>	65.8	69.4	Transcortical Sensory aphasia	Transcortical Sensory aphasia
<b>P6</b>	56	Female	Post-graduation	Teacher	34	Haemorrhagic stroke Lt MCA <sup>2</sup>	86.2	80.5	Anomic Aphasia	Anomic Aphasia
<b>P7</b>	24	Male	Discontinued graduation	Student	16	Complete thrombosis in Lt MCA <sup>2</sup>	70.6	66.8	Anomic Aphasia	Anomic Aphasia
<b>P8</b>	48	Male	Higher Secondary	Clerical	9	Acute infarcts involving the left frontoparietal lobe	45.6	21.7	Broca's Aphasia	Broca's Aphasia
<b>P9</b>	37	Male	Discontinued graduation	Clerical	28	Temporo partial haemorrhagic infarct	66.3	51.6	Broca's Aphasia	Broca's Aphasia
<b>P10</b>	57	Male	Graduation	Govt Service	18	Acute Lt front parietal infarct	66	37.6	Broca's Aphasia	Broca's Aphasia
<b>P11</b>	59	Female	Graduation	Homemaker	40	Acute Lt MCA <sup>2</sup>	87	85	Anomic Aphasia	Anomic Aphasia
<b>P 12</b>	48	Male	Post-graduation	Politics	23	Subacute infarct left fronto parietal lobe-subcortical regions	56.5	52.1	Broca's Aphasia	Broca's Aphasia
<b>P13</b>	68	Male	Post-graduation	Pastor	17	Chronic infarct in PCA <sup>4</sup>	87.4	83.5	Anomic Aphasia	Anomic Aphasia
<b>P14</b>	32	Male	Graduation	IT Engineer	24	Acute Lt fronto-temporal CVA	75.8	77.9	Conduction Aphasia	Conduction Aphasia
<b>P15</b>	45	Female	Post-Graduation	Teacher	16	Acute CVA in PCA <sup>4</sup>	87	85.3	Anomic Aphasia	Anomic Aphasia
<b>P16</b>	65	Male	Graduation	Accountant	6	Acute CVA <sup>3</sup> in Lt MCA <sup>2</sup>	40.5	34.3	Broca's Aphasia	Broca's Aphasia
<b>P17</b>	34	Male	Discontinued graduation	Business	36	Chronic infarct in PCA <sup>4</sup>	83.5	70.6	Anomic Aphasia	Anomic Aphasia
<b>P18</b>	64	Male	Post-Graduation	Business	12	Acute Lt MCA <sup>2</sup>	34	26.4	Broca's Aphasia	Anomic Aphasia
<b>P19</b>	19	Female	Higher Secondary	Student	7	Acute CVA in Lt ICA	87	77.9	Anomic Aphasia	Anomic Aphasia
<b>P 20</b>	62	Male	Graduation	Govt service	10	Acute Ischemic Lt MC A <sup>2</sup>	45.4	40	Broca's Aphasia	Broca's Aphasia

\*\*Note: 1= Month Post-stroke Onset, 2- Left Middle Cerebral Artery, 3- Cerebro Vascular Atrophy, 4- Posterior Carotid Artery, 5- Western Aphasia Battery

Table 3.2.

*Language proficiency profiling through the modified language proficiency questionnaire of each PWA in Kannada and English in their pre-morbid stage.*

Patient	Age (yrs.)	Qualification	Duration of Language Exposure (in Years)								Language proficiency								Identification as a Native speaker		Use of Language (hrs)		Overall Proficiency score (100)	
			Understanding		Speaking		Reading		Writing		Understanding		Speaking		Reading		Writing		L1	L2	L1	L2	L1	L2
			L1	L2	L1	L2	L1	L2	L1	L2	L1	L2	L1	L2	L1	L2	L1	L2	L1	L2	L1	L2	L1	L2
P1	22	Graduation	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	82	64
P2	46	Graduation	4	3	4	3	4	3	3	3	4	3	4	3	4	3	4	3	4	3	4	1	80	62
P3	20	Discontinued graduation	4	2	4	4	3	2	2	2	4	2	4	3	4	3	4	2	4	3	4	3	74	80
P4	32	Post-graduation	4	4	4	2	4	4	4	3	4	3	4	3	4	3	4	3	4	3	4	4	82	70
P5	34	Graduation	4	3	4	4	4	3	4	3	4	3	4	2	4	3	4	3	4	2	4	3	78	70
P6	56	Post-graduation	4	4	4	3	4	4	4	3	4	3	4	3	4	3	4	3	4	3	4	4	80	68
P7	24	Discontinued graduation	4	3	4	4	4	2	4	2	4	3	4	2	4	3	4	2	4	2	4	3	82	62
P8	48	Higher Secondary	3	4	4	2	4	2	4	2	4	2	4	2	4	2	4	2	4	2	4	2	84	64
P9	37	Discontinued graduation	4	2	4	2	4	2	4	2	4	2	4	2	4	2	4	2	4	2	4	1	80	62
P10	57	Graduation	4	2	4	2	4	3	4	3	4	2	4	2	4	3	4	3	4	2	4	3	80	70
P11	59	Graduation	4	2	4	3	4	3	4	3	4	3	4	2	4	3	4	3	4	2	4	3	82	72
P 12	48	Post-graduation	4	3	4	3	4	4	4	4	4	3	4	3	4	4	4	4	4	3	4	4	84	80
P13	68	Post-graduation	4	3	4	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	3	78	74
P14	32	Graduation	4	4	4	3	4	3	4	3	4	3	4	4	4	4	3	4	3	4	3	4	78	80
P15	45	Post-Graduation	4	4	4	4	4	3	4	3	4	3	4	4	4	4	3	4	4	4	2	4	78	78
P16	65	Graduation	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	82	70
P17	34	Discontinued graduation	4	4	4	2	4	3	4	3	4	2	4	2	4	2	4	3	4	2	4	3	82	72
P18	64	Post-Graduation	4	3	4	2	4	3	4	4	4	4	4	3	4	4	4	4	4	4	4	3	84	70
P19	19	Higher Secondary	4	2	4	2	4	3	4	2	4	2	4	2	4	2	4	2	4	2	4	1	80	68
P 20	62	Graduation	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	2	84	78
			4- Above 15yrs; 3- 10-15yrs; 2-5-10yrs; 1 -less than 5 yrs.								4- Native like; 3- Good; 2-Fair; 1 -Low.								4- Always to 1- Never		4- >5hrs to 1- >1hr			

### **3.5 Materials**

#### **3.5.1 Stimuli Preparation**

The study entailed various behavioral tasks for examining the linguistic abilities and reading abilities of Kannada-English bilingual PWAs (Table 3.3). In this line, various tasks and stimuli were compiled through various standardized test batteries for all the tasks of semantics, phonology, syntax, oral reading, and silent reading comprehension, specifically for Kannada and English languages. The standardized test batteries used were Linguistic Profile Test- Kannada (LPT-K) (Karanth, 1981), Manual for Adult Non-Fluent Aphasia Therapy in Kannada (MANAT-K) (Venugopal & Goswami, 2005), Manual for Adult Fluent Aphasia Therapy in Kannada (MAFAT-K) (Chaitra & Goswami, 2009), Manual for syntax processing activities for PWA (Siddi & Hema, 2021), Dementia Assessment Battery (DAB) (Sunil & Shyamala, 2009), Manual for reading, writing and arithmetic for persons with aphasia in Kannada (MTR3A2- K) (Kruthi & Goswami, 2011). Few tasks and stimuli were not available to meet the requirements of the protocol of the study. In such instances, stimuli were borrowed from Kannada and English texts of higher primary grades, Kannada and English dictionaries, and through Focus Group Discussion (FGD) with three experienced Bilingual (Kannada & English) Speech-Language Pathologists. FGD is the research method, where the researcher recruits the experts in the field and gets insight into the concerned topics with their viewpoints. It also aids in developing new stimuli aligned with the objective of the current study (Krueger & Casey, 2015). Simultaneously, for pictures-based tasks, specific-coloured pictures were retrieved from textbooks with higher primary grades and by using Google search engines for both targets and foils. These pictures were verified for the absence of cultural and linguistic bias. Together the picture-based stimuli and words were subjected to validation.

Table 3.3.

*List of tasks and subtasks compiled in linguistic and reading domains for the study protocol.*

<b>Domains</b>	<b>Semantics</b>	<b>Phonology</b>	<b>Syntax</b>
<b>Linguistic</b>	Picture Association	Minimal Pair judgement	Comprehension of Plural forms
	Picture Matching	Real word rhyme judgement	Comprehension of Tense Markers
	Auditory Comprehension	Non-word judgement	Spoken sentence to picture matching
	Auditory judgement	Parsing/blending sounds	Sentence completion with locatives
<b>Reading</b>	<b>Oral reading</b>		<b>Reading comprehension</b>
	Real word		Word level
	Irregular word		Sentence level
	Nonword		Paragraph level

### 3.5.2 Validation

The overall compiled and developed stimuli were subjected to validation by five experienced Speech Language Pathologists (SLPs) with 6.5 years of average experience in the assessment and management of PWAs. All validators were Kannada-English bilinguals who had 'good' to 'native-like' proficiency in both languages on the modified language proficiency questionnaire. SLPs validated the stimuli for appropriateness, stimulability, imageability, frequency, number of syllables (2-5 syllables), and sensitivity. Stimuli were rated based on a 'three'-point rating scale, where 'zero' signified 'not at all relevant', 'one'- 'fairly relevant', and 'two' signified highly relevant. Final stimuli were compiled using point to point comparison method and the set that received scores above 80% on an average rating were considered for the final stimuli. The final test protocol development for the study is provided in Appendix D with the scoring sheet prepared to document the responses elicited by each PWA in the study (Appendix E)

### 3.6 Procedure

Initially, all the participants were assessed with WAB-K to identify the aphasia and its type. This test assesses aspects of spoken language abilities like spontaneous speech, auditory verbal comprehension, repetition, naming, reading, writing, presence of apraxia, constructional, visuospatial, and calculation skills of PWAs. Also, to determine their post-stroke linguistic skills in

the English language (L2), WAB-E (Kertesz, 2006) was administered. The WAB deduces the individual's type of aphasia, aphasia quotient (AQ), and reading difficulties (Table 3.1).

The language proficiency in Kannada and English language during their pre-morbid state was gauged via a modified language proficiency questionnaire (Yathiraj & Amruthvarshini, 2018). The questionnaire broadly profiles the bilingual individual's exposure to L1 and L2 in years, level of proficiency, identification as a native speaker in L1 and L2, and daily dosage of language use. Overall, it quantifies the language proficiency in L1 and L2 out of 100. The profiling of language proficiency in L1 and L2 of each bilingual PWA is depicted in Table 3.2.

MOCA was administered to rule out cognitive-linguistic impairments. Individuals scoring below 26 were excluded from the study. The type of aphasia, aphasia quotient, reading difficulties, and language proficiency in Kannada and English were determined for profiling each PWA's linguistic abilities, reading difficulties, and language competency. However, these details were not considered for the main analysis of the data as the primary focus of the study was to examine the linguistic and reading abilities in detail in each language of Kannada–English bilingual PWAs and compare the relationship entailed between them. Further, specific tasks of the study were administered to all the participants to comprehensively apprehend the linguistic and reading abilities as delineated below.

### ***3.6.1 Study Protocol***

All PWAs recruited in the study were administered with a series of linguistic and reading tasks (Table 3.3) in a quiet, and distraction-free room. Tasks-specific instructions were conveyed to every PWA for each task. Also, trial stimuli (2-5) were presented for every task to ensure task familiarization. The written stimuli (black and bold, 42 font size), and colored pictures were presented over the desk in printed format on an A4 size flash card. While carrying out the tasks no specific cues were rendered. An adequate time limit was imposed while testing, and authors refrained from response-contingent feedback. A maximum of 60 secs was provided to respond for comprehension based tasks and oral reading tasks. The paragraph reading task was not time bound, the next stimuli was presented once the participant indicated 'no response' or unable to respond in the task. The instructions and presentation of stimuli were repeated to maximum of two repetitions

if requested by the patient and also in instances of ‘no responses’. Each individual was examined for maximum of 2 hours in a day with sufficient breaks during the testing phase. On an average each PWA was assessed for 4-6 hours to complete to assessment protocol.

The tasks were counterbalanced within the language and across the languages. Wherein, one-half of the total participants were tested in the Kannada language (L1), and the rest were examined in English (L2). Likewise, one-half of the PWAs were subjected to linguistic tasks first and the other half to reading tasks, to rule out the effect of stimuli complexity and performance load on the PWAs.

The study protocol was broadly divided into investigating the following:

- a) *Linguistic domain* - included subdomains like semantics, phonology, and syntax specific to Kannada and English languages.
- b) *Oral Reading domain*- included oral reading tasks like real word reading, irregular word reading (only in English), and non-word reading at the single word level, specific to Kannada and English languages.
- c) *Reading Comprehension* – included tasks at single word level, sentence level, and paragraph level in both Kannada and English languages.

#### 3.6.1.1. Linguistic Tasks

##### **Semantic Tasks**

***Picture association task (n=15):*** In this task, participants were presented with four foils and a target picture in the center, all in the form of printed picture flashcards (Figure 3.1). Each participant was instructed to match the target picture with foil of four picture flashcards on three types of associations namely, distinctive feature association (Camel- dessert) (n= 5) categorical association (apple- orange) (n=5), and noun-verb (bat- hit or scissor- cut) association (n= 5). *Instruction-* “Look at the center image and match with the related picture out of the four pictures”



Figure 3.1- Illustration of picture association task

**Picture Identification task** ( $n= 10$ ): Each participant was presented with four printed picture flashcards and they were instructed to identify the spoken word (target stimulus) from four picture choices (Figure 3.2). The items assessed in this task comprise common nouns ( $n=5$ ) and common verbs ( $n=5$ ). For example, when the target verbal stimuli were ‘barking’ and the participant had to identify out of four picture flashcards- ‘barking’, ‘brushing’, ‘rowing’, and ‘petting’. *Instruction-* “Listen to the word I say and point to the respective picture out of four pictures”.

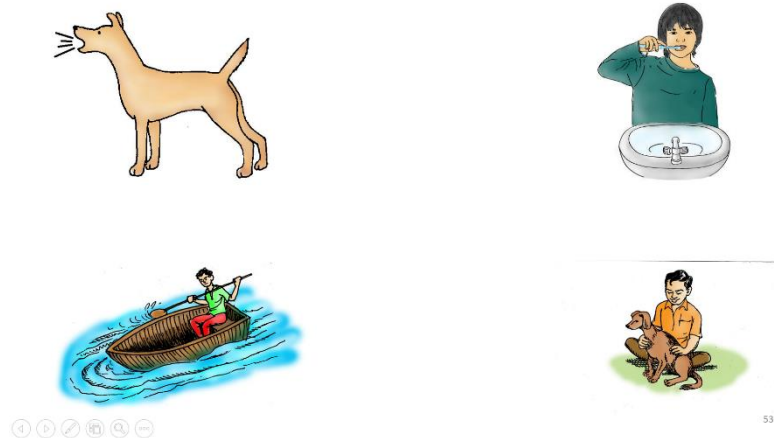


Figure 3.2- Illustration of the Picture identification task

**Auditory synonym judgment task** ( $n= 10$ ): Each participant was presented with pairs of words related in terms of synonyms through auditory mode. They were instructed to indicate ‘yes’ or ‘no’ for the relatedness of pairs. They were allowed to respond either through

gestures, or nods or verbally. For example, 'look- see', 'happy- excited', 'speak- tell' in English. In Kannada; /deha/- /shareera/, /kaṅṅu/- /nayana/ etc. *Instruction-* "Listen to the pair of words I say and indicate 'yes' if the words are related and 'no' if the words are not related".

***Auditory comprehension task*** ( $n=10$ ): Polar questions were verbally presented to the participants and they were instructed to answer 'yes' or 'no' to the questions posed. For example; 'Is the sky blue in color?' (polar question) - yes' (expected answer). In Kannada, /naai simhagintha doDDada/ (expected answer)- no'. *Instruction-* "Listen to the sentence I say and indicate 'yes' if the question is meaningful and 'no' if the questions are not meaningful".

### **Phonological Tasks**

***Real word rhyme judgement*** ( $n=10$ ): Each participant was presented with a real word rhyming words verbally, and they were instructed to judge if they sounded the same or not. For example; 'mission- passion', transform- inform', and so on. In Kannada- /baLe-maLe/, /hu:vu- haavu/ and so on. *Instructions-* "Listen to the pair of words I say and indicate 'yes' if the words sound similar and 'no' if the words sound dissimilar".

***Non-word rhyme judgement*** ( $n=10$ ): Rhyming non-words were presented verbally to each participant, and they were instructed to judge if they sounded the same or not. For example, 'Toption- Bension' and so on. In Kannada- /tapasa-kapasa/, /marli-parli/ and so on. *Instructions-* "Listen to the pair of non-meaningful words I say and indicate 'yes' if the words sound similar and 'no' if the words sound dissimilar".

***Phoneme Manipulation (Blending and Parsing) task*** ( $n=10$ ): Participants were instructed to join (blend) or segment (parse) the sounds and produce the target words verbally at the phoneme level and syllable level. For example, Phoneme Parsing: /p/ - /pat/= /at/; Blending: /m/ +/at/= /mat/. Syllables Parsing: /pla/ - /plate/= /ate/; Blending: /pla/ + /ate/= /plate/. *Instructions-* Blending: "Listen to the sounds I say and indicate the word on joining the sounds". Parsing: "Listen to the sound removed from the word and indicate the sound after splitting".

## Syntax Tasks

**Syntactic marker judgement** ( $n= 10$ ): Pairs of correct and incorrect words of plural forms and tense forms were verbally presented to each participant. They were instructed to listen to the pairs and respond if the pairs had corrected or incorrect association forms. For example: ‘table- tables’, ‘child- children’ (plural forms); ‘come- came’ (tense form), ‘fall- fell’ and ‘want- wanted’ and so on. In Kannada- /magu-makkaLu/ (plural form); /ba-bandanu/ (tense form) and so on. *Instructions*- “Listen to the pair of words I say and indicate ‘yes’ if the words are grammatically correct and ‘no’ if the words are grammatically incorrect”.

**Sentence Comprehension** ( $n= 10$ ): Sets of four picture flashcards were presented. The participant was instructed to listen to the verbal sentence and identify the respective picture (Figure 3.3). Example- “The vehicle that sails in the sea.....”. In Kannada, /samudradalli chalisuva vahana.../ “Listen to the sentence I say and point to the picture respective to the meaning”.



Figure 3.3- Illustration of spoken sentences to picture matching task.

**Sentence completion with locatives** ( $n=5$ ): Verbally incomplete sentences were presented to the participants with a picture presentation. The participant is expected to fill in with appropriate locative form (in, on, over, under, and so on) respective to the picture stimulus and the oral sentence (Figure 3.4). For example: ‘The dog is..... (under) the table’. In

Kannada /naai medzu ..... (kelage) malagide/. *Instructions-* “Listen to the sentence and fill with correct word form looking at the picture”.



Figure 3.4- Illustration of sentence completion with locatives

### 3.6.1.2. Oral Reading Tasks

A set of printed flashcards on an A4 size sheet with black font and a white background of single words (orthographic form) (font size 40) were presented (Figure 3.5). Participants were instructed to read aloud the printed words. All the words were matched for length (2-3 syllabic words) and complexity. The text was “neglect-friendly” and printed aligning to the center around an imaginary vertical midline on the paper. For each item, they were given approximately 30 seconds to respond (maximum 60 seconds). The following types of words were assessed in this task:

- i. Real word reading (Kannada and English) (N= 15). Example: /se:bu/ & ‘table’
- ii. Non-word reading (Kannada and English) (N= 15). Example: /hampara/ & ganter’
- iii. Irregular word reading (only in English) (N=10). Example: ‘yatch’



Figure 3.5- Illustration of oral reading tasks

### 3.6.1.3. Reading Comprehension Tasks:

This task involved participants reading the printed text (black, bold 40 size font on white A4 size page) in both Kannada and English languages. The comprehension abilities were assessed across single-word levels, sentence levels, and paragraph levels. The tasks were as follows:

### Single word level

**Written word-to-picture matching** ( $N= 10$ ): Written words were printed in the flash card and the participant had to match with the respective picture from the array of four choices (Figure 3.6). *Instruction-* “Read the word in the centre silently and point to the respective picture”.

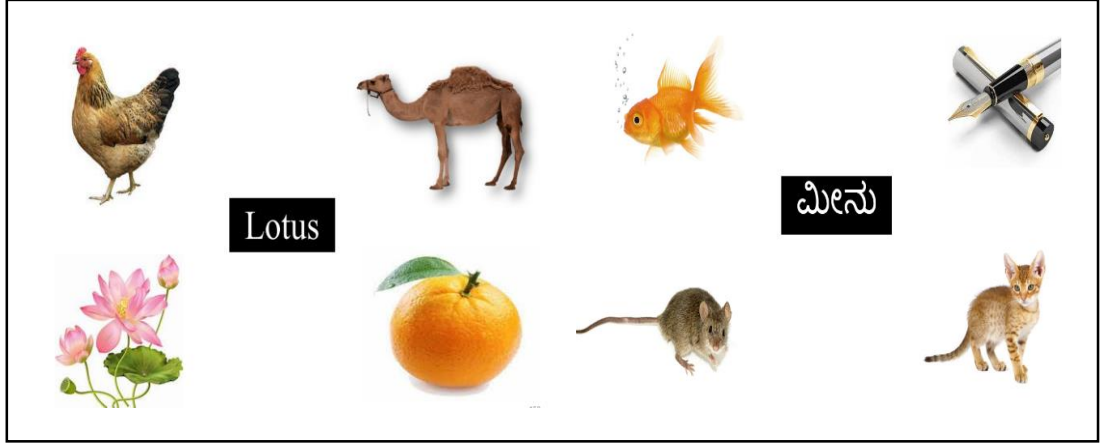


Figure 3.6- Illustration of the written word to picture matching task

**Written synonym judgment** ( $N= 10$ ): Target words with four choices of related and unrelated words to the target in printed form were presented. The participants had to read the target word and match it with the respective synonym word out of an array of four choices (Figure 3.7). Example: The correct form will be ‘Happy- joy’. In Kannada- /raja- arasa/. *Instruction-* “Read the words highlighted in the left silently and point to the same meaning word among the choice of four in the right”.

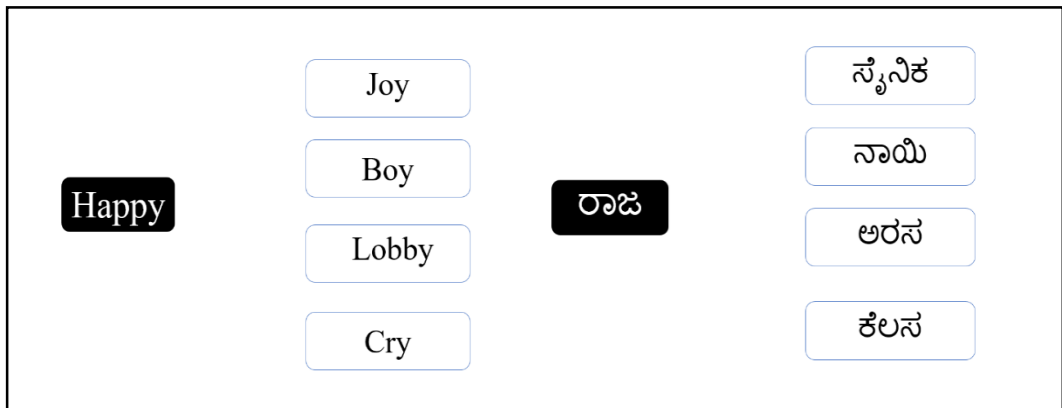


Figure 3.7- Illustration of written synonym judgement task

**Written words and semantic association** (N=10): The target word in written (printed) form on the flashcard was presented and each participant was instructed to match with the respective semantically related words out of four written (printed) words as illustrated in Figure 3.8. Example: The correct form will be - Lion- tiger'. In Kannada- /mola- praji/.  
**Instruction-** “Read the words highlighted in the left silently and point to the related word among the choice of four in the right”.

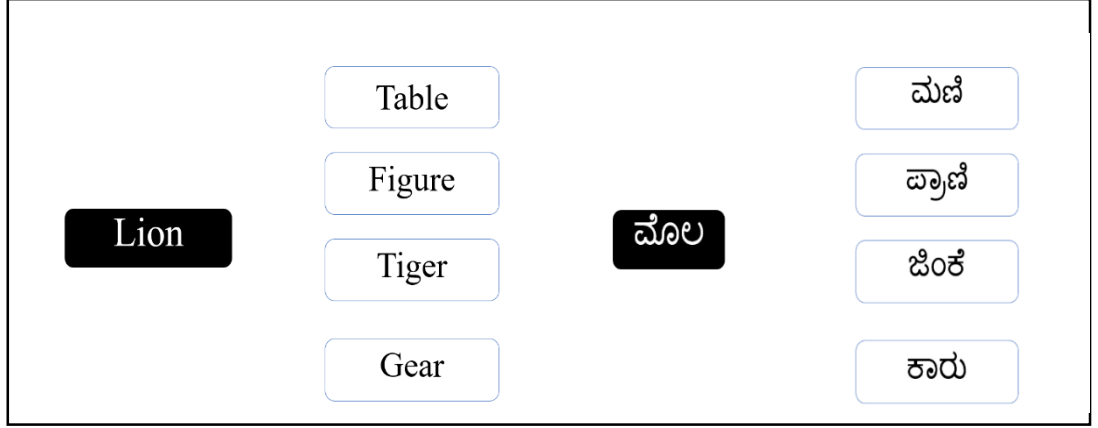


Figure 3.8- Illustration of written and semantic association task

#### Sentence level

**Written sentence to picture matching** (N= 10): Written (printed) sentences were presented with picture choices of four as illustrated in Figure 3.9. The participant was required to read the text silently and match the respective picture. **Instruction-** “Read the sentence silently and point to the respective picture among the choice of four”.

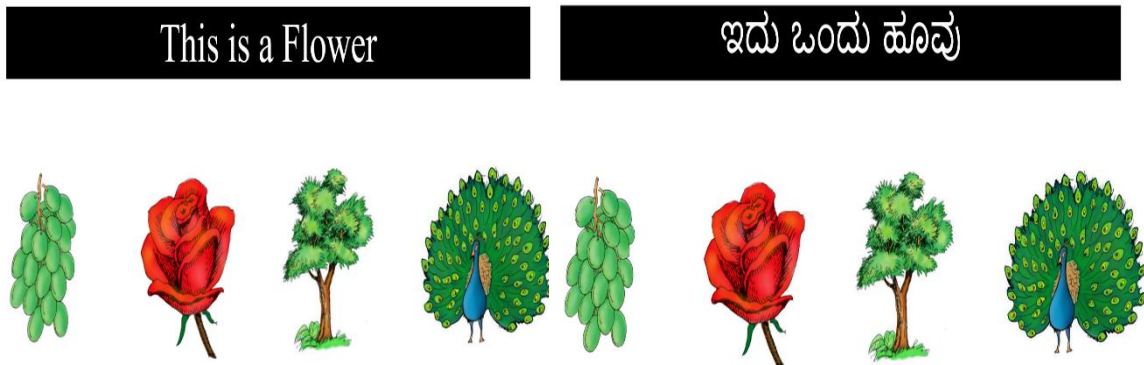


Figure 3.9- Illustration of written sentence to picture task

**Written sentence judgment (N= 10):** In this task correct and incorrect forms of sentences in printed form were presented through flashcards. Each PWA was asked to read silently and indicate if the sentence was correct or incorrect by judging the sentence read (Figure 3.10). *Instruction-* “Read the sentences silently and indicate ‘yes’ if the sentence is appropriate or ‘no’ if inappropriate”.



Figure 3.10- Illustration of written sentence judgement task

**Written sentence completion (N= 10):** Incomplete sentences with a choice of four words were presented in printed form. The participants were instructed to indicate the appropriate word to fill the incomplete sentences after silent reading (Figure 3.11). *Instruction-* “Read the sentence highlighted in the left silently and point to appropriate word among the choice of four in the right”.



Figure 3.11- Illustration of written sentence complete task

## Paragraph Level

**Paragraph to picture matching (N=3):** Participants were instructed to read the written paragraph (print form) in the flash card and match the respective picture out of a choice of four pictures (Figure 3.12). *Instruction-* “Read the sentence silently and point the picture out of four choices respective to the meaning of the paragraph”.

It is a bright sunny day. The sky is clear and the birds are chirping around. All kids are taken out to the garden and a teacher is narrating a story to them. All kids are happily listening to the story.











Figure 3.12- Illustration of paragraph to picture matching task

**Paragraph thematic matching (N=3):** In this task, lengthier paragraphs were presented (print form) through the flash card. The participant was asked to indicate which of the four pictures best represents the theme of the printed paragraph after silent reading. *Instruction-* “Read the sentence silently and point the picture out of four choices respective to the meaning of the paragraph”.

**Paragraph inferential matching (N=3):** Participants were instructed to read the written paragraph (print form) through the flash card and match it to the respective inference of the paragraph from a choice of four inferences written in the sentence. No picture choices were presented in the task (Figure 3.13). *Instruction-* “Read the sentence silently and point the inference of the four choices respective to the meaning of the paragraph”.

<p>Once upon a time, there lived a crow. One summer day, the crow felt thirsty and began to look for some water. It flew over the fields but couldn't find. It felt exhausted and she was about to give up.</p> <p>Then the crow saw a jug near a farm. It quickly landed down there to check whether there was any water. It looked inside the jug. There was some water. The crow wanted to drink but couldn't reach the water because of jug's narrow neck. It tried to push it down, but it was too heavy and thought a while. Then the crow looked around and saw small stones. The crow picked the stones up one by one and threw them inside the jug. Thus, the water level rose up enough and it quenched its thirst thanks to the crow clever plan.</p>	<p>"A friend in need is a friend indeed".</p> <p>"Think and act. Don't be greedy"</p> <p>"Time and tide wait for none".</p> <p>"Slow and steady wins the race."</p>
<p>ಒಂದಾನೊಂದು ಕಾಲದಲ್ಲಿ ಒಂದು ಕಾಗೆ ವಾಸಿಸುತ್ತಿತ್ತು. ಒಂದು ಬೇಸಿಗೆಯ ದಿನ, ಕಾಗೆಗೆ ತುಂಬಾ ಬಾಯಿಶುಚಿ ಆಯಿತು ಮತ್ತು ಸ್ವಲ್ಪ ನೀರನ್ನು ಹುಡುಕಲು ಪ್ರಾರಂಭಿಸಿತು ನೀರನ್ನು ಹುಡುಕುತ್ತಾ ಸ್ವಲ್ಪದಿಂದ ಸ್ವಲ್ಪಕ್ಕೆ ತಾರಿತು. ಆದರೆ ಕಾಗೆಗೆ ಎಲ್ಲಿಯೂ ನೀರು ಸಿಗಲಿಲ್ಲ. ಅದರಲ್ಲಿ ಒಂದು ಹನಿಯೂ ಸಿಗದಿದ್ದಕ್ಕೆ ಅದು ತುಂಬಾ ದುಃಖಿತವಾಯಿತು ಮತ್ತು ನೀರಾಶೆಗೊಂಡಿತು.</p> <p>ಅಗ ಹೊಲವೊಂದರ ಬಳಿ ಒಂದು ಹೂಜಿ ಕಂಡಿತು. ನೀರು ಇದೆಯೇ ಎಂದು ಪರೀಕ್ಷಿಸಲು ಬೇಗನೆ ಹಾಲ ಬಂತು. ಹೂಜಿಯೊಳಗೆ ನೋಡಿದಾಗ ಸ್ವಲ್ಪ ನೀರು ಇತ್ತು. ಕುಡಿಯಲು ಹೋದಾಗ ನೀರನ್ನು ತಲುಪಲು ಸಾಧ್ಯವಾಗಲಿಲ್ಲ. ಹೂಜಿಯ ಕಿರಿದಾದ ಕುತ್ತಿಗೆಯಿಂದಾಗಿ ಅದನ್ನು ಕೆಳಗೆ ತಳ್ಳಲು ಪ್ರಯತ್ನಿಸಿತು ಆದರೆ ಅದು ತುಂಬಾ ಭಾರವಾಗಿತ್ತು. ಸ್ವಲ್ಪ ಹೊತ್ತು ಯೋಚಿಸಿತು ನಂತರ ಸುತ್ತಲೂ ನೋಡಿತು ಮತ್ತು ಸಣ್ಣ ಕಲ್ಲುಗಳನ್ನು ಒಂದೊಂದಾಗಿ ಎತ್ತಿ ಹೂಜಿ ಒಳಗೆ ಎಸೆಯಿತು. ಹಾಗಾಗಿ, ನೀರನ ಮಟ್ಟವು ಸಾಕಷ್ಟು ಏರಿತು ಮತ್ತು ಕಾಗೆ ತನ್ನ ಬುದ್ಧಿವಂತಿಕೆಯಿಂದ ತನ್ನ ಬಾಯಿಶುಚಿಯನ್ನು ತಣಿಸಿಕೊಂಡಿತು.</p>	<p>"ಅತಿ ಆಸೆ ಗತಿ ಗೇಡು".</p> <p>"ಮಯ ಮತ್ತು ಅಲೆ ಯಾರಿಗೂ ಕಾಯೋದಿಲ್ಲ"</p> <p>"ನಿಧಾನವೇ ಪ್ರಧಾನ".</p> <p>"ಮಾತು ಬಲ್ಲವನಿಗೆ ಜಗಳವಿಲ್ಲ ಊಟ ಬಲ್ಲವನಿಗೆ ರೋಗವಿಲ್ಲ."</p>

Figure 3.13. Illustration of inferential paragraph matching.

All the aforementioned behavioral tasks were administered in both Kannada and English languages on all the participants in the study. The summary of the tasks is depicted in Figure 3.13 below.

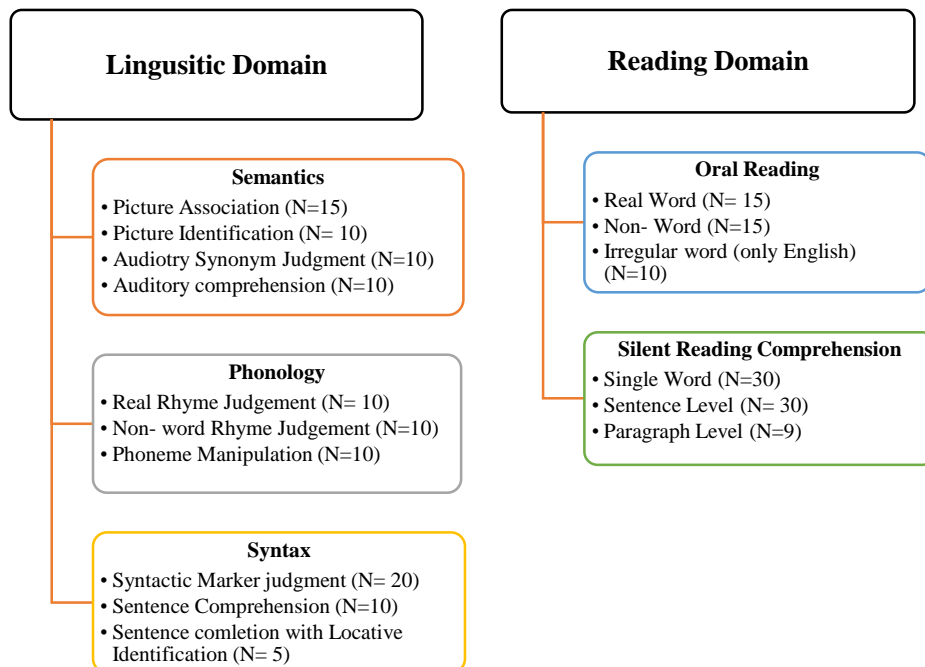


Figure 3.14. Summary of tasks administered to examine linguistic and reading abilities in Kannada and English languages.

### 3.7 Scoring and Subgrouping

Every item in each task was scored using a binary scoring pattern (correct= 1; incorrect and no responses = 0). The total scores of each task were averaged. Further, average scores of all the tasks were computed for each domain namely; semantics, phonology, syntax, oral reading, and reading comprehension. This ensured standardized comparison between the various domains that differed with respect to the length of stimuli, the number of stimuli, and the degree of complexity. Additionally, the overall linguistic quotient (LQ) and reading quotient (RQ) were computed as per the formula below.

$$\text{LQ} = \frac{\text{Sum total of semantics, phonology, and syntax}}{110 (45+30+35)} \times 100$$

$$\text{RQ} = \frac{\text{Sum total of oral reading and reading comprehension}}{99 (30+69 \text{ in Kannada})} \times 100$$

$$\text{RQ} = \frac{\text{Sum total of oral reading and reading comprehension}}{109(40+69 \text{ in English})} \times 100$$

In oral reading tasks, speech sound distortions were considered as correct responses (1). Phonological errors like sound deletion (at' for 'mat'), substitutions (bat' for 'mat'), transpositions ('tab' for 'bat'), and/ or additions ('bata' for 'bat') were scored incorrect (0). Semantic errors and no responses were also scored incorrect (0) (For example, 'bat' for 'ball'). For every task, the participants were allowed to self-correct their errors, and only the final responses were considered. This scoring was applied to categorize the PWAs into subgroups of Alexia based on their oral reading errors.

#### 3.7.1 Oral Reading Error Analysis

To analyze and understand the relationship between linguistic and reading ability, individual-specific reading profiles were noted. Subsequently, the alexia type was determined through the participant's oral reading accuracy. The oral reading accuracy estimation was adapted

from previous studies by Brookshire, Conway, Hunting, Pompon, Oelke, and Kendall (2014) and Madden, Conway, Henry, Spencer, Yorkston and Kendall (2018).

Oral reading accuracy was computed by calculating every participant's 95% reading accuracy confidence interval (CI) for real regular words, irregular words, and non-words in the English language. Similarly, for Kannada CI for real regular words and non-words were computed. The formula is as below:

$$95\% \text{ CI} = \text{PWA's average score for word type} \pm (1.96 \times \text{SEM}) \text{ (Standard error of the Mean)}$$

For example, if a participant's accuracy score for real word is 80%.

Then his/her 95% CI for real word

$$= 80\% \pm (1.96 \times \text{SEM}) \text{ (for instance 0.3)}$$

$$= 0.80 \pm 0.588 = 0.74-0.86.$$

$$= 74\%-86\%.$$

Subsequently, alexia type was determined through the participant's oral reading accuracy in both Kannada and English languages. The subgrouping is explained below:

**Surface Alexia:** Characterized by the presence of regularization of irregular words. This kind of alexia is noted merely in the English language (alphabetic script). Individuals with surface alexia tend to read irregular words as real regular words. For instance, they read “yatch” as in “watch”. These errors are not observed in alpha-syllabic scripts (for instance in Kannada and other Indian languages) as these languages are transparent in nature (Karanth, 2003).

**Phonological Alexia:** Characterized by the presence of visual/ phonological errors, and lexicalization of non-words. For example, "table" for "tablet" in case of phonological errors; "pig" for "pling" in case of lexicalization of words. Similarly, in Kannada language the phonological errors may be as in /paalu/ for /haalu/ (milk). Hence, the individuals have better real words reading than non-word reading. Farah et al. (1996); Patterson, and Lambon Ralph, (1999) noted that in the case of phonological alexia, real word reading ability was around 50- 60% accurate for real words at 95% CI.

**Deep Alexia:** Characterized by manifestation of overall larger reading difficulty accompanied with semantic reading errors (“water” for “river”), which are marked to be the hallmark of Deep Alexia.

The overall reading scores was noted to be 50% and below with semantic errors (Crisp & Lambon Ralph, 2006; Lambon Ralph & Patterson, 2007, Madden et al., 2018). In addition, the real word (95% CI) accuracy was noted to be 60% and below with non-word reading accuracy being 30% and below. Thus, both semantic and phonological errors are noted with a predominance in phonological errors followed by semantic errors.

**Global Alexia:** Refers to completely impaired or near total impaired reading ability. Prior studies noted in these individuals, the overall oral reading accuracy accounts for 10% or less (Crisp & Lambon Ralph, 2006; Lambon Ralph & Patterson, 2007; Madden et al., 2018).

### 3.7.2. Alexia Subgrouping

Based on operational definitions and errors observed in a prior studies, the following subgroups of alexia based on reading the study sub-grouped the PWAs into alexia subgroups as per the scoring depicted in Table 3.4. The subgrouping of Alexia was assigned based on the reading profiles computed through oral reading accuracy and 95% confidence interval of each word type in both Kannada and English languages. Each individual's reading profile was computed and the alexia sub-grouping formed specific to Kannada and English languages is depicted in Table 3.5.

Table 3.4

*Alexia sub-grouping criteria for each word type*

<b>Alexia Subgroups</b>	<b>Overall Reading (%)</b>	<b>Real word (%)</b>	<b>Non-Word (%)</b>	
<b>Normal reading</b>	>95%	>95%	>95%	Overall above 95% accuracy in all types
<b>Phonological Alexia</b>	≥ 50%	>60%	30% to 50%	NW reading < RW reading with phonological errors
<b>Deep Alexia</b>	≤ 50%	<60% to 30%	<30%	Poor RW and NW reading with phonological and semantic errors
<b>Global Alexia</b>	<10%	<10%	<10%	Overall poor RW and NW reading.

*\*Note- NW=Non word, RW=Real word*

Table 3.5

*Reading profiles of Persons with aphasia in Kannada (L1) and English (L2)*

<b>Participant No.</b>	<b>Kannada Reading Profile</b>	<b>Overall Reading (%)</b>	<b>Real word Reading (%)</b>	<b>Non-Word Reading (%)</b>	<b>English Reading Profile</b>	<b>Overall Reading (%)</b>	<b>Real word Reading (%)</b>	<b>Non-Word Reading (%)</b>	<b>Irregular word Reading (%)</b>
<b>P1</b>	Phonological Alexia	50.00	100.00	0.00	Phonological Alexia	65.00	100.00	20.00	80
<b>P2</b>	Deep Alexia	20.00	40.00	0.00	Deep Alexia	15.00	33.33	0.00	10
<b>P3</b>	Phonological Alexia	66.67	80.00	53.33	Phonological Alexia	62.50	86.67	46.67	50
<b>P4</b>	Phonological Alexia	66.67	80.00	53.33	Deep Alexia	37.50	46.67	26.67	40
<b>P5</b>	Phonological Alexia	83.33	100.00	66.67	Phonological Alexia	80.00	100.00	46.67	100
<b>P6</b>	Phonological Alexia	73.33	100.00	46.67	Phonological Alexia	75.00	100.00	46.67	80
<b>P7</b>	Phonological Alexia	70.00	86.67	53.33	Phonological Alexia	50.00	80.00	33.33	30
<b>P8</b>	Phonological Alexia	73.33	80.00	66.67	Phonological Alexia	82.50	100.00	53.33	100
<b>P9</b>	Phonological Alexia	83.33	100.00	66.67	Phonological Alexia	70.00	100.00	46.67	60
<b>P10</b>	Phonological Alexia	60.00	93.33	26.67	Deep Alexia	32.50	53.33	20.00	20
<b>P11</b>	Phonological Alexia	56.67	73.33	40.00	Deep Alexia	15.00	20.00	6.67	20
<b>P12</b>	Deep Alexia	16.67	33.33	0.00	Global Alexia	5.00	6.67	0.00	10
<b>P13</b>	Global Alexia	6.67	13.33	0.00	Global Alexia	10.00	13.33	0.00	20
<b>P14</b>	Deep Alexia	16.67	20.00	13.33	Deep Alexia	10.00	13.33	0.00	20
<b>P15</b>	Deep Alexia	16.67	33.33	0.00	Deep Alexia	20.00	33.33	0.00	30
<b>P16</b>	Global Alexia	0.00	0.00	0.00	Global Alexia	10.00	13.33	0.00	20
<b>P17</b>	Deep Alexia	16.67	33.33	0.00	Global Alexia	0.00	0.00	0.00	0.00
<b>P18</b>	Global Alexia	0.00	0.00	0.00	Global Alexia	0.00	0.00	0.00	0.00
<b>P19</b>	Global Alexia	0.00	0.00	0.00	Global Alexia	0.00	0.00	0.00	0.00
<b>P20</b>	Global Alexia	0.00	0.00	0.00	Global Alexia	0.00	0.00	0.00	0.00

### 3.7.3. Reliability

The inter-judge reliability for oral reading accuracy measures was analyzed based on the judgements of three experienced speech-language pathologists over real word reading, non-word reading, and irregular word reading responses of PWAs in both Kannada and English languages.

Three raters were native speakers of Kannada with 6.5 years of average experience in the assessment and management of PWAs. All raters were Kannada-English bilinguals who had 'good' to 'native-like' proficiency in both languages on the modified language proficiency questionnaire. The raters were oriented over scoring for the speech distortions, phonological errors, and semantic errors, and accordingly were asked to score the oral reading accuracy of random samples of the data. The raters were given the audio recordings of 25% of the PWAs (5 samples out of 20) to analyze the reading accuracy. All raters independently scored the reading accuracy for a) real word, b) non-word, and c) irregular word reading of both Kannada and English audio-recorded samples. The data obtained was subjected to Cronbach's alpha ( $\alpha$ ) to estimate the internal consistency for each type of oral reading accuracy measure and results are tabulated in Table 3.6.

Table 3.6

*Inter-rater reliability of Oral reading accuracy in Kannada and English through Cronbach's alpha*

Language	Oral reading type	Cronbach's alpha ( $\alpha$ )
<b>Kannada</b>	Real Word Reading	0.998
	Non -Word Reading	0.995
<b>English</b>	Real Word Reading	0.998
	Non -Word Reading	0.996
	Irregular Word Reading	0.982

The results of Cronbach's correlation coefficient ( $\alpha$ ) showed values above 0.9 for all types of oral reading accuracy scoring in both Kannada and English languages. This signified excellent inter-rater reliability for these measures. Values above 0.9 are excellent reliability, between 0.9 to 0.7 denotes 'good' reliability, 0.6 to 0.7 denotes 'acceptable', 0.6 to 0.5 is 'poor', and less than 0.5 is considered 'unacceptable' (Kline, 1999). Thus, from the above results the oral reading accuracy scoring between the three raters manifested excellent reliability. The other dependent variables,

namely, semantic, phonological, phonology, and reading comprehension abilities all depended on the 'yes-no' responses of the participant, subjectively. Verbal responses with variabilities were noted only in oral reading responses. As this measure was the sole predictor of subgrouping alexia in Kannada and English languages, the investigator intended to consider the inter-rater reliability for oral reading accuracy scoring.

### 3.8 Outcome measures

#### 3.8.1 Objective 1

To examine the relationship between semantics and phonology (linguistics) with oral reading abilities in bilingual PWAs in Kannada and English languages in isolation, the scores of all oral reading tasks (overall reading, real word reading, non-word reading, and irregular word reading) were correlated with phonological and semantic scores of every participant separately for each language (Kannada and English) through correlation analysis. Also, Multi Linear regression analysis (MLR) was carried out with semantic and phonological scores with respect to each oral reading word type. The tasks of phonology and semantics were the predictors influencing oral reading accuracy across all the word types in Kannada and English. The variables are depicted in Table 3.7 for MLR analysis.

Table 3.7

*MLR stepwise analysis between sub-tasks of phonology and semantics with Oral reading in Kannada and English*

	Linguistic Tasks (Dependent Variables)	Oral Reading (Single Word) (Independent Variables)	
		Kannada	English
Semantic tasks	Picture Association		
	Picture Identification\		
	Auditory Synonym		
	Judgment		
Phonological tasks	Auditory comprehension	❖ Overall oral reading	❖ Overall oral reading
	Real Word rhyme	❖ Real word Reading	❖ Real word Reading
	judgement	❖ Non-word reading	❖ Irregular word reading
	Nonword rhyme judgment		❖ Non-word reading
	Phonological manipulation		

### 3.8.2 Objective 2

To examine the relationship between semantics, phonology, and syntax (linguistic) with silent reading comprehension in bilingual PWAs, the average scores of semantics, phonology, and syntax were compared with the scores of single-word comprehension, sentence comprehension, and paragraph comprehension of every participant in both Kannada and English languages through correlation analysis.

Further, the tasks of semantic, phonology and syntax were individually compared with all the silent reading comprehension scores through multiple linear regression analysis to understand the predictors of silent reading comprehension in Kannada and English languages. The variables are depicted in Table 3.8 for MLR analysis.

Table 3.8

*MLR stepwise analysis between sub-tasks of semantics, phonology and syntax with silent reading comprehension in Kannada and English*

	Linguistic Tasks (Dependent Variables)	Oral Reading (Single Word) (Independent Variables)	
		Kannada	English
Semantic tasks	Picture Association		
	Picture Identification		
	Auditory Synonym Judgment		
	Auditory comprehension		
Phonological tasks	Real Word rhyme judgement	❖	Overall reading comprehension
	Nonword rhyme judgment	❖	Word level
	Phonological manipulation	❖	Sentence level
		❖	Paragraph level
Syntax tasks	Syntax marker judgement		
	Sentence comprehension		
	Locative Identification		

### 3.8.3 Objective 3

To understand the orthography effect on reading impairment across Kannada and English reading abilities in bilingual PWAs, the reading abilities were compared at two levels: a) Between Kannada and English and b) within Kannada and English performance of PWAs (Table 3.9).

Table 3.9

*List of Variables considered in objective 3*

<b>Independent Variable</b>	<b>Dependent Variable</b>
Orthography transparency- Kannada and English	Reading Quotient (RQ)
	Oral reading
	Silent Reading Comprehension

### 3.8.4 Objective 4

To understand the cross-linguistic effect (Kannada versus English) in linguistic impairment in bilingual PWAs. The linguistic abilities were compared at two levels: a) Between Kannada and English and b) within Kannada and English performance of PWAs (Table 3.10).

Table 3.10

*List of Variables considered in objective 4*

<b>Independent Variable</b>	<b>Dependent Variable</b>
Language- Kannada and English	Language Quotient (LQ),
	Semantics,
	Phonology
	Syntax

### 3.8.5 Objective 5

To compare a few aspects of linguistic and reading abilities across and within the type of alexia in Kannada and English languages among bilingual PWAs. The participants were grouped based on the alexia type (Phonological, Deep, or Global Alexia) and subsequently their performance in semantics, phonology, syntax, oral reading, and reading comprehension were compared across all

types of alexia groups and within alexia groups separately in Kannada and English languages. The variables are depicted in the Table 3.11 and 3.12 below.

Table 3.11

*Linguistic and reading performance comparison across Alexia sub-types.*

<b>Domains (Dependent Variables)</b>	<b>Sub types of alexia (Independent Variable)</b>	
	<b>Kannada</b>	<b>English</b>
<b>Linguistic tasks</b>		
Phonology	Phonological	
Semantics	vs	
Syntax	Deep Alexia	
<b>Reading tasks</b>	vs	
Oral Reading	Global Alexia	
Silent Reading Comprehension		

Table 3.12

*Linguistic and reading performance comparison within Alexia sub-types*

<b>Subtypes of alexia (Independent Variable)</b>	<b>Linguistic</b>		<b>Reading</b>	
	Kannada	English	Kannada	English
Phonology Alexia	Phonology			
Deep Alexia	vs		Oral Reading	
	Semantics		vs	
Global Alexia	vs		Silent Reading Comprehension	
	Syntax			

These outcome measures were subjected for detailed data analysis to address each of the objectives of the study. The data analysis is discussed in detail below.

### 3.9 Statistic Analysis

In the study, twenty PWAs were addressed as a whole group for analyzing the relationship shared and within-group comparisons between linguistic and reading domains, considering the independent variables as Kannada and English languages. Further, with extended interest, the study grouped the PWAs into alexia sub-groups based on each PWA's oral reading accuracy to analyze

within and across alexia sub-groups comparisons, considering alexia sub-groups (phonological, deep, and global) as independent variables. The study addressed the PWAs as a whole group owing to the primary objective of the study to gauge the relationship between linguistic and reading abilities irrespective of aphasia type, and severity. Wherein, the primary objective of the study was to also explain the influence of linguistic abilities on reading impairments in PWAs with alexia with underlying principles of primary system hypothesis in bilingual context. As a secondary objective, the alexia sub-grouping was analyzed to understand the linguistic and reading abilities within and across alexia sub-groups. Also, the practicality of analyzing the sub-groups of alexia to investigate the relationship between linguistic and reading abilities, and predictors of reading abilities through linguistic tasks was not viable due to sample inadequacy to run the tests. A similar study design was followed in the experiment by Madden et al. (2018).

The independent variables in the study were the languages used (Kannada & English) and the type of alexia (phonological alexia, deep alexia, and global alexia) of PWAs. The dependent variables in the study were measures of semantics, phonology, and syntax (linguistic abilities) along with measures of oral reading and reading comprehension (reading abilities).

The data compiled was subjected to detailed statistical analyses through Statistical Package for Social Sciences (Version 26.0) (SPSS Inc. Chicago). First, the data was verified for normality distribution via the Shapiro-Wilk test of normality. Few outcome measures manifested normal distribution ( $p > 0.05$ ) (semantics, phonology, syntax, language quotient, reading quotient, and reading comprehension) and few non-normal ( $p < 0.05$ ) (overall oral reading, real word reading, non- word reading). Further, descriptive statistics was applied to compute the central tendency measures of mean, median, and quartile with stand deviations. This was followed by the application of specific tests respective to the objectives of the study.

The performances of all twenty PWAs on linguistic and reading domains in Kannada and English languages were compiled and subjected to detailed statistical analysis through Statistical Package for Social Science (Version 26.0) (IBM Corp., 2019).

- First, the normality of the data was assessed using the Shapiro-Wilk test. Some outcome measures exhibited a normal distribution ( $p > 0.05$ ), while others did not ( $p < 0.05$ ).

Descriptive statistics were then used to calculate central tendency measures, including the mean, median, quartiles, and standard deviations.

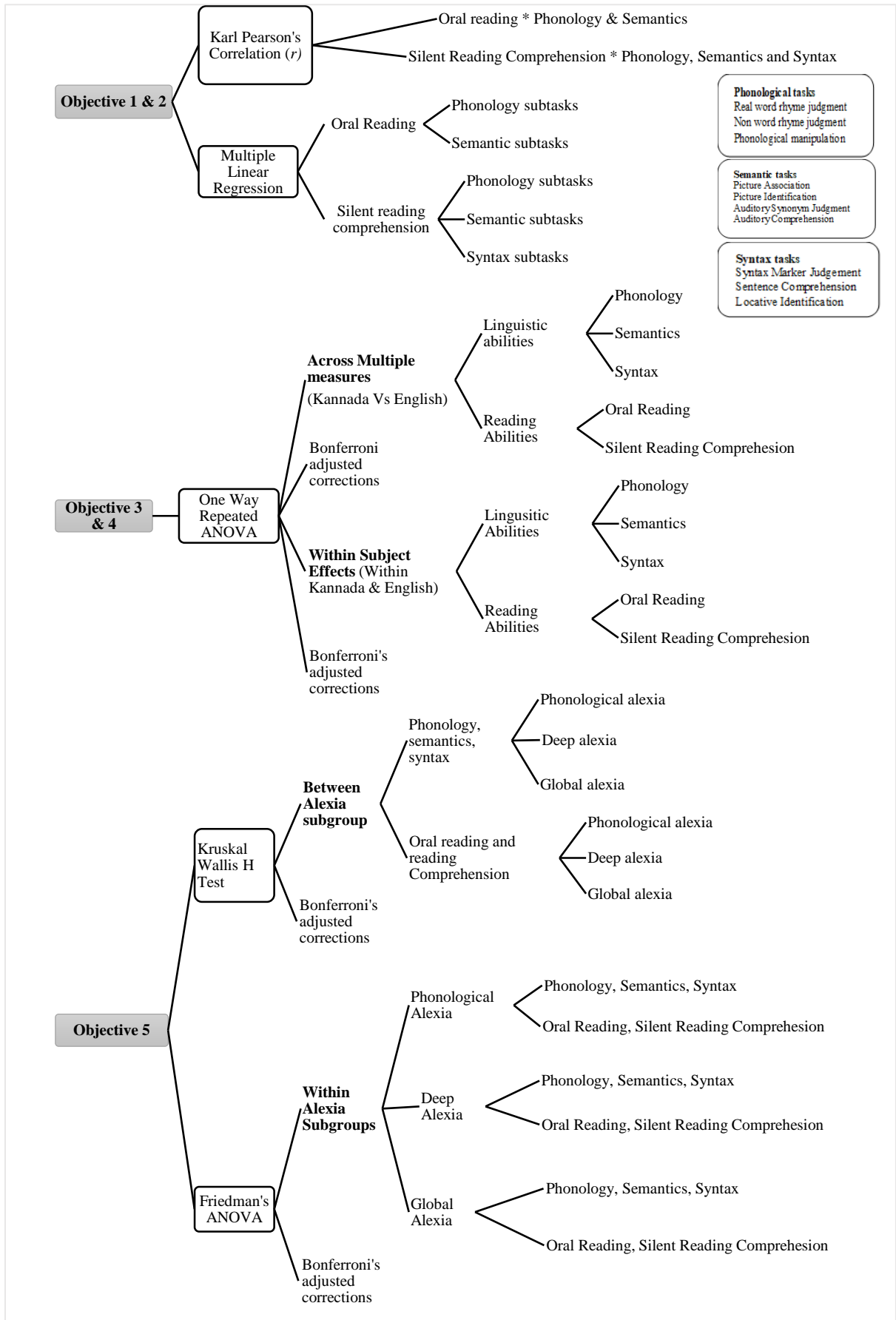
- The objective 1 and 2 were analyzed for the relationship shared between the main domains through bivariate Karl Pearson's correlation coefficient ( $r$ ) analysis, followed by Multiple Linear Regression (MLR) analysis to delineate relations between specific tasks of linguistic abilities and reading abilities.
- The strength of correlation is typically interpreted based on the absolute value of Pearson's correlation coefficient ( $r$ ). Value of  $r= 0.90- 1.00$  is denoted very strong correlation,  $r= 0.70$  to  $0.89$  is strong,  $0.50- 0.69$  is moderate,  $0.30- 0.49$  is weak and  $0.00-0.29$  is very weak or no correlation (Pearson, 1896).
- In MLR, the models were analysed for multicollinearity through Variance Inflation Factor (VIF) and tolerance collinearity (T). This situation arises when two or more independent variables are highly correlated with one another. As a result, it becomes challenging to determine which independent variable is responsible for the variance in the dependent variable, and it can also cause technical difficulties when calculating a multiple regression model. VIF value less than 2 confirms absence of multicollinearity. Tolerance value (T) above 0.1 denotes absence of multicollinearity (Laerd Statistics, 2015, Madden, 2018).
- Objective 3 aimed to investigate the reading abilities across and within Kannada and English languages. Parametric One- way repeated measure ANOVA (Multiple measure analysis) was applied for across language effects, and non- parametric Wilcoxon Sign Rank test for within language effects.
- Objective 4 focused to examine the linguistic abilities across and within Kannada and English languages, which was addressed through parametric One-Way Repeated Measure ANOVA with pairwise comparisons via adjusted Bonferroni' s corrections ( $\alpha= 0.05$ ).
- Objective 5 aimed at examining the linguistic and reading abilities across and within alexia sub groups in Kannada and English languages, which was analyzed through non-parametric Kruskal Wallis H test for between alexia sub group comparisons and Friedman's test for

within alexia sub group comparisons. Adjusted Bonferroni's corrections were applied for pairwise comparisons subsequent to Kruskal Wallis and Friedman's tests.

- For results of One-Way Repeated measure ANOVA, the effect sizes at  $\eta_p^2 \leq 0.009$ , 0.06 and 0.1 were considered as low, medium and large effects, respectively (Norouzian & Plonsky, 2018) on every pairwise comparisons.
- For results of Kruskal Wallis and Friedman's test, effect size ( $r_e$ ) =  $Z/\sqrt{N}$  (N- total no. of observations) was computed manually for all pairwise comparisons. Value of  $r_e \leq 0.3$ , 0.3-0.5, and  $>0.5$  were considered as low, medium, and large effects, respectively (Field, 2005).
- An attempt was made to apply higher order statistics like Principle Component Analysis (PCA) or structural equation modelling, however as sample adequacy was not met, these tests could not be applied. Hence, the data is discussed with correlation and multiple linear regression analysis.
- Also, combined model could not be applied due to task and stimuli variabilities between Kannada and English.

The details of statistical analysis are explained in detail in the following chapter. The flow chart of data analysis is depicted in Figure 3.15.

Figure 3.15. Summary of Statistical Analysis of the Data



## CHAPTER IV

### RESULTS

The study aimed to explore the relationship between linguistic performances (semantics, phonology, and syntax) and reading performances (oral reading and reading comprehension) in bilingual PWAs in Kannada and English languages. The linguistic abilities refer to the processing aspects like semantics, phonology, and syntax. The reading abilities refer to the written language aspects like oral reading and reading comprehension. To address the linguistic and reading abilities in bilingual PWAs, a series of specific behavioral tasks were designed in Kannada and English languages. The participants' abilities in semantics, phonology, and syntax were examined through various sub tasks, and scores were computed in terms of binary scoring ('0' - incorrect/ no response and '1' - correct response). Similarly, the participants' performance in oral reading and reading comprehension domains were examined through subtasks, following the same binary scoring system mentioned above. Further, each domain scores were averaged. The total number of stimuli in all tasks and subtasks in Kannada and English remained same, except for oral reading task. The scores of oral reading task was converted into percentage as the total number of stimuli varied between Kannada and English languages. This ensured standardized comparison between the various domains that differed with respect to length of the stimuli, the number of stimuli, and degree of complexity. The study also analyzed the oral reading accuracy of each bilingual PWA to determine their alexia subtypes, exclusively in Kannada and English languages.

The performance of twenty Kannada - English bilingual PWAs with alexia secondary to left hemispheric stroke were subjected to detailed statistical analysis. The independent variables considered in the study were the languages known (Kannada & English) and the type of alexia (phonological alexia, deep alexia, and global alexia) of PWAs. The dependent variables considered in the study were measures of semantics, phonology, syntax, and language quotient (LQ) (linguistic abilities), oral reading, reading comprehension, and reading quotient (RQ) (reading abilities) which served as outcome measures in the study.

The results are discussed under the following main headings:

- 4.1 Relationship between a few aspects of phonology, and semantics (linguistic form) with oral reading abilities in bilingual PWAs in Kannada language.
- 4.2 Relationship between a few aspects of phonology, and semantics (linguistic form) with oral reading abilities in bilingual PWAs in English language.
- 4.3 Relationship between semantics, phonology, and syntax (linguistic) with silent reading comprehension in bilingual PWAs in Kannada language.
- 4.4. Relationship between semantics, phonology, and syntax (linguistic) with silent reading comprehension in bilingual PWAs in English language.
- 4.5. Orthography effects (alpha syllabic versus alphabetic system) on reading abilities in Kannada and English languages of bilingual PWAs.
- 4.6. Cross linguistic variations in linguistic abilities of Kannada and English languages in bilingual PWAs.
- 4.7. Performance in linguistic and reading abilities in bilingual PWAs across and within alexia groups in Kannada and English languages.

The performance of all twenty PWAs on linguistic and reading domains in Kannada and English were compiled and subjected to detailed statistical analysis. The details of statistical analysis applied based on each objective of the study are described in the Table 4.1 below.

Table 4.1

*Description of statistical analysis employed in the study specific to each objective.*

Sl. No.	Objective	Statistical Analysis	
<b>Objective 1.</b>	Relationship between phonology, and semantics (linguistic) with oral reading abilities in bilingual PWAs in Kannada & English.	<i>Descriptive statistical analysis</i>	
		Mean, Standard deviation, Interquartile range on measures of	
		Kannada	English
		–Phonology	–Phonology
		–Semantics	–Semantics
		–Overall oral reading	–Overall oral reading
		–Real word oral reading	–Real word oral reading
–Non- word reading	–Non- word reading		

- 
- Non- word oral reading
  - Irregular word oral reading

i. Correlation between performance in overall oral reading, real word oral reading, and non-word oral reading with phonology and semantics in Kannada

**Bivariate Pearson’s Correlation Coefficient Analysis ( $r$ )**

ii. Predictors of overall oral reading, real word oral reading, non- word oral reading abilities through subtasks of phonology and semantics, in Kannada & English.

**Multi Linear regression (MLR) analysis in stepwise method**

---

**Objective 2.** Relationship between semantics, phonology, and syntax (linguistic) with silent reading comprehension in bilingual PWAs in Kannada & English.

Descriptive statistical analysis  
Mean, Standard deviation, Interquartile range on measures of

---

Kannada & English

- 
- Phonology
  - Semantics
  - Syntax
  - Overall silent reading comprehension
  - Single word reading comprehension
  - Sentence reading comprehension
  - Paragraph reading comprehension

i. Correlation analysis between performance in overall reading comprehension, single word reading comprehension, sentence reading comprehension, and paragraph reading comprehension, and performance in semantics, phonology, and syntax in Kannada & English languages.

**Bivariate Pearson’s Correlation Coefficient Analysis ( $r$ )**

ii. Predictors of overall reading comprehension, single word reading comprehension, sentence reading comprehension, and paragraph reading comprehension through subtasks of

**Multi Linear regression (MLR) analysis in stepwise method**

---

semantics, phonology, and syntax in Kannada & English languages.

<b>Objective 3.</b>	Examine the orthography effect (alpha syllabic vs alphabet system) in reading abilities of Kannada and English languages in PWAs.	<i>Descriptive statistical analysis</i> Mean, Standard deviation, Interquartile range on measures of
		Kannada & English
		<ul style="list-style-type: none"> <li>-Reading Quotient</li> <li>-Oral Reading</li> <li>-Silent Reading comprehension</li> </ul>
i.	To compare performance in reading abilities (oral reading and reading comprehension) between Kannada and English languages.	<p><b>One Way Repeated Measure ANOVA</b> (Multiple measure analysis)</p>
ii.	To compare performance in reading abilities (oral reading and reading comprehension) within Kannada and English languages.	<p><b>Wilcoxon Sign Rank test</b></p>
<b>Objective 4.</b>	Examine cross linguistic variations in linguistic abilities of Kannada and English languages in PWAs.	<i>Descriptive statistical analysis</i> Mean, Standard deviation, Interquartile range on measures of
		Kannada and English
		<ul style="list-style-type: none"> <li>- Language Quotient</li> <li>- Semantics</li> <li>- Phonology</li> <li>- Syntax</li> </ul>
i.	To compare performance in linguistic abilities (semantics, phonology, and syntax) between Kannada and English languages.	<p><b>One Way Repeated Measure ANOVA</b> (Multiple measure analysis)</p>
ii.	To compare performance in linguistic abilities (semantics, phonology, and syntax) within Kannada and English languages.	<p><b>One Way Repeated Measure ANOVA</b> - Bonferroni's adjusted pairwise</p>

<b>Objective 5 (Secondary Objective)</b>	To compare a few aspects of linguistic and reading abilities across and within the type of alexia in Kannada and English languages among bilingual PWAs.	<i>Descriptive statistical analysis</i> Mean, Standard deviation, Interquartile range on measures of	Kannada and English		
			Alexia groups	Linguistic	Reading
			<b>Phonological</b>	Phonology	Oral reading
			<b>Deep</b>	Semantics	Reading
			<b>Global</b>	Syntax	comprehension
i.	To compare phonology, semantics and syntax between alexia sub-groups in Kannada and English languages.	} —	<b>Kruskal Wallis H Test</b> (Between sub-groups effects)		
ii.	To compare oral reading and reading comprehension abilities between alexia sub- groups in Kannada and English.		— Bonferroni’s adjusted pairwise comparison		
iii.	To compare semantics, phonology, and syntax within alexia sub-groups in Kannada and English languages.	} —	<b>Friedman's ANOVA</b> (Within Sub groups analysis)		
iv.	To compare oral reading and reading comprehension abilities within alexia sub- groups in Kannada and English.		— Bonferroni’s adjusted pairwise comparison		

#### 4.1 Relationship between a few aspects of phonology, and semantics (linguistic) with oral reading abilities in bilingual PWAs in Kannada.

The section delineates the relationship between linguistic abilities and reading abilities of Kannada-English bilingual PWAs in Kannada language. Each participant’s performance was analysed across linguistic abilities (semantics, and phonology) and reading abilities (oral reading and reading comprehension). The average scores of all 20 PWAs were subjected to descriptive analysis to observe the central tendency and dispersion measures (Mean, S.D, and interquartile range) of each domain. The results are illustrated in the Table 4.2 and Figure 4.1.

Table 4.2

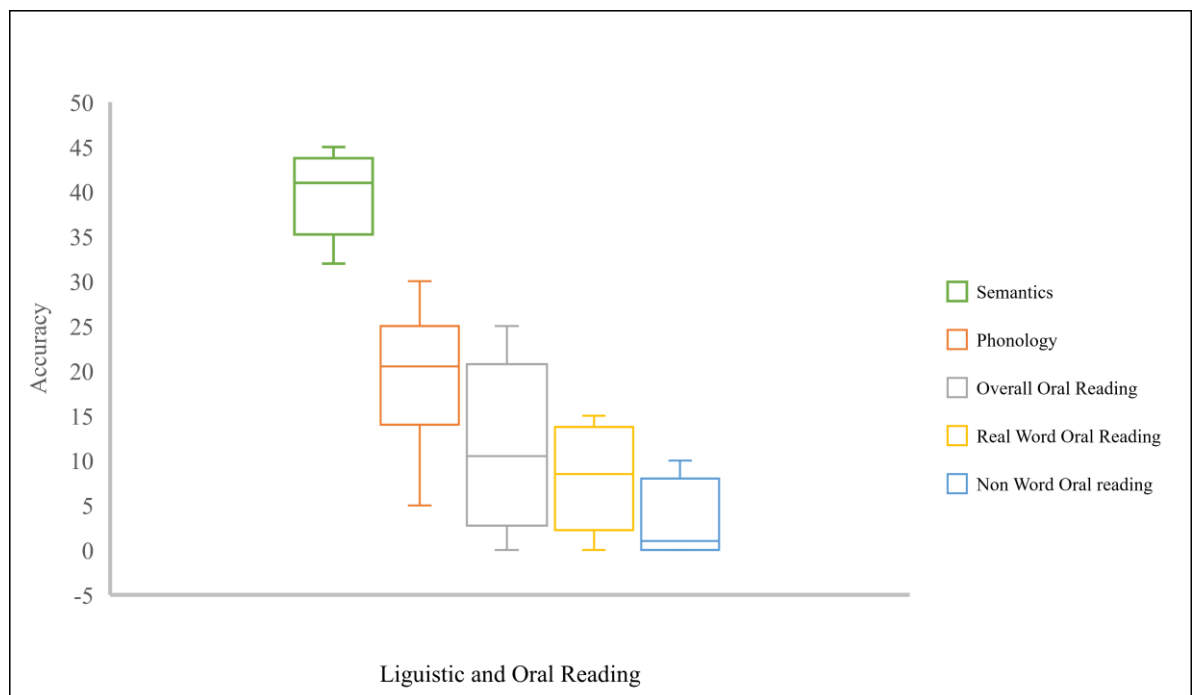
*Performance of PWAs in semantics, phonology (linguistic) and oral reading in Kannada language*

Tasks	Kannada (L1)			
	Mean	Median	S.D	Interquartile range
Semantics	39.80	41.00	4.28	8.50
Phonology	18.85	20.5	7.45	11.00
Overall Oral reading	11.65	10.5	9.60	18.00
Real word oral reading	8.00	8.50	5.90	11.50
Non- word oral reading	3.65	1.00	4.17	8.00

*Note: S.D- Standard deviation; L1- First language*

Figure 4.1

Box plot depicting the performance in Oral reading and Linguistic domains in Kannada



*Note: X – axis indicates the domains (Semantics, phonology, and oral reading tasks); Y- axis denotes the accuracy in performance with mean scores; The horizontal line indicates the mean scores and the error bars in the data points indicate the standard error.*

On comparing the central tendency measures (means) of semantics and oral reading abilities, the scores were dispersed. From Table 4.1 and Figure 4.1, the trend in performance was noted to be highest in semantics ( $\bar{X}$ = 39.80, S. D= 4.28) and least in phonology ( $\bar{X}$ =18.85, S. D= 7.45) in Kannada language. The lowest performance was noted in overall oral reading ( $\bar{X}$ = 11.65, S.D= 9.60) against phonology and semantic abilities. Specifically, oral reading abilities were gauged through real word and non- word reading in the PWAs. The oral reading abilities in non- word reading was poorest ( $\bar{X}$ = 3.65, S. D= 4.17) compared to real word reading ( $\bar{X}$ = 8.00, S. D= 5.90) concerning Kannada language.

To further validate the relationship between phonology, semantics and oral reading abilities, the correlation analysis was applied on the diverse performance observed across these domains. This was followed by Multiple Linear Regression (MLR) analysis to examine the predictors of oral reading abilities with subtasks of phonology and semantics in specific to Kannada language, as described below in section 4.1.1 and 4.1.2.

#### ***4.1.1. Relationship between phonology, semantics with oral reading abilities in Kannada (Correlation).***

The bivariate Karl Pearson's Correlation Coefficient test was applied between phonology, semantics and oral reading abilities to elucidate the relationship between each of these individually. The oral reading abilities were found to share significantly strong correlation ( $r = 0.50-1.00, p < 0.05$ ) (Pearson, 1896) with all aspects of linguistic abilities (semantics, phonology) in Kannada language performance of all PWAs (N= 20) (Table 4.2). Specifically, phonology strongly correlated with oral reading abilities ( $r = 0.610, p = 0.004$ ), followed by semantics ( $r = 0.564, p = 0.01$ ). The real word and non-word reading abilities positively correlated with phonology, and semantics. Of these, phonology shared the strongest significant correlation with real word reading ( $r = 0.623, p = 0.003$ ) and non- word reading ( $r = 0.510, p = 0.022$ ) (Figure 4.2). Semantics showed next highest significant correlation with real word reading ( $r = 0.574, p = 0.008$ ). However, semantics showed moderate correlation with non-word reading abilities ( $r = 0.476, p = 0.034$ ) (Figure 4.3). Figure 4.2 and Figure 4.3 depict the scatter plot with regression line illustrating the linear relationship with phonology, semantics and both types of oral reading skills, respectively.

Table 4.3

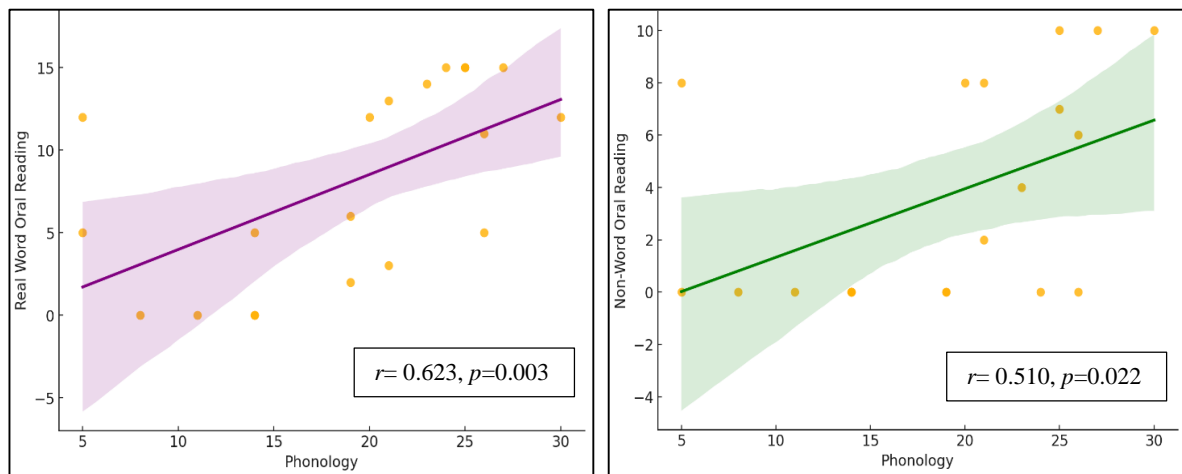
Results of Pearson's Correlation coefficient ( $r$ ) analysis between phonology and semantics with oral reading in Kannada.

	Phonology	Semantics	Oral reading	Real word Reading	Non Word reading
Oral reading	0.610**	0.564*			
Real Word Reading	0.623**	0.574**	0.962**		
Non Word Reading	0.510*	0.476*	0.922*	0.780**	

Note: \*\* $p < 0.01$ , \* $p < 0.05$ .

Figure 4.2

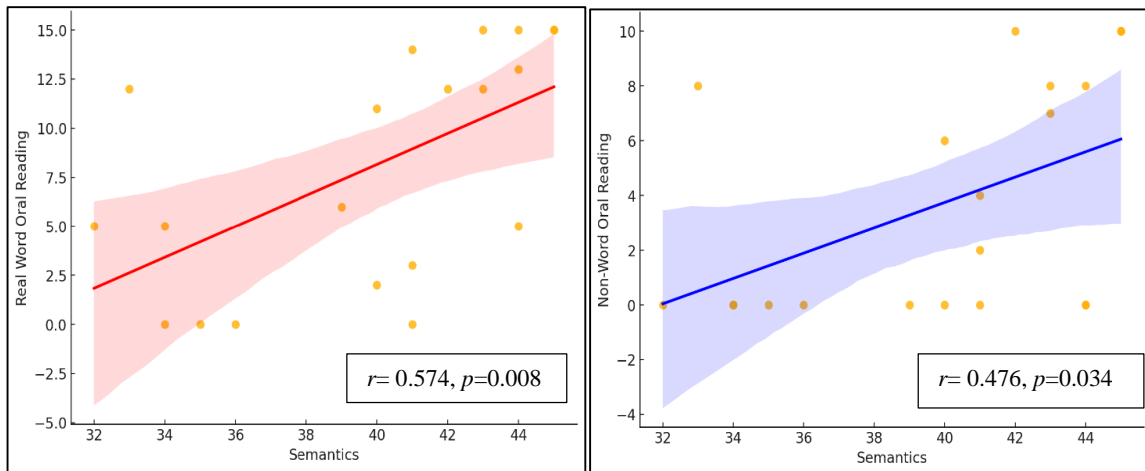
Regression plot depicting correlation of real word and non-word reading with phonology in Kannada



Note- X-axis represent phonology scores, and Y-axis represent real word oral reading scores. The linear line represents the linear relation between phonology and each type of oral reading performance. The shaded region represents 95% confidence region around the line.

Figure 4.3

Regression plot depicting correlation of real word, non-word reading with semantics in Kannada



Note- X-axis represent semantic scores, and Y-axis represent real word and non- word oral reading scores.

The linear line represents the linear relation between semantics and each type of oral reading performance.

The shaded region represents 95% confidence region around the line.

Subsequent to examining linear relationship between phonology, semantics (linguistic abilities) and oral reading confirmed through bivariate correlation and scatter plots above, the study further explored the predictors of oral reading abilities through subtasks of phonology and semantics in Kannada applying Multiple Linear Regression (MLR) analysis.

#### 4.1.2. Phonological and Semantic predictors of Oral Reading abilities.

##### 4.1.2.a) Oral reading abilities and phonological subtasks of Kannada

The MLR analysis was applied on variables of phonology. Table 4.4 demonstrates the results of three MLR models with scores of subtasks of phonology entered in stepwise manner with standardised residual analysis. The real word rhyme judgement, non-word rhyme judgment, and phonological manipulation (parsing & blending phoneme) tasks were entered simultaneously as independent variable or predictors of a) Overall oral reading abilities, b) Real word reading abilities and c) Non- word reading abilities, which were the respective dependant variables. Phonology exhibited significantly highest correlation ( $r>0.5$ ,  $p<0.01$ ) with overall oral reading, real word reading, and non- word reading based on correlation analysis (Section 4.1.1).

The predicted model was verified for normality distribution through Shapiro- Wilk test. The standardised residuals were normally distributed in overall oral reading condition ( $p= 0.928$ ), real word reading condition ( $p= 0.896$ ), and non-word reading condition ( $p= 0.524$ ). Further, the predictors were observed for multicollinearity through Variance Inflation Factor (VIF) and tolerance collinearity (T). The VIF for phonological manipulation task was 1.00, real word rhyme judgment was 1.214, and non- word rhyme judgment was 1.176. As all VIF values were less than 2, the multicollinearity was absent (Douglas et al., 2021). The tolerance statistical collinearity (T) value for phonological manipulation task was 1.00, real word rhyme judgment was 0.824, and non- word rhyme judgment was 0.851 depicting no interference between the predictors as the values were greater than 0.1 (Laerd Statistic, 2015; Madden 2016). Thus, the predictors were independent of interference to each other in the model.

The MLR model predicted the phonological manipulation task as the most significant predictor of overall oral reading abilities in Kannada language with highest variance ( $R^2_{adj}= 0.231, p = 0.019$ ) (Table 4.4).

Further, the specific relationship between real word oral reading and non- word oral reading conditions with phonological tasks were analysed. The phonological predictor of real word oral reading was predicted as phonological manipulation task with a high statistical significant variance ( $R^2_{adj}= 0.265, p = 0.012$ ). The non-word rhyme judgment task proved to be the phonological predictor for non –word oral reading ( $R^2_{adj}= 0.163, p = 0.044$ ). The results are depicted in Table 4.4.

Table 4.4

*Multiple linear regression analysis of oral reading abilities with phonology sub tasks in Kannada.*

<i>Stepwise Standard Regression</i>						
	$R^2_{Total}$	$R^2_{Adj}$	$F_{Total}$	$\beta$	$t$	$p$ value
<b>Overall Oral Reading</b>	0.271	0.231	6.689 (1,18)*			
Real Word Rhyme judgement				0.248	1.138	0.271
Non Word Rhyme judgement				0.250	1.118	0.279
<b>Phonological manipulation</b>				<b>0.52</b>	<b>1.307</b>	<b>0.019*</b>
<b>Real word Reading</b>	0.304	0.265	7.849 (1,18)**			
Real Word Rhyme judgement				0.286	1.34	0.19
Non Word Rhyme judgement				0.177	0.822	0.422
<b>Phonological manipulation</b>				<b>0.551</b>	<b>2.80</b>	<b>0.012*</b>
<b>Non word Reading</b>	0.207	0.163	4.697 (1,18)*			
Real Word Rhyme judgement				0.157	0.436	0.668
<b>Non Word Rhyme judgement</b>				<b>0.455</b>	<b>2.167</b>	<b>0.044*</b>
Phonological manipulation				0.275	1.228	0.236

Note: \*\*\* $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$ .  $\beta$ - Beta refers to standardised coefficients,  $t$ - test statistics.

#### 4.1.2.b) Oral reading abilities and semantic subtasks of Kannada

Multiple Linear Regression (MLR) analysis was further performed to delineate the predictors of oral reading abilities in Kannada with the subtasks of semantics after evidencing strong linear relationship with overall oral reading, real word reading and non- word reading conditions ( $r > 0.05$  at  $p < 0.01$ ) (Section 4.1.1). Table 4.5 illustrates the results of three MLR models with scores of subtasks of semantics entered in stepwise manner with standardised residual analysis. The subtasks of semantics, namely auditory comprehension, picture identification, picture association and auditory judgement were entered parallel as independent variable or predictors of a) Overall oral

reading abilities, b) Real word reading abilities and c) Non word reading abilities, which were the respective dependant variable or outcome measures.

Initially, the standardised residuals of the MLR model analysis were subjected to normality distribution through Shapiro- Wilk test. The test revealed that standardised residuals were normally distributed in overall oral reading condition ( $p= 0.595$ ), real word reading condition ( $p= 0.107$ ), and non-word reading condition ( $p= 0.508$ ).

Further, the predictors were analysed for collinearity factor analysis to rule out the multicollinearity through VIF and tolerance collinearity (T). The values of VIF for auditory comprehension was 1.00, auditory judgment task was 1.37, picture identification task was 1.19, and picture association task was 1.36. As all VIF values were less than 2 the multicollinearity was absent (Douglas et al., 2021). The tolerance statistical collinearity (T) value was estimated to be 1.00 for auditory comprehension task, 0.837 for picture identification task, 0.863 for picture association task and 0.755 for auditory judgment task. In this instance, as tolerance value was above 0.1 multicollinearity was ruled out (Laerd Statistics, 2015, Madden et al., 2018), suggesting that these predictors do not interfere with each other in the analysis.

The results of MLR model clearly suggested that the auditory comprehension and picture identification tasks manifested higher and significant variance ( $p < 0.01$ ) for overall oral reading ( $R^2_{adj}= 0.568$ ,  $p < 0.001$ ) in Kannada language.

The auditory comprehension and picture identification tasks were also the strong semantic predictors of real word oral reading ( $R^2_{adj}= 0.367$ ,  $p < 0.001$ ), and non –word oral reading ( $R^2_{adj}= 0.415$ ,  $p < 0.01$ ). The picture association and auditory judgment were excluded from the model as they did not show statistical significant variance ( $p > 0.05$ ) with any of the oral reading conditions. This indicated that the picture association and auditory judgment tasks are not the predicting factors of oral reading abilities in Kannada language. Results are depicted in Table 4.5 below.

Table 4.5

*Multiple linear regression analysis of oral reading abilities and semantic sub tasks in Kannada.*

<i>Stepwise Standard Regression</i>						
	$R^2_{Total}$	$R^2_{Adj}$	$F_{Total}$	$\beta$	$t$	$p - value$
<b>Overall Oral Reading</b>	0.613	0.568	13.468 (2,17) <sup>***</sup>			
Auditory Comprehension				<b>0.826</b>	<b>5.00</b>	<b>0.000<sup>***</sup></b>
Picture Identification				<b>0.541</b>	<b>3.27</b>	<b>0.004<sup>**</sup></b>
Picture Association				0.030	0.16	0.267
Auditory Judgement				0.205	1.17	0.257
<b>Real word Reading</b>	0.607	0.560	13.104 (2,17) <sup>***</sup>			
Auditory Comprehension				<b>0.833</b>	<b>5.011</b>	<b>0.000<sup>***</sup></b>
Picture Identification				<b>0.496</b>	<b>2.984</b>	<b>0.008<sup>**</sup></b>
Picture Association				0.027	0.149	0.883
Auditory Judgement				0.201	1.140	0.271
<b>Non word Reading</b>	0.477	0.415	7.745 (2,17) <sup>**</sup>			
Auditory Comprehension				<b>0.706</b>	<b>3.679</b>	<b>0.002<sup>**</sup></b>
Picture Identification				<b>0.531</b>	<b>2.767</b>	<b>0.013<sup>**</sup></b>
Auditory Judgement				0.184	0.889	0.387
Picture Association				.107	0.509	.618

*Note: \*\*\* $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$ .  $\beta$ - Beta refers to standardised coefficients,  $t$ - test statistics.*

The relationship between the oral reading abilities and linguistic abilities (phonology and semantics) were investigated through bivariate correlation analysis and further subjected to multiple linear regression analysis after examining a strong linear correlation to deduce the predictors of oral reading abilities from subtasks of phonology and semantics. The results of correlation analysis revealed strongest and significant correlation between oral reading and phonology, followed by semantics. The study further explored the probable predictors of oral reading abilities from subtasks of semantics, and phonology through stepwise MLR analysis.

The phonological manipulation task was the strongest phonological predictor of overall oral reading, and real word oral reading. The non-word rhyme judgment task proved to be the phonological predictor of non –word oral reading. The real word rhyme judgement task did not predict the any oral reading conditions. Further, considering the semantic predictors of oral reading

abilities, the auditory comprehension and picture identification together accounted for a distinct statistically significant variance for overall oral reading, real word oral reading, and non –word oral reading. The picture association and auditory judgment tasks are not identified as predicting factors of oral reading abilities in Kannada language. Subsequent to determining the relations and predictors of oral reading abilities of Kannada language from linguistic tasks, the study attempted to investigate the same for English language in the following section.

#### **4.2 Relationship between a few aspects of phonology, and semantics (linguistic) with oral reading abilities in bilingual PWAs in English.**

The section delineates the relationship between linguistic abilities and oral reading abilities of Kannada-English bilingual PWAs in English language. Each participant’s performance was analysed with respect to linguistic abilities (semantics, and phonology) and reading abilities (oral reading). The average scores of all 20 PWAs were subjected to descriptive analysis to observe the central tendency and dispersion measures (mean, median, S.D, and interquartile range) of all the domains. The results are depicted in Table 4.6.

Table 4.6

*Performance of PWAs in semantics, phonology (linguistic) and oral reading domains in English*

Tasks	English (L2)			
	Mean	Median	S.D	Interquartile range
Semantics	39.35	40.00	4.09	7.25
Phonology	19.20	20.00	6.83	10.25
Overall Oral reading	12.80	7.00	12.09	23.25
Real word reading	6.75	5.00	6.12	13.25
Non word reading	2.60	0.5	3.11	6.50
Irregular word reading	3.45	2.00	3.30	4.75

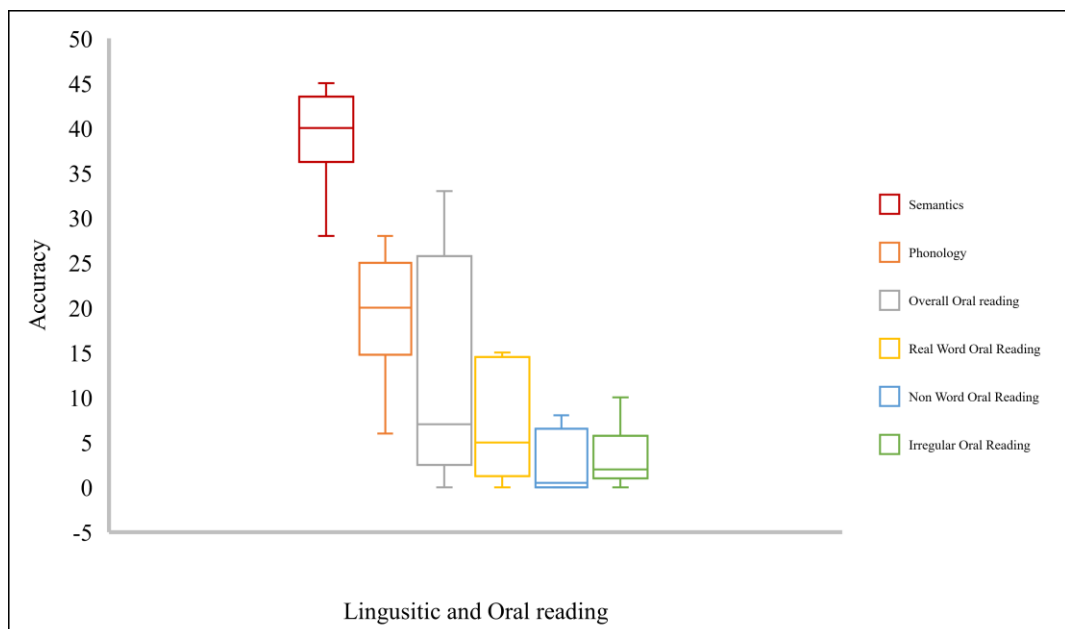
*\*Note: S.D- Standard deviation; L2- Second language*

Table 4.6 depicts the descriptive statistical analysis of performance of PWAs in tasks of phonology and semantics and performance in oral reading abilities. Discrete performance was noticed on comparing the central tendency measure (Means) of reading and linguistic scores. From Table 4.6 and Figure 4.4 on observing the trend in linguistic abilities in English, the performance in

semantics was highest ( $\bar{X}= 39.35$ , S. D= 4.09) and lowest in phonology ( $\bar{X}=19.20$ , S. D= 6.83). The non-word oral reading reflected poorest scores ( $\bar{X}= 2.60$ , S. D= 3.11) compared to real word reading in oral reading domain (Table 4.6). To further explore the influence of semantics and phonology on oral abilities in these PWAs, the relationship between them was appraised through correlation analysis. This was followed by MLR analysis to examine the predictors of oral reading with phonology and semantic subtasks. The raw scores of all 20 PWAs of their performance in English language were subjected to correlation and MLR analysis as described below in section 4.2.1 and 4.2.2.

*Figure 4.4*

Box plot depicting the performance in Oral reading and linguistic domains in English



*Note: X – axis indicates the domains (Semantics, phonology and oral reading tasks); Y- axis denotes the accuracy in performance with mean scores; Horizontal line indicates the mean scores and the error bars in the data points indicate the standard error.*

#### **4.2.1 Relationship between phonology, semantics with oral reading abilities in English (Correlation).**

In order to elucidate the relationship between phonology and semantics (linguistic aspect) with oral reading in English language, the Bivariate Pearson’s Correlation analysis was employed. The oral reading abilities were found to share significantly strong correlation ( $r= 0.50-1.00$ ,  $p< 0.05$ )

(Pearson, 1896) with phonology and semantics in English language (Table 4.7). Specifically, semantics strongly correlated with oral reading abilities ( $r= 0.657, p=0.002$ ), followed by phonology ( $r= 0.598, p=0.005$ ). The real word, non-word reading, and irregular word reading were positively correlated with semantics, and phonology. Of these, semantics showed strongest correlation with real word oral reading ( $r= 0.685, p=0.001$ ), irregular word reading ( $r= 0.604, p=0.005$ ), and non-word reading ( $r= 0.575, p=0.008$ ) (Figure 4.5). The pattern of correlation between semantics and oral reading contexts was real word reading > irregular word reading > non- word reading. Comparable correlation alike semantics was noted between phonology and real word oral reading ( $r= 0.610, p=0.004$ ), irregular word reading ( $r= 0.603, p=0.005$ ), and non- word reading ( $r= 0.511, p=0.021$ ) (Figure 4.6). The correlation trend with phonology was real word reading > irregular word reading > non- word reading.

Table 4.7

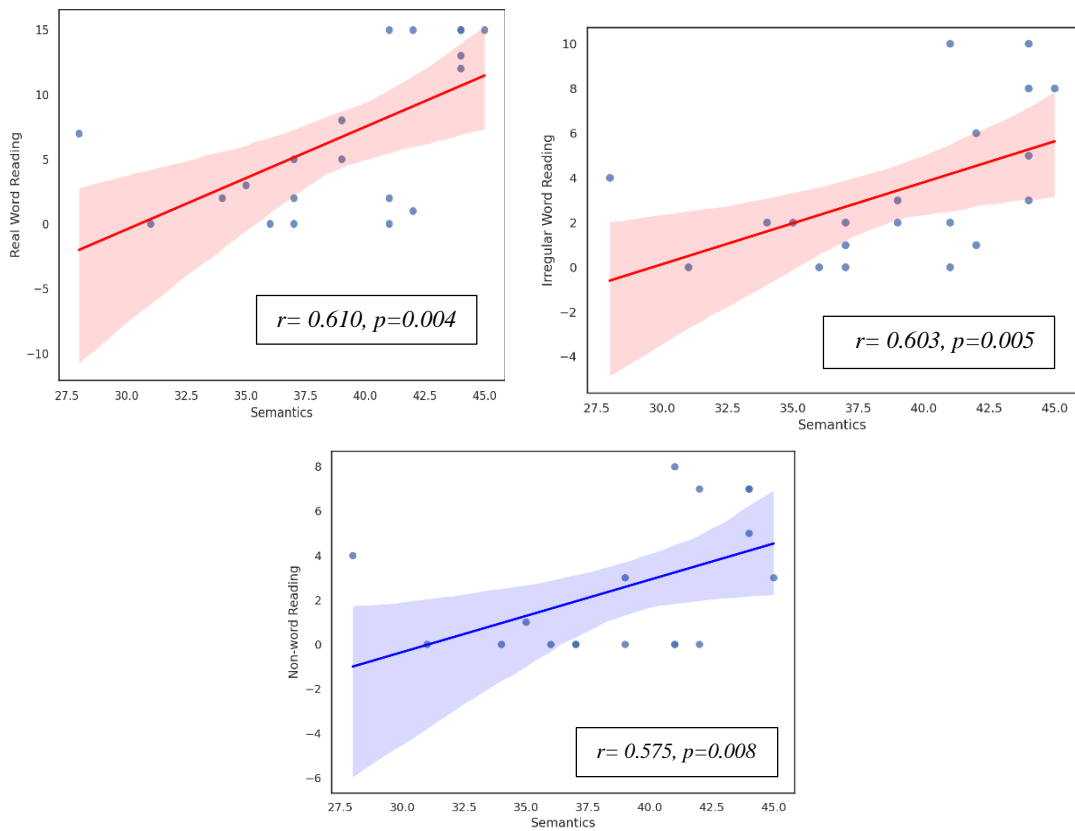
*Results of Pearson's Correlation coefficient (r) analysis between phonology and semantics with oral reading in English.*

	Semantics	Phonology	Overall	Real	Non	Irregular
			Oral	Word	Word	Word
			reading	reading	reading	reading
<b>Overall Oral reading</b>	0.657**	0.598**				
<b>Real Word Reading</b>	0.685**	0.610**	0.986**			
<b>Non Word Reading</b>	0.575*	0.511**	0.946**	0.909**		
<b>Irregular Word Reading</b>	0.604**	0.603**	0.948**	0.907**	0.843**	

Note: \*\* $p<0.01$ , \* $p< 0.05$ .

Figure 4.5

Regression plot depicting correlation between oral reading types with semantics in English.

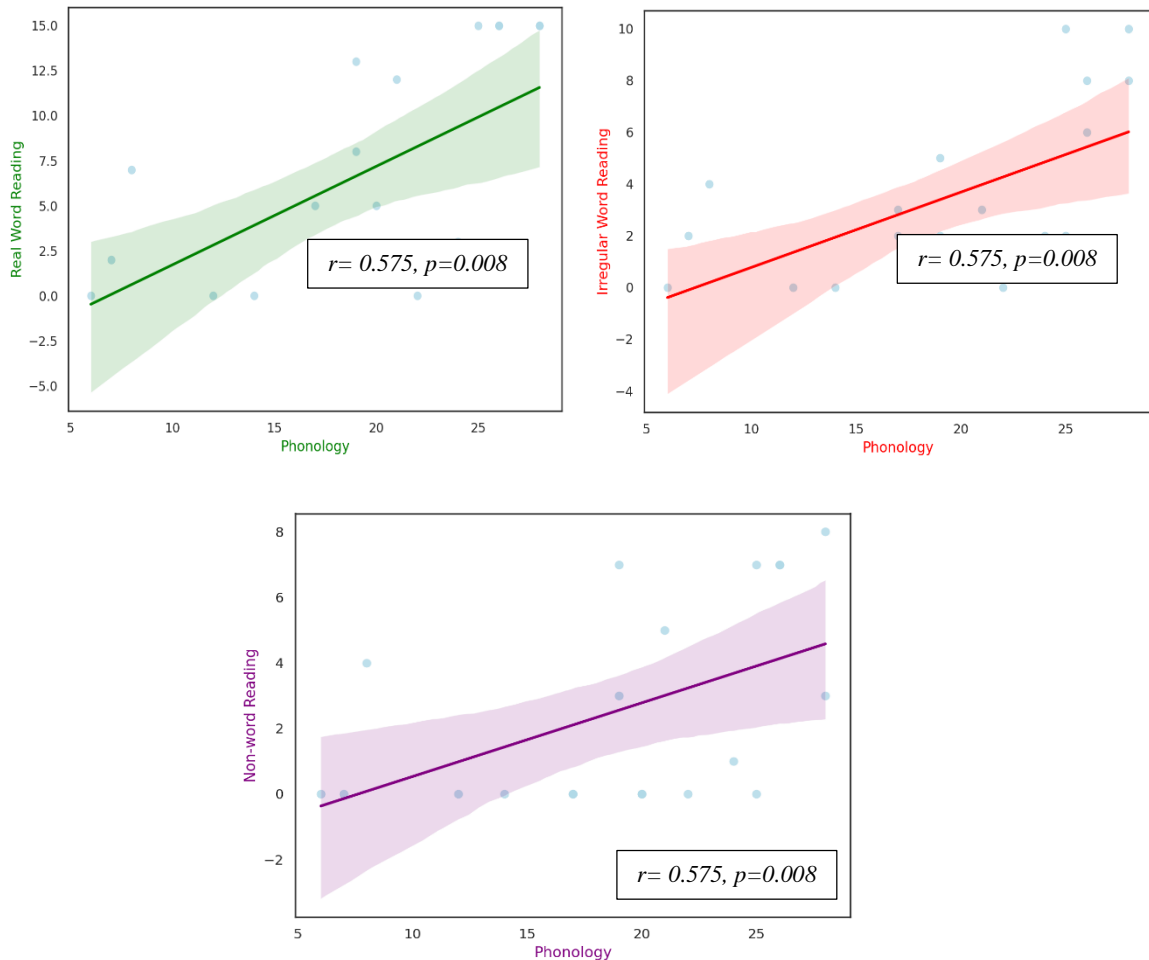


Note- X-axis represent semantic scores, and Y-axis represent real word oral reading scores. The linear line represents the linear relation between semantics and each type of oral reading performance. The shaded region represents 95% confidence region around the line.

Subsequent to ascertaining the correlation between oral reading abilities with semantics and phonology, the study further explored the probable predictors of oral reading abilities with subtasks of semantics, and phonology through MLR analysis.

Figure 4.6

Regression plot depicting correlation between oral reading types with phonology in English.



Note- X-axis represent phonology scores, and Y-axis represent oral reading scores. The linear line represents the linear relation between phonology and each type of oral reading performance. The shaded region represents 95% confidence region around the line.

#### 4.2.2. Phonological and Semantic predictors of Oral Reading abilities.

##### 4.2.2.a) Oral reading abilities and semantic subtasks of English

Multiple Linear Regression (MLR) analysis was performed to delineate the predictors of oral reading abilities in English language with the subtasks of semantics, and phonology. Table 4.8 illustrates the results of four MLR models with performance scores of subtasks of semantics. The subtasks of semantics, namely auditory comprehension, picture identification, picture association, and auditory judgement were entered parallel as

independent variable of a) Overall oral reading abilities, b) Real word reading abilities, c) Non word reading abilities, and d) Irregular word reading as the respective dependant variables of the analysis.

First, the standardised residuals of the MLR model analysis were subjected to normality distribution through Shapiro- Wilk test. The test revealed that standardised residuals were normally distributed in overall oral reading condition ( $p= 0.101$ ), real word reading condition ( $p= 0.164$ ), non-word reading condition ( $p= 0.320$ ), and irregular word ( $p= 0.123$ ).

The multicollinearity factor analysis was observed through VIF and Tolerance collinearity (T) of the predictors. The values of VIF for auditory comprehension was 1.00, auditory judgment task was 2.07, picture identification task was 1.05, and picture association task was 1.11. As all VIF values were less than 2 the multicollinearity was absent (Douglas et al., 2021). The tolerance statistical collinearity (T) value was estimated to be 1.00 for auditory comprehension task, 0.946 for picture identification task, 0.899 for picture association task and 0.481 for auditory judgment task. As tolerance value was above 0.1, multicollinearity was ruled out (Laerd Statistics, 2015, Madden 2016). Thus, the multicollinearity factor analysis suggested that these predictors do not interfere with each other in the analysis.

The results of MLR model revealed auditory comprehension task as a significant predictor of overall oral reading abilities in English language with a statistically significant variance ( $R^2_{adj}= 0.264, p = 0.012$ ).

Further, on analysing the predictors of specific oral reading abilities, the auditory comprehension task was the strong semantic predictor of real word oral reading ( $R^2_{adj}= 0.296, p = 0.008$ ), non –word oral reading ( $R^2_{adj}= 0.171, p = 0.04$ ), and irregular word oral reading ( $R^2_{adj}= 0.266, p = 0.020$ ). Overall, the MLR model in this instance suggested that the auditory comprehension task manifested higher and significant variance ( $p <0.01$ ), in common with all four oral reading conditions. The picture association, picture identification task, and auditory judgment were excluded from the model as they did not show statistical

significant variance ( $p > 0.05$ ) with any of the oral reading conditions, indicating that these are not the sensitive predictors of oral reading abilities in English language. Results are depicted in Table 4.8.

Table 4.8

*Multiple linear regression analysis of Oral reading abilities and semantic sub tasks in English*

<i>Stepwise Standard Regression</i>						
	$R^2_{Total}$	$R^2_{Adj}$	$F_{Total}$	$\beta$	$t$	$p - value$
<b>Overall Oral Reading</b>	0.302	0.264	17.803(1,18)*			
<b>Auditory Comprehension</b>				<b>0.55</b>	<b>2.79</b>	<b>0.012*</b>
Picture Identification				0.186	0.915	0.373
Picture Association				0.256	1.25	0.228
Auditory Judgement				0.013	0.043	0.966
<b>Real word Reading</b>	0.333	0.296	8.972 (1,18)**			
<b>Auditory Comprehension</b>				<b>0.577</b>	<b>2.99</b>	<b>0.008**</b>
Picture Identification				0.198	0.998	0.332
Picture Association				0.236	1.17	0.257
Auditory Judgement				0.045	0.157	0.877
<b>Non word Reading</b>	0.267	0.266	6.546 (1,18)*			
<b>Auditory Comprehension</b>				<b>0.463</b>	<b>2.218</b>	<b>0.04*</b>
Picture Identification				0.187	0.866	0.398
Auditory Judgement				0.269	1.24	0.232
Picture Association				0.064	0.205	0.840
<b>Irregular word Reading</b>	0.267	0.266	6.54 (1,18)*			
<b>Auditory Comprehension</b>				<b>0.516</b>	<b>2.55</b>	<b>0.020*</b>
Picture Identification				0.141	0.670	0.512
Picture Association				0.250	1.189	0.251
Auditory Judgement				0.069	0.232	0.819

Note: \*\*\* $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$ .  $\beta$ - Beta refers to standardised coefficients,  $t$ - test statistics.

#### 4.2.2 b) Oral reading abilities and phonological subtasks of English

The MLR analysis was further applied on subtasks of phonology after evidencing strong linear relation with oral reading abilities of English language. Table 4.9 demonstrates the results of four MLR models with scores of subtasks of phonology entered in stepwise manner with standardised residual analysis. The real word rhyme judgement, non-word rhyme judgment, and phonological manipulation (parsing & blending phoneme) tasks were entered simultaneously as predictors of a) Overall oral reading abilities, b) Real word reading abilities, c) Non word reading abilities, and d) Irregular word reading which were the respective dependant variables in the model.

The standardised residuals of the MLR model analysis were subjected to normality distribution computation. The Shapiro Wilk test revealed that standardised residuals were normally distributed in overall oral reading condition ( $p= 0.201$ ), real word reading condition ( $p= 0.062$ ), and non-word reading condition ( $p= 0.191$ ), and irregular word reading condition ( $p= 0.442$ ) of the MLR predictors.

The multicollinearity factor analysis was observed through VIF and Tolerance collinearity (T) of the predictors. The values of VIF of all phonological predictors were less than 2, suggesting absence of multicollinearity (Douglas et al., 2021). The VIF of phonological manipulation was 1.00, real word rhyme judgement task was 1.04, non- word rhyme judgment task was 1.08. The tolerance statistical collinearity (T) value was estimated to be 1.00 for phonological manipulation, real word rhyme judgement task was 0.953, non- word rhyme judgment task was 0.926. As tolerance value was above 0.1, multicollinearity was ruled out (Laerd Statistics, 2015, Madden 2016). Thus, the multicollinearity factor analysis suggested that the phonological predictors did not interfere with each other in the analysis.

The results of MLR model evinced that the phonological manipulation task showed higher and significant variance ( $p < 0.05$ ), in common with overall oral reading, real word reading conditions, non-word reading, and irregular word reading.

The phonological manipulation task accounted for a clear statistical significant variance for overall oral reading ( $R^2_{adj}= 0.216$ ,  $p = 0.022$ ), real word oral reading ( $R^2_{adj}= 0.211$ ,  $p = 0.024$ ), non-word reading ( $R^2_{adj}= 0.181$ ,  $p = 0.035$ ), and irregular word ( $R^2_{adj}= 0.273$ ,  $p = 0.011$ ). The real word

rhyme and non-word rhyme judgment tasks was excluded from the overall reading, real word reading, non -word oral reading and irregular word reading models as statistical variance was not significant ( $p > 0.05$ ) with any of the oral reading variables, indicating that these tasks were not a convincing predictor for oral reading abilities in English.

Table 4.9

*Multiple linear regression analysis of Oral reading abilities and phonology sub tasks in English*

<i>Stepwise Standard Regression</i>						
	$R^2_{Total}$	$R^2_{Adj}$	$F_{Total}$	$\beta$	$t$	$p - value$
<b>Overall Oral Reading</b>	0.257	0.216	6.235 (1,18)*			
Real Word Rhyme judgement				0.331	1.671	0.113
Non Word Rhyme judgement				0.353	1.771	0.094
<b>Phonological manipulation</b>				<b>0.507</b>	<b>2.497</b>	<b>0.022*</b>
<b>Real word Reading</b>	0.252	0.211	6.067 (1,18)*			
Real Word Rhyme judgement				0.265	1.266	0.223
Non Word Rhyme judgement				0.273	1.290	0.214
<b>Phonological manipulation</b>				<b>0.502</b>	<b>2.46</b>	<b>0.024*</b>
<b>Non word Reading</b>	0.224	0.181	5.189 (1,18)*			
Real Word Rhyme judgement				0.076	0.189	0.274
Non Word Rhyme judgement				0.273	1.26	0.291
<b>Phonological manipulation</b>				<b>0.473</b>	<b>2.278</b>	<b>0.035*</b>
<b>Irregular word Reading</b>	0.311	0.273	8.142 (1,18)*			
Real Word Rhyme judgement				0.306	1.591	0.130
Non Word Rhyme judgement				0.298	1.521	0.147
<b>Phonological manipulation</b>				<b>0.558</b>	<b>2.853</b>	<b>0.011*</b>

Note: \*\*\* $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$ .  $\beta$ - Beta refers to standardised coefficients,  $t$ - test statistics.

The relationship between the oral reading abilities and linguistic abilities (phonology and semantics) of English language was investigated through bivariate correlation analysis and further subjected to MLR analysis after ensuring strong linear correlation to deduce the predictors of oral

reading abilities from subtasks of semantics, and phonology. The results of correlation analysis revealed strongest and significant correlation between oral reading and semantics, followed by phonology. Thus, the study further explored the probable predictors of oral reading abilities from subtasks of semantics, and phonology through stepwise MLR analysis.

The phonological manipulation task was the phonological predictor of overall oral reading, real word oral reading, non- word, and irregular word reading. The real word rhyme judgement and non-word rhyme judgement tasks did not predict the oral reading abilities in English language. Further, considering the semantic predictors of oral reading abilities, the auditory comprehension accounted for a statistically significant variance for overall oral reading, real word oral reading, non –word oral reading, and irregular word oral reading. The picture association, picture identification and auditory judgment tasks were not identified as predicting factors of oral reading abilities in English language.

To summarize, the study explored the relationship between a few aspects of semantics, and phonology with oral reading abilities in Kannada and English languages of bilinguals PWAs owing to objective 1 of the study. The correlation analysis in Kannada language between semantics, and phonology with oral reading abilities revealed strongest correlation with phonology, followed by semantics. However, in English language the correlation analysis revealed strongest correlation with semantics, followed by phonology. Further, MLR analysis was applied. In both Kannada and English languages, semantics, and phonological subtasks were analysed for predictors of oral reading abilities. In Kannada language, the semantic predictors of all the oral reading conditions (overall oral reading, real word reading, and non- word reading) are auditory comprehension and picture identification tasks. The phonological predictors of oral reading abilities in Kannada language is the phonological manipulation task for overall reading, and real word oral reading conditions. The non-word rhyme judgement task was found to be the predictor of non- word oral reading ability in Kannada language. In English language, the semantic predictors of all the oral reading conditions (overall oral reading, real word reading, non- word reading and irregular word reading) is deemed to be the auditory comprehension task alone. The phonological predictor of overall oral reading, real

word reading, non-word reading, and irregular oral reading conditions is the phonological manipulation task.

Subsequent to determining the relations and predictors of oral reading abilities of Kannada and English languages from semantics, and phonology, the study attempted to investigate the same for reading comprehension abilities in bilingual PWAs across Kannada and English languages in the following sections.

#### **4.3. Relationship between semantics, phonology and syntax (linguistic) with silent reading comprehension in bilingual PWAs in Kannada.**

The section delineates the relationship between linguistic abilities and reading comprehension abilities of Kannada-English bilingual PWAs in Kannada language. Each participant was analysed for their abilities in semantics, phonology, and syntax and reading comprehension. The average scores of all 20 PWAs were subjected to descriptive analysis to observe the central tendency and dispersion measures (mean, median, S.D, and interquartile range) of all the domains. The results are depicted in Table 4.10.

Table 4.10

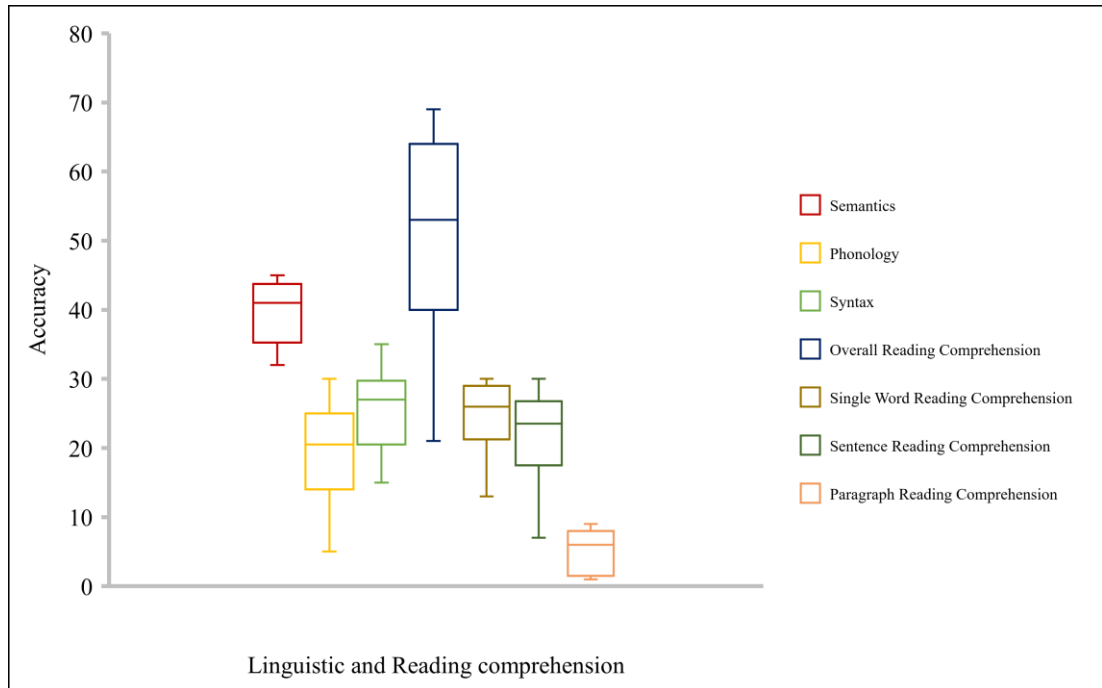
*Performance scores of PWAs in reading comprehension and linguistic domains in Kannada*

Tasks	Kannada (L1)			
	Mean	Median	S.D	Interquartile range
Semantics	39.80	41.00	4.28	8.50
Phonology	19.15	20.50	6.90	11.00
Syntax	25.95	27.00	5.61	9.25
Overall Reading comprehension	50.60	53.00	14.59	24.00
Single word reading comprehension	24.45	26.00	5.03	7.75
Sentence reading comprehension	21.00	23.50	7.34	9.25
Paragraph reading Comprehension	5.15	6	2.88	6.50

*Note: S.D- Standard deviation; L1- First language*

Figure 4.7

Box plot depicting the performance in Reading comprehension and Linguistic domains in Kannada.



Note: X – axis indicates the domains (Semantics, syntax, phonology and reading comprehension); Y-axis denotes the accuracy in performance with mean scores; X mark indicates the mean scores and the error bars in the data points indicate the standard error.

Table 4.10 depicts the descriptive statistical analysis of performance of PWAs in tasks of semantics, phonology, and syntax of linguistic abilities and performance in reading comprehension abilities. Varied performance was noticed on comparing the central tendency measure (Means) of reading comprehension and linguistic domains. From Table 4.10 and Figure 4.7, the trend in linguistic abilities was observed of PWAs in Kannada language. The performance in semantics was highest ( $\bar{X}= 39.80$ , S.D= 4.28) and lowest in phonology ( $\bar{X}=19.15$ , S.D= 6.90). The trend in performance in reading abilities among PWAs in Kannada language reflected enhanced single word reading comprehension ( $\bar{X}=24.45$ , S.D=5.03), followed by sentence reading comprehension ( $\bar{X}=21.00$ , S.D= 7.35) and paragraph reading comprehension ( $\bar{X}=5.15$ , S.D= 2.88). The findings suggest with increase

in complexity of the written text or print, the performance regressed in PWAs on reading comprehension abilities in Kannada language.

To further to explore the relationship they share between linguistic aspects and reading comprehension correlation analysis was explored. This was followed by MLR analysis to examine the predictors of reading comprehension with semantics, phonology, and syntax subtasks. The raw scores of all 20 PWAs of their performance in Kannada language were subjected to correlation and MLR as described below in section 4.3.1 and 4.3.2.

**4.3.1 Relationship between linguistic aspects and reading comprehension abilities in Kannada (Correlation).**

To interpret the relationship between each linguistic aspect (semantics, phonology and syntax) with reading comprehension in Kannada language, the bivariate Karl Pearson’s correlation test was employed between them. The results of correlation analysis are as shown in Table 4.11.

Table 4.11

*Results of Pearson’s Correlation coefficient (r) analysis between semantics, phonology, and syntax with reading comprehension in Kannada.*

	Semantics	Phonology	Syntax	Overall reading comprehension	Single word reading comprehension	Sentence reading comprehension
<b>Overall reading comprehension</b>	0.384	0.552**	0.570*			
<b>Single word reading comprehension</b>	0.402	0.525*	0.543*	0.949**		
<b>Sentence reading comprehension</b>	0.329	0.529*	0.535*	0.984**	0.898**	
<b>Paragraph reading comprehension</b>	0.402	0.529*	0.575**	0.900**	0.770*	0.869*

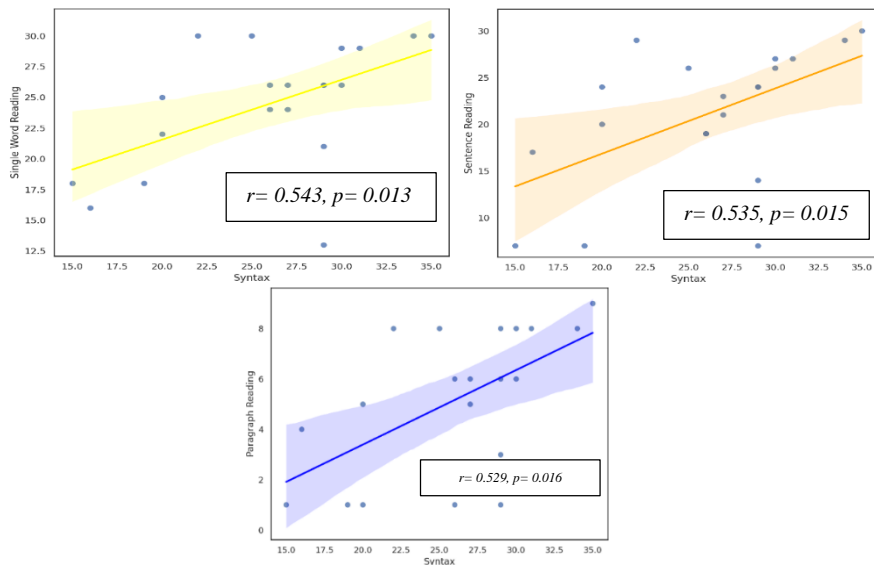
Note: \*\* $p < 0.01$ , \* $p < 0.05$ .

The correlation analysis revealed positive correlation between overall reading comprehension and all aspects of linguistic abilities as depicted from Table 4.11, indicating that semantics, phonology, and syntax influence directly on reading comprehension abilities.

Specifically, syntax scores significantly reflected highest correlation with overall reading comprehension ( $r= 0.570, p= 0.009$ ), single word reading comprehension ( $r= 0.503, p= 0.013$ ), sentence reading comprehension ( $r= 0.535, p= 0.015$ ), and paragraph reading comprehension ( $r= 0.575, p= 0.008$ ) (Figure 4.8). The extent of correlation of syntax with reading comprehension conditions were paragraph > sentence > single word. The second highly correlated aspect of linguistic ability is phonology with overall reading comprehension ( $r= 0.552, p= 0.012$ ), single word reading comprehension ( $r= 0.525, p= 0.017$ ), sentence reading comprehension ( $r= 0.529, p= 0.016$ ), and paragraph reading comprehension ( $r= 0.529, p= 0.016$ ) (Figure 4.9). The correlation trend with phonology was paragraph reading comprehension= sentence reading comprehension > single word reading comprehension. Although, there was high positive correlation between semantic composite scores and all reading comprehension conditions, it was not significant ( $p> 0.05$ ). The least positively correlated aspect of linguistics was semantics in Kannada language which did not manifest significant relationship in this instance (Table 4.11). Figure 4.8 and Figure 4.9 depict the scatter plot with regression line illustrating a linear relationship with syntax, phonology and all types of reading comprehension conditions, respectively.

Figure 4.8

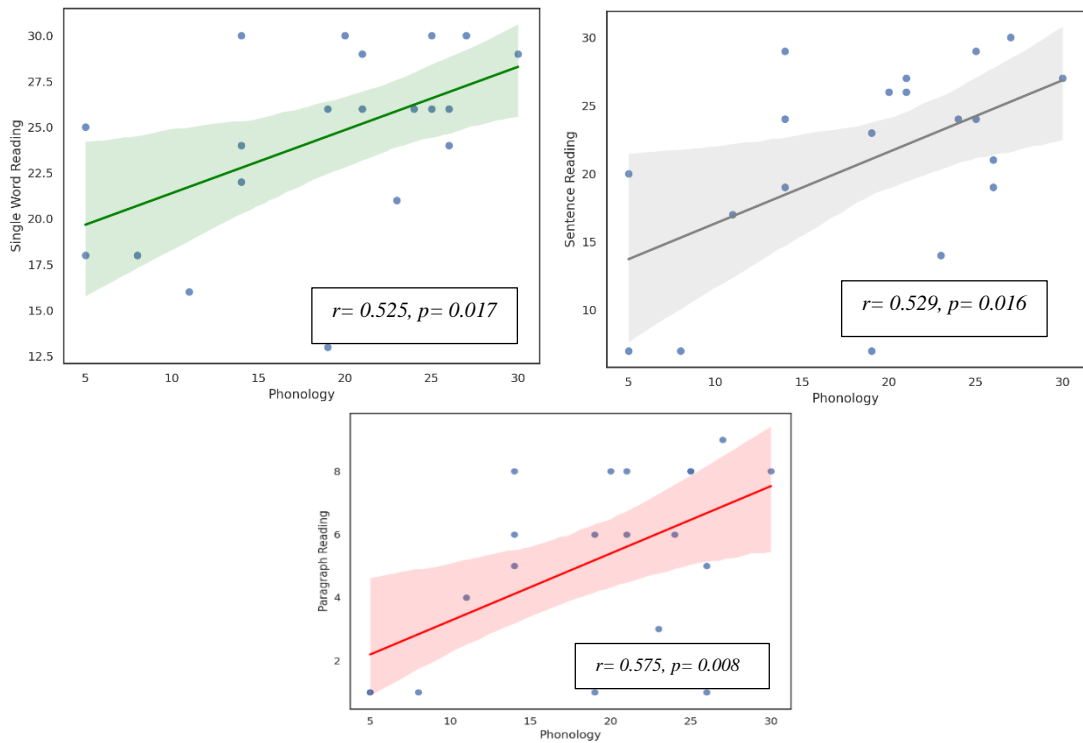
Regression plot depicting correlation between syntax and levels of reading comprehension.



Note- X-axis represent syntax scores, and Y-axis represent reading comprehension scores. The linear line represents the linear relation between syntax and each type of silent reading comprehension. The shaded region represents 95% confidence region around the line.

Figure 4.9

Regression plot depicting correlation between phonology and levels of reading comprehension.



Note- X-axis represent phonology scores, and Y-axis represent reading comprehension scores. The linear line represents the linear relation between phonology and each type of reading comprehension performance. The shaded region represents 95% confidence region around the line.

Subsequent to examining a strong linear relationship between phonology, and syntax (linguistic abilities) and reading comprehension confirmed through bivariate correlation and scatter plots above, the study further explored the predictors of reading comprehension abilities on subtasks of phonology and syntax through MLR analysis in Kannada language. Semantic subtasks were not analysed as the correlation was weak and not significant ( $r = 0.384$ ,  $p > 0.05$ ).

#### 4.3.2 Syntactic and phonological predictors of reading comprehension abilities in Kannada.

##### 4.3.2.a) Reading comprehension abilities and syntax subtasks of Kannada

After computing the bivariate correlation analysis, the subtasks of syntax were analysed to predict the sensitive tasks for reading comprehension in Kannada through four MRL models run on syntactic subtasks. Table 4.12 demonstrates the outcomes of four MLR models with scores of subtasks of syntax entered in stepwise manner with standardised

residual analysis. The subtasks of syntax, namely comprehension of syntactic markers (plurals, tense), spoken sentence judgment, and locative identification were entered simultaneously as independent variables of a) overall reading comprehension abilities, b) single word reading comprehension, iii) sentence reading comprehension, and iv) paragraph reading comprehension as the respective dependant variables.

First, the standardised residuals of the predictors were subjected to normality analysis. The results of Shapiro Wilk test indicated that standard residuals of the model were normally skewed in overall reading model ( $p= 0.079$ ), single word reading comprehension model ( $p= 0.141$ ), sentence reading comprehension model ( $p= 0.112$ ), and paragraph reading comprehension model ( $p= 0.697$ ).

The multicollinearity factor analysis was observed through VIF and Tolerance collinearity (T) of the predictors. The values of VIF for syntax marker judgment was 1.00, spoken sentence judgment task was 1.34, and locative identification task was 1.36. As all VIF values were less than 2, the multicollinearity was absent (Douglas et al., 2021). The tolerance statistical collinearity (T) value was estimated to be 1.00 for syntax marker judgment task, 0.745 for spoken sentence comprehension task, 0.731 for locative identification task. As tolerance value was above 0.1, multicollinearity was ruled out (Laerd Statistics, 2015, Madden 2016). Thus, the multicollinearity factor analysis suggested that these predictors do not interfere with each other in the analysis.

The results of MLR revealed that the syntactic maker judgement task showed predominant and significant variance ( $p < 0.05$ ), in common with all four reading comprehension conditions. The syntactic maker (plural/tense) judgment task accounted for a significant variance for overall reading comprehension ( $R^2_{adj} = 0.251$ ,  $p = 0.014$ ).

Further, the specific conditions of reading comprehension were analysed for syntactic predictors. The syntax maker judgement task manifested strong significant variance with single word reading comprehension ( $R^2_{adj} = 0.315$ ,  $p = 0.006$ ), sentence reading comprehension ( $R^2_{adj} = 0.222$ ,  $p = 0.021$ ), and paragraph reading comprehension ( $R^2_{adj} = 0.281$ ,  $p = 0.009$ ) (Table 4.12). The sentence

judgement and locative identification tasks were excluded from the model as they did not show statistical significant variance ( $p > 0.05$ ) with any of the reading comprehension conditions, indicating that only syntax maker judgement task is a strong predictor of reading comprehension abilities in Kannada language.

Table 4.12

*Multiple linear regression analysis of reading comprehension abilities and syntactic sub tasks in Kannada.*

<i>Stepwise Standard Regression</i>						
	$R^2_{Total}$	$R^2_{Adj}$	$F_{Total}$	$\beta$	$t$	$p$ - value
<b>Overall Reading Comprehension</b>	0.291	0.251	9.37(1,18)*			
<b>Syntactic maker judgement</b>				<b>0.539</b>	<b>2.715</b>	<b>0.014*</b>
Sentence comprehension				0.335	1.507	0.150
Locatives identification				0.024	0.101	0.921
<b>Single word Reading comprehension</b>	0.351	0.315	9.732(1,18)**			
<b>Syntactic maker judgement</b>				<b>0.592</b>	<b>3.12</b>	<b>0.006**</b>
Sentence comprehension				0.258	1.188	0.257
Locatives identification				0.192	0.991	0.336
<b>Sentence Reading comprehension</b>	0.263	0.222	6.419 (1,18)*			
<b>Syntactic maker judgement</b>				<b>0.513</b>	<b>2.534</b>	<b>0.021*</b>
Sentence comprehension				0.288	1.24	0.230
Locatives identification				0.08	0.03	0.974
<b>Paragraph Reading comprehension</b>	0.319	0.281	8.43(1,18)**			
<b>Syntactic maker judgement</b>				<b>0.565</b>	<b>2.90</b>	<b>0.007**</b>
Sentence Comprehension				0.157	0.687	0.501
Locatives identification				0.017	0.072	0.943

Note: \*\*\* $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$ .  $\beta$ - Beta refers to standardised coefficients,  $t$ - test statistics.

The MLR analysis for reading comprehension abilities was performed on subtasks of syntax which was highly correlated ( $r = 0.5-1$ ,  $p < 0.05$ ) with reading comprehension (Table 4.11). The next closely correlated domain was phonology with moderate correlation ( $r = 0.30-0.49$ ,  $p < 0.05$ ) (Table 4.11) with linear scatter plots (Figure 4.9). The MLR analysis of phonological subtasks with reading comprehension in Kannada language is discussed next.

#### 4.3.2.b) Reading comprehension abilities and subtasks of phonology of Kannada

After the MLR analysis was performed to define the predictors of reading comprehension abilities in Kannada language with the subtasks of syntax, the similar analysis was performed on subtasks of phonology. Table 4.13 illustrates the outcomes of four MLR models with scores of subtasks of phonology entered in stepwise manner with standardised residual analysis. The subtasks of phonology were, namely real word rhyme judgment, non- word rhyme judgment, and phonological manipulation. These were entered parallel as independent variables of a) Overall reading comprehension abilities, b) Single word reading comprehension, c) Sentence reading comprehension, and d) Paragraph reading comprehension as the respective dependant variable.

The standardised residuals of each model were subjected to normality assumptions through Shapiro Wilk Test, and the results depicted that the standardised residuals were skewed in overall reading comprehension condition ( $p = 0.091$ ), single word reading comprehension ( $p = 0.312$ ), and paragraph reading comprehension ( $p = 0.319$ ).

The VIF values of the phonological predictors were observed to be less than 2, suggesting the phonological subtasks real word rhyme judgment (VIF=1.00), non- word rhyme judgment (VIF=2.80), and phonological manipulation (VIF= 1.214) did not show multicollinearity effects (Douglas et al., 2021). Simultaneously, the tolerance collinearity statistics was observed to be above 0.1 in real word rhyme judgment (T= 1.00), non- word rhyme judgment (T= 0.357), and phonological manipulation (T= 0.824), inferring the absence of multicollinearity within the predictors of phonology for all the reading comprehension models in the MLR analysis.

The results portrayed that the real word rhyme judgment task manifested predominant and significant variance ( $p < 0.05$ ) in common with all four reading comprehension conditions. The phonological predictors of reading comprehension, that is the real word rhyme judgment task) accounted for a clear statistically significant variance for overall reading comprehension ( $R^2_{adj} = 0.44$ ,  $p = 0.001$ ).

In specific the real word rhyme judgement task manifested significant variance with single word reading comprehension ( $R^2_{adj} = 0.424$ ,  $p = 0.001$ ), sentence reading comprehension ( $R^2_{adj} = 0.451$ ,  $p = 0.001$ ), and paragraph reading comprehension ( $R^2_{adj} = 0.453$ ,  $p = 0.001$ ). The non -word

rhyme judgment and phonological manipulation task were excluded from the model as they did not show statistical significant variance ( $p > 0.05$ ) with any of the reading comprehension conditions. This indicated that the non -word rhyme judgment and phonological manipulation tasks are not suitable to predict reading comprehension abilities in Kannada language. The MLR results are depicted in Table 4.13 below.

Table 4.13

*Multiple linear regression analysis of reading comprehension abilities and phonological sub tasks in Kannada*

	$R^2_{Total}$	$R^2_{Adj}$	$F_{Total}$	$\beta$	$t$	$p - value$
<b>Overall Reading Comprehension</b>	0.469	0.440	15.92 (1,18)**			
<b>Real Word Rhyme Judgment</b>				<b>0.685</b>	<b>3.99</b>	<b>0.001**</b>
Non- Word Rhyme Judgment				0.315	1.101	0.286
Phonological Manipulation				0.143	0.749	0.464
<b>Single word Reading comprehension</b>	0.454	0.424	14.99 (1,18)***			
<b>Real Word Rhyme Judgment</b>				<b>0.674</b>	<b>3.87</b>	<b>0.001**</b>
Non- Word Rhyme Judgment				0.001	0.004	0.997
Phonological Manipulation				0.123	0.632	0.536
<b>Sentence Reading comprehension</b>	0.479	0.451	16.581 (1,18)**			
<b>Real Word Rhyme Judgment</b>				<b>0.692</b>	<b>4.072</b>	<b>0.001**</b>
Non- Word Rhyme Judgment				0.326	1.156	0.263
Phonological Manipulation				0.207	1.112	0.282
<b>Paragraph Reading comprehension</b>	0.482	0.453	16.751(1,18)**			
<b>Real Word Rhyme Judgment</b>				<b>0.94</b>	<b>4.093</b>	<b>0.001**</b>
Non- Word Rhyme Judgment				0.080	0.275	0.787
Phonological Manipulation				0.039	0.207	0.839

Note: \*\*\* $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$ .  $\beta$ - Beta refers to standardised coefficients,  $t$ - test statistics.

To sum up, the relationship between the reading comprehension abilities and linguistic abilities (semantics, phonology, and syntax) was investigated through bivariate correlation analysis and further subjected to multiple linear regression analysis on the strongest correlated pairs to deduce the predictors of reading comprehension abilities from subtasks of semantics, phonology, and syntax. The results of correlation analysis revealed strongest and significant correlation between reading comprehension and syntax, followed by phonology. Semantics was least correlated with no significance. Thus, the study further explored the probable predictors of reading comprehension abilities from subtasks of syntax, and phonology through stepwise MLR analysis.

On analysing the syntactic predictors of reading comprehension abilities, the syntactic marker judgment task accounted as a significant predictor for overall reading comprehension, single word reading comprehension, sentence reading comprehension, and paragraph reading comprehension. The phonological predictor of overall reading comprehension, single word reading comprehension, sentence reading comprehension, and paragraph reading comprehension was the real word rhyme judgement task.

Subsequent to determining the relations and predictors of reading comprehension abilities of Kannada language from linguistic tasks, the study attempted to investigate the same for English language in the following section.

#### **4.4 Relationship between semantics, phonology and syntax (linguistic) with silent reading comprehension in bilingual PWAs in English.**

The section unfolds the relationship between linguistic abilities and reading comprehension abilities of Kannada-English bilingual PWAs in English language. Each participant was analysed for their abilities in semantics, phonology, and syntax and reading comprehension. The average scores of all 20 PWAs were subjected to descriptive analysis to observe the central tendency and dispersion measures (mean, S.D, and interquartile range) of all the domains. The results are depicted in Table 4.14.

Table 4.14

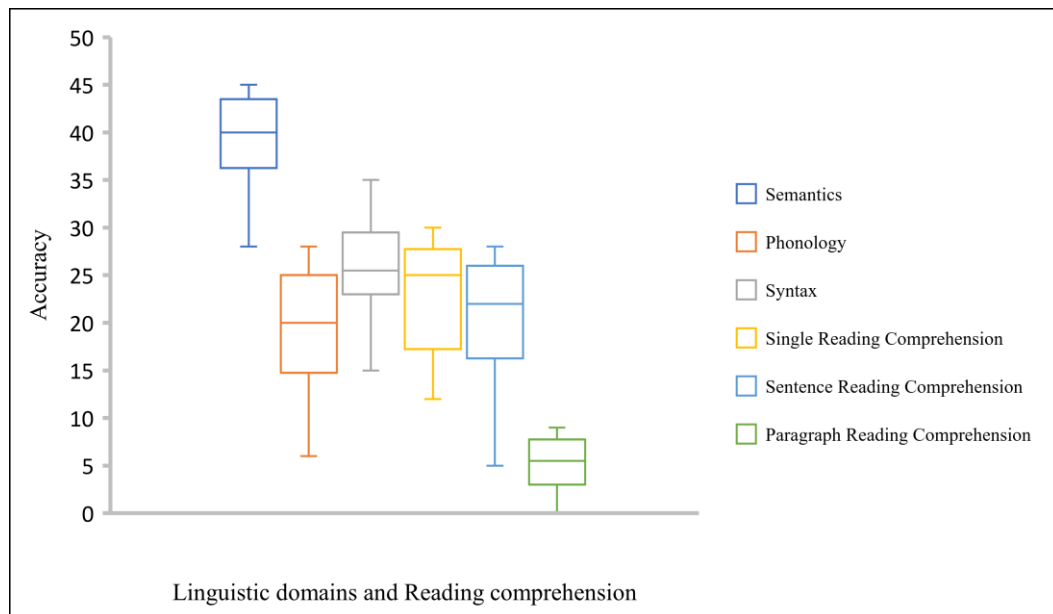
Performance scores of PWAs in reading comprehension and linguistic domains in English

Tasks	English (L2)			
	Mean	Median	S.D	Interquartile range
Semantics	39.65	40.00	3.65	6.50
Phonology	19.20	20.00	6.83	10.25
Syntax	25.30	25.50	5.30	6.50
Overall Reading comprehension	48.15	53.00	15.46	22.75
Single reading comprehension	23.15	25.00	5.87	10.50
Sentence reading comprehension	20.00	22.00	7.55	9.75
Paragraph reading Comprehension	5.00	5.50	2.79	4.75

Note: S.D- Standard deviation; L2- Second language

Figure 4.10

Box plot depicting the performance of PWAs in linguistic domains and reading comprehension in English



Note: X – axis indicates the domains (Semantics, syntax, phonology and reading comprehension); Y- axis denotes the accuracy in performance with mean scores; Horizontal mark indicates the mean scores and the error bars in the data points indicate the standard error.

Table 4.14 depicts the descriptive statistical analysis of performance of PWAs in tasks of semantics, syntax, and phonology of linguistic abilities and performance in reading comprehension abilities in English language. From the descriptive statistics, the trend in linguistic abilities in English was analysed. The performance in semantics was highest ( $\bar{X}$ = 39.65, S. D= 3.65) and lowest in phonology ( $\bar{X}$ =19.20, S. D= 6.83). Moderate performance was noted in syntax ( $\bar{X}$ = 25.30, S. D= 5.30). Among the reading comprehension abilities in English language the PWAs demonstrated robust performance in single word reading comprehension ( $\bar{X}$ =23.15, S.D= 5.87), followed by sentence reading ( $\bar{X}$ = 20.00, S.D=7.55), and least in paragraph reading ( $\bar{X}$ =5.00, S.D=2.79). Thus, this indicated that the PWAs performed poorly in reading comprehension of text or print with increase in length and complexity in English.

To further explore the relationship between linguistic and reading comprehension abilities, correlation analysis was employed, followed by MLR. The MLR analysis was run to examine the predictors of reading comprehension with semantics, phonology, and syntax subtasks. The raw scores of all 20 PWAs of their performance in English language were subjected to correlation and MLR as described below in section 4.4.1 and 4.4.2.

#### ***4.4.1. Relationship between linguistic and reading comprehension abilities in English (Correlation).***

To interpret the relationship between each linguistic aspect (semantics, phonology, and syntax) with reading comprehension, the bivariate Pearson's correlation test was employed between them. The results of correlation analysis are as shown in Table 4.15.

Table 4.15

*Results of Karl Pearson's Correlation coefficients between the Linguistic domains and Reading comprehension in English.*

	Semantics	Phonology	Syntax	Overall reading comprehension	Single word reading comprehension	Sentence reading comprehension
<b>Overall reading comprehension</b>	0.655**	0.309*	0.419			
<b>Single word reading comprehension</b>	0.671**	0.470*	0.463*	0.960**		
<b>Sentence reading comprehension</b>	0.587**	0.312	0.378	0.969**	0.878**	
<b>Paragraph reading comprehension</b>	0.631**	0.326	0.320	0.896**	0.837**	0.814**

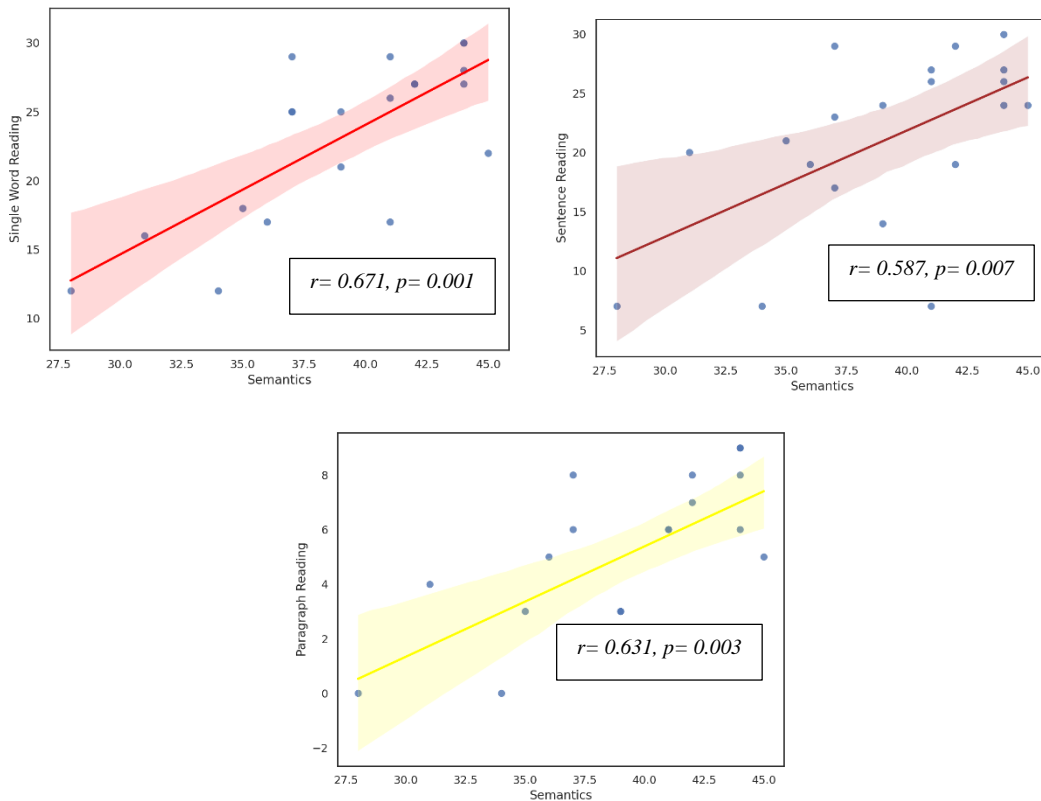
Note: \*\* $p < 0.01$ , \* $p < 0.05$ .

The correlation analysis revealed positive linear correlation between overall reading comprehension and all aspects of linguistic abilities as evinced from Table 4.15, indicating that semantics, phonology, and syntax influence directly on reading comprehension abilities. To elaborate, higher the semantic or syntactic or phonology abilities, better the overall reading comprehension, and viz versa. Semantics reflected strong and linear relation with reading comprehension abilities compared to syntax and phonology. Specifically, semantic composite scores significantly fared highest correlation with overall reading comprehension ( $r = 0.655$ ,  $p = 0.002$ ), single word reading comprehension ( $r = 0.671$ ,  $p = 0.001$ ), sentence reading comprehension ( $r = 0.587$ ,  $p = 0.007$ ), and paragraph reading comprehension ( $r = 0.631$ ,  $p = 0.003$ ), indicating strong and linear correlation ( $r = 0.5-1.0 =$  strong correlation) (Pearson, 1896) as depicted in Figure 4.11. Although, the positive correlation was noted with syntax, phonology and reading comprehension conditions, they failed to show significant correlation ( $p > 0.05$ ) (Table 4.15). Figure 4.11 depicts the scatter plot

with regression line illustrating a linear relationship with semantics and all types of reading comprehension conditions.

*Figure 4.11*

Regression plot depicting correlation between semantics and levels of reading in English



*Note- X-axis represent semantics scores, and Y-axis represent reading comprehension scores. The linear line represents the linear relation between semantics and each type of reading comprehension performance. The shaded region represents 95% confidence region around the line.*

Further, the MLR analysis was employed on reading comprehension abilities to investigate their predictors from semantic subtasks of English language, as semantics reflected linear strong significant correlation with reading comprehension.

#### **4.4.2. Semantic predictors of Reading comprehension abilities through MLR in English.**

##### *4.4.2.a) Reading comprehension abilities and semantic subtasks of English*

Multiple Linear Regression (MLR) analysis was performed to define the predictors of reading comprehension abilities in English language with the subtasks of semantics, and syntax as these were the two strongly correlated aspects of linguistic abilities with reading comprehension.

Table 4.16 elucidates the outcomes of four MLR models with scores of subtasks of semantics entered in stepwise manner with standardised residual analysis. The subtasks of semantics, namely auditory comprehension, picture identification, picture association, and auditory judgement were entered simultaneously as independent variables of a) Overall reading comprehension abilities, b) Single word reading comprehension, c) Sentence reading comprehension, and d) Paragraph reading comprehension as the respective dependant variables.

The standardised residuals of each model was subjected to normality assumptions through Shapiro Wilk Test, and the results depicted that the standardised residuals were skewed in overall reading comprehension condition ( $p= 0.194$ ), single word reading comprehension ( $p= 0.179$ ), sentence reading comprehension ( $p= 0.243$ ), and paragraph reading comprehension ( $p= 0.795$ ).

Further, the predictors were observed for multicollinearity effects via VIF and tolerance collinearity (T). The values of VIF of auditory comprehension was 1.00, picture identification was 1.113, picture association was 1.057 and auditory judgement was 2.079. As all values were less than 2, multicollinearity effect was absent (Douglas et al., 2021). Subsequently the tolerance collinearity (T) also confirmed absence of multicollinearity ( $T>0.01$ ) (Laerd Statistics; Madden, 2016) as the values for auditory comprehension was 1.00, picture identification was 0.946, picture association was 0.899 and auditory judgement was 0.481.

The results of MLR analysis demonstrated that the auditory comprehension task showing predominant and significant variance ( $p<0.01$ ) in common with all four reading comprehension levels (overall reading comprehension, single word reading comprehension, sentence reading comprehension, and paragraph reading comprehension). The MLR analysis accounted for a clear statistically significant relation between overall reading comprehension and auditory comprehension and picture identification tasks ( $R^2_{adj}= 0.348$ ,  $p = 0.004$ ).

The single word reading comprehension showed significant variance with same two predictors (auditory comprehension and picture identification) ( $R^2_{adj}= 0.492$ ,  $p = 0.002$ ). The sentence reading comprehension ( $R^2_{adj}= 0.296$ ,  $p=0.008$ ) and paragraph reading comprehension ( $R^2_{adj}= 0.268$ ,  $p=0.011$ ) shared significant statistical variance with auditory comprehension task alone.

Table 4.16

*Multiple linear regression analysis of reading comprehension abilities and semantic sub tasks in English.*

<i>Stepwise Standard Regression</i>						
	$R^2_{Total}$	$R^2_{Adj}$	$F_{Total}$	$\beta$	$t$	$p - value$
<b>Overall Reading Comprehension</b>	0.382	0.348	11.126 (1,18)**			
Picture Identification				0.307	1.89	0.109
Picture Association				0.336	1.83	0.085
Auditory Judgement				0.238	0.884	0.389
<b>Auditory Comprehension</b>				<b>0.618</b>	<b>3.336</b>	<b>0.004**</b>
<b>Single word Reading comprehension</b>	0.546	0.492	10.210(2,17)**			
<b>Picture Identification</b>				<b>0.410</b>	<b>2.437</b>	<b>0.026*</b>
Picture Association				0.166	0.916	0.373
Auditory Judgement				0.254	1.08	0.296
<b>Auditory Comprehension</b>				<b>0.527</b>	<b>3.133</b>	<b>0.006**</b>
<b>Sentence Reading comprehension</b>	0.333	0.296	8.978 (1,18)**			
Picture Association				0.340	1.771	0.094
Picture Identification				0.217	1.102	0.286
Auditory Judgement				0.156	0.551	0.589
<b>Auditory Comprehension</b>				<b>0.577</b>	<b>2.996</b>	<b>0.008**</b>
<b>Paragraph Reading comprehension</b>	0.306	0.268	7.944(1,18)**			
Picture Association				<b>0.365</b>	<b>1.885</b>	<b>0.077</b>
Picture Identification				0.252	1.271	0.221
Auditory Judgement				0.279	0.985	0.339
<b>Auditory Comprehension</b>				<b>0.553</b>	<b>2.81</b>	<b>0.011*</b>

Note: \*\*\* $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$ .  $\beta$ - Beta refers to standardised coefficients,  $t$ - test statistics.

Thus, the MLR analysis of semantic subtasks for reading comprehension conditions proved that the auditory comprehension task is the most suitable task to predict reading comprehension abilities in English language.

In brief, the study explored the relationship between domains of linguistic abilities (semantics, phonology, and syntax) with silent reading comprehension abilities in Kannada and English languages of bilingual PWAs. To examine this, initially bivariate correlation analysis was

performed, followed by MLR analysis. The correlation analysis in Kannada language between semantics, phonology, and syntax with silent reading comprehension abilities revealed strongest correlation with syntax, followed by phonology, and semantics. However, contrasting correlation pattern was noted in English, wherein only semantics was strongly correlated to silent reading comprehension abilities.

Further, MLR analysis was applied on the strongest correlated domain of linguistic abilities. In Kannada language, syntax, and phonological subtasks were analysed for predictors of silent reading comprehension abilities as they strongly correlated with each other. The syntactic predictors of all the silent reading comprehension conditions (overall reading comprehension, single word reading comprehension, sentence reading comprehension, and paragraph reading comprehension) were the syntactic marker comprehension task. The real word rhyme judgement task manifested to be the phonological predictor of silent reading comprehension in Kannada language.

Contrary to Kannada language, in the English language, semantics alone correlated strongly with silent reading comprehension abilities. Thus, MLR was performed on subtasks of semantics. The semantic predictors of all four levels of reading comprehension (overall reading comprehension, single word reading comprehension, sentence reading comprehension, and paragraph reading comprehension) was the auditory comprehension task alone. The auditory comprehension and picture identification task were found to be the predictors for single word reading comprehension.

Subsequent to determining the relations and predictors of oral reading abilities and silent reading comprehension of Kannada and English languages with the linguistic domains (semantics, phonology, and syntax), the study attempted to investigate the orthographic transparency (alphabetic and alpha- syllabary) influencing the performance of bilingual PWAs in reading abilities across Kannada and English languages in the following section.

#### **4.5. Orthography effects (alpha syllabary versus alphabetic) on reading abilities in Kannada and English languages of bilingual PWAs.**

In this section, the results of reading abilities (oral reading, and reading comprehension) are discussed as per the objective three. This objective was intended to study the orthography effect

(alpha syllabic vs alphabet system) on reading impairments across Kannada and English languages in bilingual PWAs. Kannada script entails alpha-syllabary or syllabic orthographic system. English entails the properties of alphabet orthographic system. In other words, they are also referred through orthographic transparency. The scripts which directly follow phoneme – grapheme –correspondence (PGC) are known to be transparent script, and the ones which do not always follow the PGC (e.g., in English /put/ and /but/) are known to be opaque scripts. In this instance, Kannada is viewed as more transparent script as opposed to opaque script in English language.

The comparison of Kannada- English orthographic specific performance in reading aspects was observed at two levels as follows:

4.5.1. Reading abilities (oral reading, and reading comprehension) between Kannada and English language performances.

4.5.2. Reading abilities (oral reading, and reading comprehension) within Kannada and English language performances.

***4.5.1. Reading abilities (oral reading and reading comprehension) between Kannada and English language performances.***

The average score of oral reading tasks and reading comprehension, and reading quotient (RQ) of were compared across Kannada and English to observe the orthographic effect on reading. The RQ was calculated as cumulative of oral reading and reading comprehension in terms of percentage. For comparison of oral reading performances between Kannada and English languages, the raw scores were converted into percentage as the total scores were not equal across two languages. At first, the central tendency and disperse measures (mean, median, S.D) were computed for overall reading quotient (RQ), oral reading and reading comprehension. The results are illustrated in Table 4.17.

Table 4.17

Results of One way repeated measure ANOVA (multiple measure -pairwise comparison) with descriptive statistics.

Domains	Language	Mean	Median	S.D	Pairwise comparison	F(1, 19)	p	$\eta_p^2$
Oral Reading (%)	Kannada	38.83	35.00	31.73	K>E	4.51	0.047	0.192
	English	32.00	17.50	30.36				
Reading Comprehension	Kannada	50.60	53.00	14.59	K $\cong$ E	1.53	0.231	0.075
	English	48.15	53.00	22.75				
Reading Quotient	Kannada	63.13	62.62	20.45	K>E	7.81	0.012	0.291
	English	56.10	53.66	21.71				

Note- S.D – Standard deviation, F- statistical value at 2 degrees of freedom, p-refers to statistical value,  $\eta_p^2$ - partial eta square denoting effect size, K- Kannada, E- English,  $\cong$  refers to equivalent.

The results of descriptive statistics revealed clear dominance in RQ in Kannada language ( $\bar{X}$ = 63.13, S.D= 20.45) compared to English language ( $\bar{X}$ = 56.10, S.D= 21.71). In specific, oral reading skills were also superior in Kannada (L1) ( $\bar{X}$ = 38.83, S.D= 31.73) compared to English (L2) ( $\bar{X}$ = 32.00, S.D= 30.36). However, the reading comprehension skills were observed to be almost equivalent in both Kannada ( $\bar{X}$ = 50.60, S.D= 14.59) and English ( $\bar{X}$ = 48.15, S.D= 22.75) languages.

One way repeated measure ANOVA for multiple measures was applied to compare the extent of variability in performance on reading domains between Kannada and English languages. The reading quotient was compared across Kannada and English reading performances, results revealed significant superior RQ in Kannada compared to English language of PWAs at  $F(1,19) = 7.81, p = 0.012$  with large effect ( $\eta_p^2 = 0.291$ ).

Further, the oral reading abilities and reading comprehension abilities were analysed for orthographic specific effects between Kannada and English languages. The results revealed significant dominance in performance in Kannada compared to English language concerning oral reading abilities { $F(1,19) = 4.51, p = 0.047$ } with large effect ( $\eta_p^2 = 0.192$ ). The non-parametric

equivalent Wilcoxon sign rank test was also applied as oral reading scores were not abiding to normal distribution ( $p < 0.05$ ). The results showed significant difference between oral reading in Kannada and English ( $|Z| = 1.918$ ,  $p = 0.05$ ) with moderate effect ( $r_e = 0.3 - 0.49$ ) (Field, 2015). However, only reading comprehension was not varying across Kannada and English ( $p > 0.05$ ) as depicted in Table 4.17. Overall, the results proved orthography dependency persistent in reading abilities in Kannada – English bilingual PWAs.

Thus, the results of orthography effect (Kannada versus English) on reading (oral reading and reading comprehension) revealed dissociations in performance across languages. In particular, the test statistics applied on reading abilities revealed enhanced performance in Kannada language (L1) compared to English (L2) in overall reading quotient, and oral reading abilities. However, reading comprehension was found to be comparable in both languages. Thus, orthography effect was demonstrated in reading processes across both languages (L1 vs L2).

The study further looked into the variations in performance within specific orthographic system (alphabet & syllabic- English & Kannada) on reading domains. The results are discussed in the following section.

#### ***4.5.2. Reading abilities (oral reading, and reading comprehension) within Kannada and English language performances.***

The reading sub-domains were subjected for within language comparisons (Kannada and English). The raw scores of all twenty PWAs of their oral reading and reading comprehension performances were converted into percentage as the total oral reading scores varied across Kannada and English languages. The average percentage scores of both oral reading and reading comprehension were subjected to descriptive statistical analysis, initially. The results are depicted in Table 4.18 below.

On observing the performance in reading tasks in Kannada and English, there were clear dispersions. In Kannada language, the performance was best in reading comprehension ( $\bar{X} = 73.84$ , S.D = 20.39) and poorest in oral reading ( $\bar{X} = 38.83$ , S.D = 31.73). Similar pattern was noted in English language as well, oral reading abilities ( $\bar{X} = 32.00$ , S.D = 30.36) were poorer than reading comprehension ( $\bar{X} = 69.96$ , S.D = 22.11) (Table 4.18). Overall the trend in performance in reading

sub domains in both Kannada and English languages was reading comprehension > oral reading. The trend is illustrated in Figure 4.13.

Table 4.18

*Results of Wilcoxon Sign Rank test for within language effects with descriptive statistics.*

Language	Linguistic domains	Mean	Median	S.D	Pairwise comparison	Z	p	r <sub>e</sub>
Kannada (N= 20)	Oral Reading (OR)	38.83	35.00	31.73	OR<RC	3.547	0.001	0.79
	Reading comprehension (RC)	73.84	76.81	20.39				
English (N=20)	Oral Reading	32.00	17.50	30.36	OR<RC	3.808	0.001	0.85
	Reading comprehension	69.96	76.81	22.11				

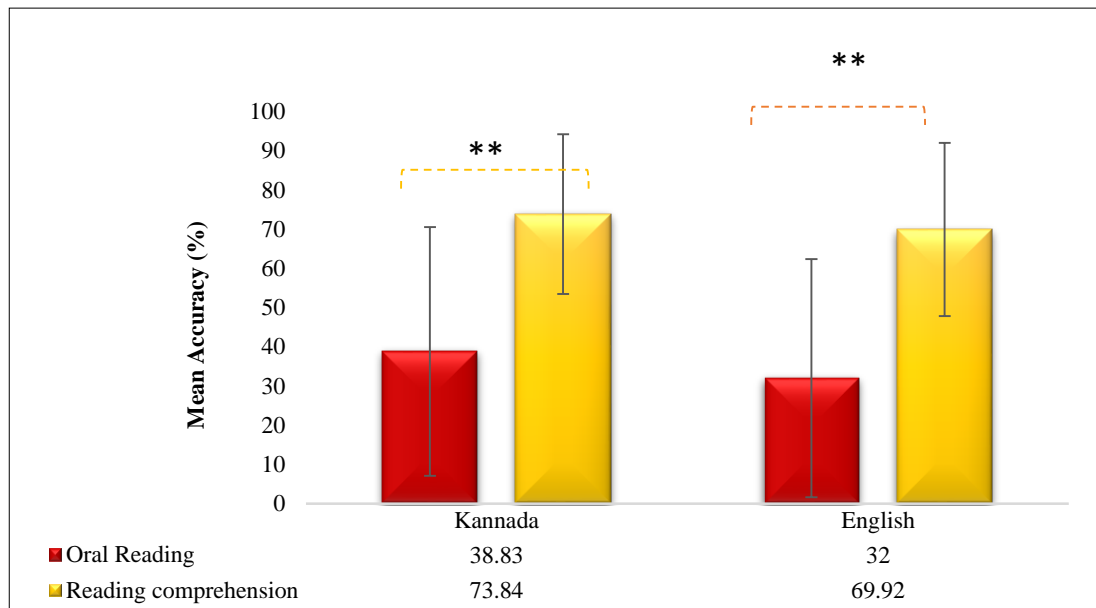
*Note: S.D refers to Standard deviation, z- refers to test statistics, p- statistical significance value, r<sub>e</sub>- effect size.*

Further, performance across oral reading and reading comprehension within the languages (Kannada and English) was compared. The percentage scores of oral reading and reading comprehension were not normally distributed ( $p < 0.05$ ), hence non-parametric Wilcoxon Sign rank pairwise comparison test was applied.

The results revealed that the oral reading abilities and reading comprehension significantly differed within both Kannada and English language performances ( $p < 0.001$ ) with large effect  $r_e = 0.79$ , and  $0.85$ , respectively. Effect size ( $r_e$ ) above  $0.5$  is considered large (Field, 2005). Overall, the results depicted that in both Kannada and English languages the oral reading abilities were predominantly poor compared to reading comprehension abilities. The trend in performance and pairwise variations are depicted in Figure 4.12.

Figure 4.12

Trend in performance in Reading domains within Kannada and English languages.



Note- X – axis indicates the domains (Reading domains specific to languages); Y- axis denotes the accuracy in performance with mean performance bars. ----- indicates the significant pairwise comparison, \*\*  $p$  value  $<0.001$ .

Thus, the results of orthographic effect (alpha syllabic versus alphabetic) on reading (oral reading and reading comprehension) abilities revealed dissociations in performance across languages. In particular, on observing the performance in reading abilities, results revealed enhanced performance in Kannada language (L1) compared to English (L2) in overall reading quotient and oral reading. However, reading comprehension was found to be parallel in both languages. The orthographic influence within Kannada and English language on reading abilities revealed reading comprehension superior to oral reading abilities in both the languages. This indicated, irrespective of orthographic differences (alphabetic or alpha-syllabic), the reading abilities within each was much affected in oral reading abilities compared to reading comprehension.

Further, to observe the dissociations in linguistic abilities (semantics, phonology and syntax) among bilingual PWAs across Kannada (L1) and English languages (L2), the performances were compared across L1 and L2 to observe cross linguistic variations in the next section.

#### **4.6. Cross linguistic variations in linguistic abilities of Kannada and English languages in PWAs.**

The section delineates the cross linguistic dissociations across Kannada and English languages on performances of semantics, phonology, and syntax as per the objective four. The comparison of Kannada- English cross linguistic performance in linguistic aspects was observed at two levels as follows:

4.6.1. Comparison of semantics, phonology, and syntax between Kannada and English languages.

4.6.2. Comparison of semantics, phonology, and syntax within Kannada and English languages.

##### ***4.6.1. Comparison of semantics, phonology, and syntax between Kannada and English languages.***

The performances of all twenty PWAs on linguistic domains, comprising semantics, phonology, and syntax were analysed across Kannada and English languages. The overall linguistic quotient (LQ) (calculated as cumulative of semantic, phonology, and syntax in terms of percentage) were compared. At first, the central tendency and disperse measures (mean, S.D and interquartile range) were computed for overall linguistic quotient, semantic, phonology, and syntax of Kannada and English languages. The results are illustrated below in Table 4.19. On observing the central tendency measures across Kannada and English languages, PWAs showed almost parallel performance in Kannada (L1) ( $\bar{X}$ = 77.18, S.D= 14.31) and English ( $\bar{X}$ = 76.50, S.D= 13.22) on comparing the overall linguistic quotients (LQ). In specific, performance in semantics, phonology and syntax were also comparable between both in Kannada (L1) and English (L2) as noted from Table 4.19.

The data was subjected to normality analysis, and results showed normal distribution ( $p>0.05$ ). Further, the parametric one way repeated measure ANOVA for multiple pairwise comparison was applied to compare performances in semantic, phonology, and syntax between Kannada and English languages. The overall LQ was not significantly deviant between Kannada and English languages {F (1,19) = 0.135,  $p>0.05$ }, suggesting no dissociations in performance when overall language competency is considered across Kannada and English in bilingual PWAs.

Table 4.19

Results of One way repeated measure ANOVA (multiple measure -pairwise comparison) with descriptive statistics.

Domains	Language	Mean	S.D	Interquartile range	Pairwise comparison	$F(1,19)$	$p$
Semantics	Kannada	39.80	4.28	8.50	K $\cong$ E	0.94	0.762
	English	39.65	3.64	6.50			
Phonology	Kannada	19.15	6.90	11.00	K $\cong$ E	0.347	0.958
	English	19.20	6.83	10.25			
Syntax	Kannada	25.95	5.61	9.25	K $\cong$ E	0.003	0.563
	English	25.30	5.30	6.50			
Linguistic Quotient	Kannada	77.18	14.31	25.68	K $\cong$ E	0.135	0.717
	English	76.50	13.22	18.41			

Note- S.D – Standard deviation, F- statistical value at 2 degrees of freedom, p-refers to statistical value, K- Kannada, E- English,  $\cong$  refers to equivalent.

Specific sub domains of linguistic abilities were analysed for deviations between Kannada and English languages. The results revealed no significant dominance in performance between Kannada and English concerning semantics { $F(1,19) = 0.94, p > 0.05$ }, phonology { $F(1,19) = 0.347, p > 0.05$ }, and syntax { $F(1,19) = 0.003, p > 0.05$ }. All together, the cross linguistic comparison of linguistic abilities in PWAs revealed uniform performance between Kannada and English languages.

Thus, the results of cross linguistic effect (Kannada versus English) on semantic, phonology, and syntax abilities revealed no dissociations in performance across Kannada (L1) and English (L2) languages in all bilingual PWAs. This implied equivalent performance in the linguistic processing across both the languages (L1 & L2). Further, the study looked into within language distinctions in the linguistic abilities within Kannada and English language to understand the linguistic processing patterns (semantic, phonology, and syntax) in each language.

**4.6.2. Comparison of semantics, phonology, and syntax within Kannada and English language.**

In this section, the performance of linguistic domains within Kannada and English languages are discussed. The average scores of semantic, phonology, and syntax of Kannada and English languages were separately analysed for within language effects. Initially descriptive analysis was performed and results are depicted in Table 4.20 below.

Table 4.20

*Results of One-way Repeated measure ANOVA within Kannada and English language effects with descriptive statistics.*

Language	Linguistic domains	Mean	S.D	F (2,38)	p	$\eta_p^2$
<i>Kannada</i> (N= 20)	Semantics	32.00	4.28	296.26	0.001	0.94
	Phonology	8.00	6.90			
	Syntax	15.00	5.61			
<i>English</i> (N=20)	Semantics	33.00	3.64	250.48	0.001	0.92
	Phonology	6.00	6.83			
	Syntax	15.00	5.30			

*Note: S.D refers to Standard deviation, df- refers to degrees of freedom, F- statistical test value, p- statistical significance value,  $\eta_p^2$ - effect size.*

On observing the performance in linguistic sub domains in Kannada and English, there were clear distinctions. In Kannada, the performance was best in semantics ( $\bar{X}$ = 32.00, S.D = 4.28) and poorest in phonology ( $\bar{X}$ = 8.00, S.D= 6.90). Similar pattern was noted in English language as well, wherein semantic abilities were best ( $\bar{X}$ = 33.00, S. D= 3.64) and weakest in phonology ( $\bar{X}$ = 6.00, S. D= 6.83). Overall the trend in performance in linguistic sub domains in both Kannada and English languages was semantics>syntax>phonology. The trend is illustrated in Figure 4.12.

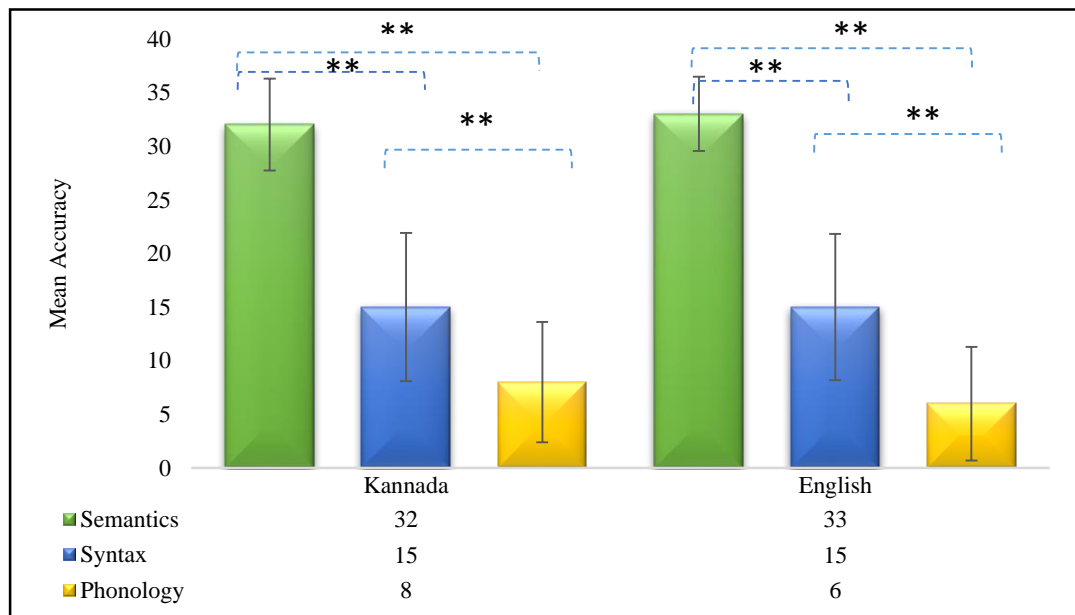
Further, One-way repeated measure ANOVA was applied to verify the within language (Kannada, English) effect in performance of linguistic sub domains. Results revealed significant deviance in performance across semantic, phonology, and syntax within Kannada language [ F

(2,38) = 296.26,  $p < 0.05$ ] with larger effect size  $\eta_p^2 = 0.94$  (Field, 2015) at power of test  $\alpha = 1$ . The pairwise comparison was done using Bonferroni's adjusted multiple comparisons. Results showed significant difference between semantics- syntax, semantics –phonology and syntax-phonology ( $p < 0.001$ ).

Similarly, performance within English language across linguistic abilities was observed through one-way repeated measure ANOVA. Results revealed significant deviance in performance across semantic, phonology, and syntax within English language [F (2,38) = 250.48,  $p < 0.05$ ] with larger effect  $\eta_p^2 = 0.92$  (Field, 2015) at power of test  $\alpha = 1$ . Further, the pairwise comparison was done using Bonferroni's adjusted multiple comparisons. Results indicated significant difference between semantics- syntax, semantics –phonology and syntax-phonology ( $p < 0.001$ ), similar to Kannada language. The trend in performance and pairwise variations are depicted in Figure 4.13. Thus, in both Kannada and English languages the semantics was predominantly better compared to syntax and phonology, wherein all three significantly varied with each other.

Figure 4.13

Trend in performance in Linguistic domains within Kannada and English languages



Note- X – axis indicates the domains (Semantics, phonology, and syntax); Y- axis denotes the accuracy in performance with mean performance bars. ----- indicates the significant pairwise comparison, \*\*  $p$  value  $< 0.001$ .

**4.7 Performance in Linguistic abilities and Reading in Bilingual PWAs across and within Alexia groups in Kannada and English languages.**

The PWAs were initially grouped into alexia types (phonological, deep, and global alexia) based on their oral reading accuracy to investigate the performance in linguistic and reading abilities in bilingual PWAs across and within alexia groups in Kannada and English languages, as per the secondary objective of the study. The alexia grouping of twenty bilingual PWAs is as depicted in Table 4.21. The subgrouping of alexia was assigned based on the reading profiles computed through oral reading accuracy (95% confidence interval) of each word type in both Kannada and English languages. Based on operational definitions and errors observed by prior study by Madden, Conway, Henry, Spencer, Yorkston, and Kendall (2018), the following subgroups of alexia based on reading profiles were formulated (Discussed in detail in section 3.7.2). Based on the operational definitions and oral reading accuracy (95% CI) scoring criteria for each word type, the study sub – grouped the PWAs into alexia sub groups as depicted in Table 4.21. Each individual’s reading profile was computed and alexia sub grouping was formed specific to Kannada and English languages (Table 4.22).

Table 4.21

*Alexia sub grouping criteria for each word type*

<b>Alexia groups</b>	<b>Sub Overall Reading (%)</b>	<b>Real word (%)</b>	<b>Non-Word (%)</b>	
<b>Normal reading</b>	>95%	>95%	>95%	Overall above 95% accuracy in all types
<b>Phonological Alexia</b>	≥ 50%	>60%	30% to 50%	NW reading <RW reading with phonological errors
<b>Deep Alexia</b>	≤ 50%	<60% to 30%	<30%	Poor RW and NW reading with phonological and semantic errors
<b>Global Alexia</b>	<10%	<10%	<10%	Overall poor RW and NW reading.

*\*Note- NW- Non- word, RW- Real word*

Table 4.22

*Reading profiles of twenty Kannada- English Bilingual PWAs in Kannada and English languages*

Participant No.	Kannada Reading Profile	N	Overall Reading (%)	Real word Reading (%)	Non Word Reading (%)	English Reading Profile	N	Overall Reading (%)	Real word Reading (%)	Non Word Reading (%)	Irregular word Reading (%)
P1	Phonological Alexia		50.00	100.00	0.00	Phonological Alexia	65	100.00	20.00	80.00	
P3	Phonological Alexia		66.67	80.00	53.33	Phonological Alexia	62.5	86.67	46.67	50.00	
P5	Phonological Alexia		83.33	100.00	66.67	Phonological Alexia	80.00	100.00	46.67	100.00	
P6	Phonological Alexia		73.33	100.00	46.67	Phonological Alexia	7	75.00	100.00	46.67	80.00
P7	Phonological Alexia		70.00	86.67	53.33	Phonological Alexia	50.00	80.00	33.33	30.00	
P8	Phonological Alexia	10	73.33	80.00	66.67	Phonological Alexia	82.50	100.00	53.33	100	
P9	Phonological Alexia		83.33	100.00	66.67	Phonological Alexia	70.00	100.00	46.67	60.00	
P4	Phonological Alexia		66.67	80.00	53.33	Deep Alexia	37.50	46.67	26.67	40.00	
P10	Phonological Alexia		60.00	93.33	26.67	Deep Alexia	32.50	53.33	20.00	20.00	
P11	Phonological Alexia		56.67	73.33	40.00	Deep Alexia	5	15.00	20.00	6.67	20.00
P2	Deep Alexia		20.00	40.00	0.00	Deep Alexia	15.00	33.33	0.00	10.00	
P15	Deep Alexia		16.67	33.33	0.00	Deep Alexia	20.00	33.33	0.00	30.00	
P12	Deep Alexia	5	16.67	33.33	0.00	Global Alexia	5.00	6.67	0.00	10.00	
P14	Deep Alexia		16.67	20.00	13.33	Global Alexia	10.00	13.33	0.00	20.00	
P17	Deep Alexia		16.67	33.33	0.00	Global Alexia	0.00	0.00	0.00	0.00	
P16	Global Alexia		0.00	0.00	0.00	Global Alexia	8	10.00	13.33	0.00	20.00
P13	Global Alexia		6.67	13.33	0.00	Global Alexia	10.00	13.33	0.00	20.00	
P18	Global Alexia	5	0.00	0.00	0.00	Global Alexia	0.00	0.00	0.00	0.00	
P19	Global Alexia		0.00	0.00	0.00	Global Alexia	0.00	0.00	0.00	0.00	
P20	Global Alexia		0.00	0.00	0.00	Global Alexia	0.00	0.00	0.00	0.00	

The study analysed the performance of all PWAs in each alexia sub groups (phonological, deep, and global) and investigated the influence of linguistic aspects, namely semantics, phonology, and syntax exclusively in Kannada and English languages. The results of this section is discussed under the following sub- headings:

- 4.7.1. Comparison of semantics, phonology, and syntax between alexia sub-groups in Kannada and English languages.
- 4.7.2. Comparison of oral reading and reading comprehension abilities between alexia sub-groups in Kannada and English languages.
- 4.7.3. Comparison of semantics, phonology, and syntax within each alexia sub-groups in Kannada and English languages.
- 4.7.4. Comparison of oral reading and reading comprehension abilities within alexia sub- groups in Kannada and English languages.

***4.7.1 Comparison of semantics, phonology, and syntax between alexia sub-groups in Kannada and English languages.***

The section unfolds the performance of the PWAs in linguistic domains (semantics, phonology, and syntax) across the sub groups of alexia (global, deep and phonological alexia). The average scores of all domains of each PWA were subjected to descriptive analysis to observe the central tendency and dispersion measures (mean, median, S.D, and interquartile range) of all the domains specific to Kannada and English languages. The performance scores specific to sub groups of alexia did not abide to properties of normal distribution, and thus non- parametric tests were applied. The results are illustrated in Table 4.23. On observing the central tendency analysis, individuals with phonological alexia out performed in semantics (M= 43.00, IQR= 3.55), phonology (M= 24.50, IQR= 5.50), and syntax (M= 29.00, IQR= 5.25), compared to deep alexia and global alexia sub groups. Better performance was noted among individuals with deep alexia in semantics (M= 34.00, IQR=5.00), phonology (M= 15.00, IQR= 11.50), and syntax (M= 26.00, IQR= 8.50) compared to phonological alexia. Weakest performance was noted in global alexia in semantics (M=

35.00, IQR= 6.00), phonology (M= 11.00, IQR= 6.00), and syntax (M=22.00, IQR=10.00) compared to phonological alexia and deep alexia.

Table 4.23

*Results of Kruskal Wallis test and descriptive statistics of sub groups of Alexia in Kannada.*

Tasks	Groups	N	Median	Mean	S.D	Interquartile range	$\chi^2(2)$	<i>p</i>
<i>Semantics</i>	Global Alexia	5	35.00	35.00	3.93	6.00	9.455	0.009
	Deep Alexia	5	34.00	35.2	2.77	5.00		
	Phonological Alexia	10	43.00	42.00	3.55	3.55		
<i>Phonology</i>	Global Alexia	5	11.00	11.00	3.00	6.00	11.30	0.004
	Deep Alexia	5	15.00	17.20	6.30	11.50		
	Phonological Alexia	10	24.50	24.10		5.50		
<i>Syntax</i>	Global Alexia	5	22.00	22.40	5.22	10.00	4.74	0.093
	Deep Alexia	5	26.00	24.60	4.44	8.50		
	Phonological Alexia	10	29.00	28.40	5.56	5.25		

*Note- N= Number of participants, S.D – Standard deviation,  $\chi^2(2)$ - Test Statistics at 2 degrees of freedom, *p*-test significance.*

Table 4.24

*Pairwise comparison of linguistic abilities in sub groups of alexia in Kannada.*

Tasks	<i>Semantics</i>	<i>r<sub>e</sub></i>	<i>Phonology</i>	<i>r<sub>e</sub></i>	<i>Syntax</i>	<i>r<sub>e</sub></i>
<b>GA vs PA</b>	PA>GA*	2.02	PA>GA*	2.76	PA>GA	-
<b>GA vs DA</b>	DA>GA	-	DA>GA	-	DA>GA	-
<b>DA vs PA</b>	PA>DA*	2.02	PA>DA	-	PA>DA	-

*Note- GA- Global alexia, PA- Phonological alexia, DA- Deep alexia, (\*) refers to *p*- value < 0.05, *r<sub>e</sub>* = effect size*

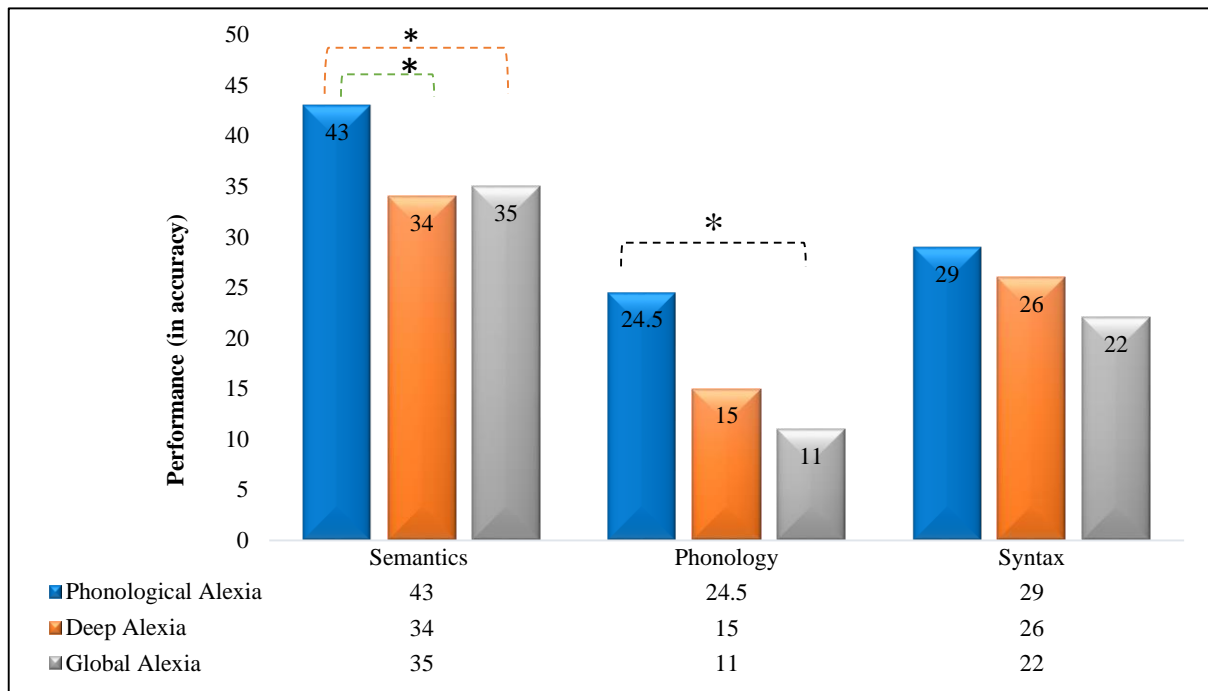
The Kruskal Wallis Test was performed to compare the performance in linguistic domains (semantics, phonology, and syntax) across the sub groups of alexia (global, deep and phonological alexia). On observing the scores in Kannada language, the PWAs showed significantly varied performance in semantics ( $\chi^2(2) = 9.45, p = 0.009, N = 20$ ) with highest scores in phonological alexia compared to deep, and global alexia (Table 4.23). Mann Whitney U post hoc pair wise comparisons revealed semantic abilities were significantly superior in phonological alexia compared to both global alexia ( $|Z| = 7.85, p = 0.045, N = 15$ ), and deep alexia ( $|Z| = 8.35, p = 0.029, N = 15$ ) with large effect size  $r_e = 2.02$ , and  $r_e = 2.15$ , respectively (Table 4.23 and Table 4.24). Semantic abilities were witnessed to be better in deep alexia when compared to global alexia, but not statistically significant (Table 4.24).

Similarly, the performance in phonology was significantly deviant across the alexia subgroups ( $\chi^2(2) = 11.30, p = 0.004, N = 20$ ), wherein superior performance was noticed in phonological alexia, followed by deep, and global alexia (Table 4.23). Mann Whitney U post hoc pairwise analysis revealed significantly higher scores in phonology in phonological alexia compared to global alexia ( $|Z| = 10.70, p = 0.003, N = 15$ ), with large effect size  $r_e = 2.76$ .

The performance remained uniform in syntax across the sub groups of alexia ( $p > 0.05$ ). Syntax was also notably better in phonological alexia on examining the central tendency measures ( $M = 29, S. D = 5.56$ ). Syntax was better in phonological alexia compared to deep and global alexia, however not statistically significant ( $p > 0.05$ ). The results of pairwise comparison between different alexia sub groups is as depicted in Table 4.24 and Figure 4.14.

Figure 4.14

Trend in performance and pairwise comparison of linguistic abilities in sub groups of alexia in Kannada.



Note- X – axis indicates the domains (Semantics, syntax, and phonology); Y- axis denotes the accuracy in performance with mean performance bars. ----- indicates the significant pairwise comparison, \* p value <0.05.

Likewise, the performance in English language was also compared across sub groups of alexia of PWAs with respect to linguistic domains (semantics, phonology, and syntax). On observing the central tendency measures, individuals of phonological alexia group out performed in semantics (M= 44.00, IQR= 2.00), phonology (M= 26.00, IQR=7.00), and syntax (M= 30.00, IQR=4.00) compared to deep and global alexia groups. Deep alexia group performed better than global alexia in semantics (M= 37.00, IQR=4.50), phonology (M=19.00, IQR= 9.50), and syntax (M= 23.00, IQR= 7.00). Poorest performance was noted among global alexia in semantics (M= 37.00, IQR=4.75), phonology (M= 15.50, IQR=13.25), and syntax (M= 24.50, IQR=8.50) compared to phonological and deep alexia. The trend in performance in linguistic domains across alexia sub groups (phonological >deep > global alexia) in English language (Table 4.25).

Table 4.25

Results of Kruskal Wallis test and descriptive statistics of sub groups of Alexia in English.

Tasks	Groups	N	Median	Mean	S.D	Interquartile range	$\chi^2(2)$	<i>p</i>
Semantics	Global Alexia	8	37.00	38.10	2.85	4.75	11.90	0.003
	Deep Alexia	5	37.00	36.80	2.48	4.50		
	Phonological Alexia	7	44.00	43.42	1.39	2.00		
Phonology	Global Alexia	8	15.50	15.37	6.88	13.25	8.55	0.014
	Deep Alexia	5	19.00	17.60	5.94	9.50		
	Phonological Alexia	7	26.00	24.71	3.45	7.00		
Syntax	Global Alexia	8	24.50	23.50	5.12	8.50	9.84	0.007
	Deep Alexia	5	23.00	21.80	3.70	7.00		
	Phonological Alexia	7	30.00	29.80	3.23	4.00		

Note- N= Number of participants, S.D – Standard deviation,  $\chi^2(2)$ - Test Statistics at 2 degrees of freedom, *p*- test significance.

Table 4.26

Pairwise comparison of linguistic abilities in sub groups of alexia in English.

Tasks	Semantics	$r_e$	Phonology	$r_e$	Syntax	$r_e$
GA vs PA	PA>GA*	2.32	PA>GA*	2.32	PA>GA*	1.95
GA vs DA	DA>GA		DA>GA		DA>GA	
DA vs PA	PA>DA*	2.93	PA>DA		PA>DA*	2.85

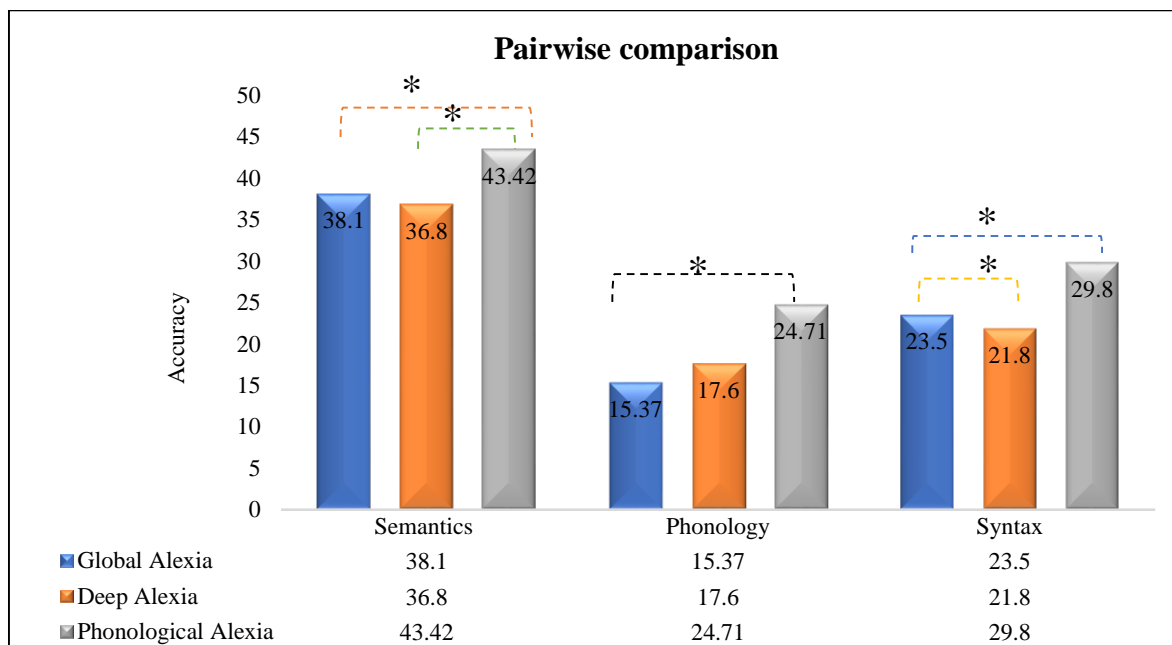
Note- GA- Global alexia, PA- Phonological alexia, DA- Deep alexia, (\*) refers to *p*- value < 0.05,  $r_e$  = effect size

Further, the study applied Kruskal Wallis H test to statistically observe the across groups differences. The results revealed that semantics, phonology, and syntax significantly varied across phonological, deep and global alexia at  $p < 0.05$  level of significance, as illustrated in Table 4.25. Semantic abilities were observed to be highest in phonological alexia compared to deep alexia, and global alexia. Adjusted Bonferroni pair wise comparisons revealed that semantic abilities were found to be significantly superior in phonological alexia compared to global alexia ( $|Z| = 9.01, p = 0.009, N = 15, r_e = 2.32$ ) and deep alexia ( $|Z| = 10.14, p = 0.009, N = 12, r_e = 2.93$ ) with high effect size. However, semantics between global and deep alexia groups were observed to be comparative.

Similarly, phonological abilities were exponentially better in phonological alexia, followed by deep alexia, and weakest in global alexia. Pairwise comparison revealed significantly superior phonological abilities in phonological alexia compared to global alexia ( $|Z| = 9.01, p = 0.009, N = 15, r_e = 2.32$ ) with large effect. (Table 4.26).

Figure 4.15

Trend in performance and pairwise comparison of linguistic abilities in sub groups of alexia in English.



Note- X – axis indicates the domains (Semantics, syntax, and phonology); Y- axis denotes the accuracy in performance with mean performance bars. ----- indicates the significant pairwise comparison, \* p- value  $< 0.05$ .

Syntax was found to be pronounced in phonological alexia compared to deep and global alexia. However, in deep and global alexia syntactic skills were almost comparable. The pairwise comparison (Adjusted Bonferroni's corrections) depicted in Table 4.26 indicated that syntactic abilities were found to be significantly deviant between phonological alexia and global alexia ( $|Z|=7.56, p=0.04, N=15, r_e=1.95$ ), and between phonological alexia and deep alexia ( $|Z|=9.90, p=0.012, N=12, r_e=2.85$ ) with larger effects. However, no significant difference was observed between deep and global alexia. Overall, phonological alexia manifested higher syntactic abilities (Table 4.25). The trend in linguistic abilities in each sub group in English language is depicted in Figure 4.15.

To summarise, the linguistic performance in semantics, phonology, and syntax were compared across alexia sub groups (phonological, deep, and global) in Kannada and English languages through Kruskal Wallis H test with adjusted Bonferroni's pair wise comparisons. In Kannada language, the semantic abilities were found to be significantly prominent in phonological alexia compared to deep and global alexia. Phonological skills were also renowned in phonological alexia followed by deep and global alexia. Statistically, significant performance was observed in phonology between phonological and global alexia. Syntactic abilities were also observed to be best in phonological alexia compared to other types of alexia. However, statistical significance was not noted in the syntactic abilities across sub groups of alexia in Kannada language.

In similar lines, the performance in English language was also compared across the alexia sub groups. Semantics, phonology, and syntax significantly differed across sub groups of alexia (phonological, deep, and global). Alike the results of Kannada language, semantics was noted to be most robust in phonological alexia, followed by deep and global alexia. Phonology was also most predominant in phonological alexia and modest in global alexia. Statistical significance was evidenced between phonological and global alexia. Further, syntax was observed to be best in phonological alexia. Statistically, syntax was superior in phonological alexia compared to global and deep alexia. Overall, performance in semantics, phonology and syntax was superior in phonological alexia, followed by deep and weakest in global alexia in both Kannada and English languages.

Furthermore, the reading abilities, namely oral reading and reading comprehension was compared across different alexia sub groups (phonological, deep, and global). This is discussed in the following sections.

**4.7.2 Comparison of oral reading and reading comprehension abilities between alexia sub- groups in Kannada and English languages.**

The performance of the PWAs in reading domains (oral reading and reading comprehension) were compared across the sub groups of alexia (global, deep, and phonological alexia). The average scores of oral reading and reading comprehension of each PWA were subjected to descriptive analysis to observe the central tendency and dispersion measures (median, S.D, and interquartile range) specific to Kannada language.

Table 4.27

*Results of Kruskal Wallis test and descriptive statistics on reading abilities of sub groups of Alexia in Kannada.*

Tasks	Groups	N	Median	Mean	S.D	Interquartile range	$\chi^2(2)$	p
Oral reading	Global Alexia	5	0	0.40	0.89	1.00	16.28	0.000
	Deep Alexia	5	5.00	4.80	1.09	1.50		
	Phonological Alexia	10	20	20.5	3.24	5.00		
Reading comprehension	Global Alexia	5	37.00	41.00	17.36	32.00	3.53	0.171
	Deep Alexia	5	51.00	51.60	4.92	9.50		
	Phonological Alexia	10	61.00	55.64	13.92	17.75		

*Note- N= Number of participants, S.D – Standard deviation*

On observing the central tendency measures of reading abilities across alexia sub groups in Kannada language, phonological alexia group performed the best in both oral reading (M= 20, IQR=5.00) and reading comprehension (M= 61.00, IQR= 17.75) abilities compared to deep and global alexia (Table 4.27). Fair performance was observed among individuals with deep alexia in oral reading (M= 5.00, IQR= 1.50), and reading comprehension (M= 51.00, IQR=9.50). Merest

performance was noted in global alexia in both oral reading (M= 0, IQR=1.00), and reading comprehension (M= 37.00, IQR=32).

Table 4.28

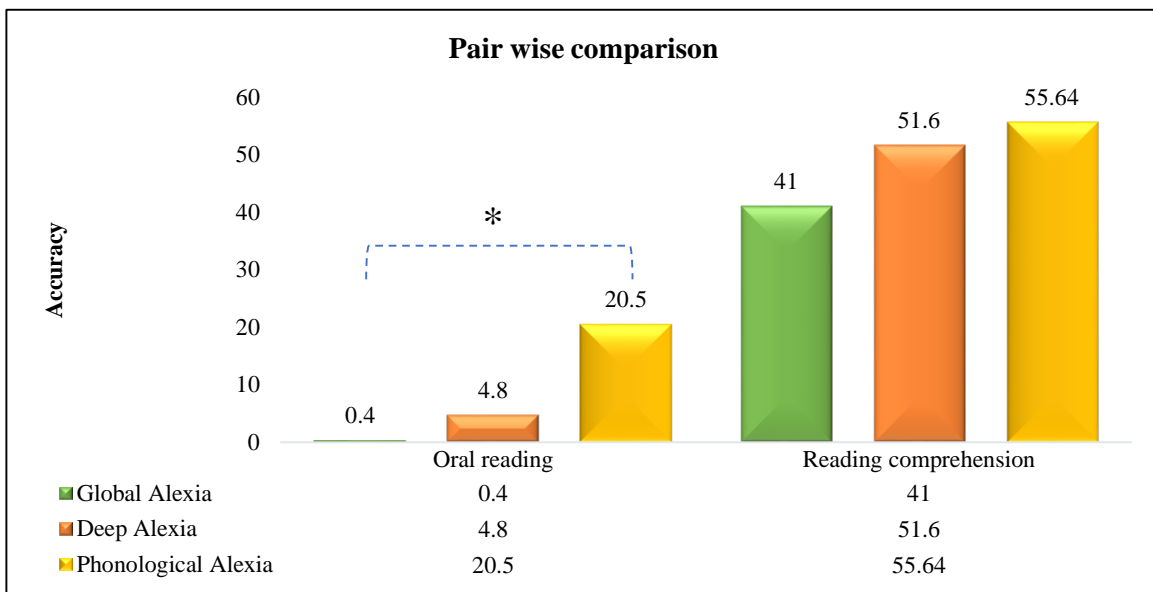
*Pairwise comparison of reading abilities in sub groups of alexia in Kannada.*

Tasks	Oral reading	Reading comprehension
<b>GA vs PA</b>	<b>PA&gt;GA*</b>	PA>GA
<b>GA vs DA</b>	DA>GA	DA>GA
<b>DA vs PA</b>	PA>DA	PA>DA

Note- GA- Global alexia, PA- Phonological alexia, DA- Deep alexia, (\*) refers to p- value < 0.05

Figure 4.16

Trend in reading abilities between sub groups of alexia with pairwise comparisons in Kannada



Note- X – axis indicates the domains (Oral reading, reading comprehension); Y- axis denotes the accuracy in performance with mean performance bars. ----- indicates the significant pairwise comparison, \* p- value <0.05.

The performance in oral reading and reading comprehension across alexia subgroups was analysed through Kruskal Wallis test with adjusted Bonferroni’ s pairwise comparisons. The oral reading abilities were significantly deviant across sub groups of alexia ( $\chi^2(2) = 16.28, p = 0.000, N = 20$ ). Specifically, oral reading abilities were found to be significantly better in phonological alexia compared to global alexia ( $|Z| = 12.50, p = 0.00, N = 15, r_e = 3.22$ ) with large effect (Table 4.27). Oral

reading abilities were noted to be better in phonological alexia than in deep alexia, but not statistically significant ( $p > 0.05$ ). Also, between deep alexia and global alexia, oral reading was superior in deep alexia but not statistically significant ( $p > 0.05$ ). Further, reading comprehension abilities were compared across sub groups of alexia, and no significant deviancy were noted across the groups ( $p > 0.05$ ). However, on comparing the central tendency measures, reading comprehension abilities were found to be promising in phonological alexia, followed by deep and global alexia (Table 4.28 and Figure 4.16).

Further, performance in reading domains (oral reading and reading comprehension) was compared across sub groups of alexia (phonological, deep, and global) in English language. Table 4.29 illustrates the central tendency measures of reading abilities across alexia sub groups in English language. Wherein, the phonological alexia group performed the best in both oral reading (M= 28.00, IQR= 7.00) and reading comprehension (M= 61.00, IQR= 10.00) abilities compared to deep and global alexia. Fair performance was observed among individuals with deep alexia in oral reading (M= 8.00, IQR= 7.00), and reading comprehension (M= 41.00, IQR=26.00). Merest performance was noted in global alexia in both oral reading (M= 1.00, IQR=4.00), and reading comprehension (M= 46.50, IQR=19.75).

Table 4.29

*Results of Kruskal Wallis test and descriptive statistics of sub groups of Alexia in English.*

Tasks	Groups	N	Median	Mean	S.D	Interquartile range	$\chi^2(2)$	<i>p</i>
<i>Oral Reading</i>	Global Alexia	8	1.00	1.75	1.50	4.00	16.28	0.000
	Deep Alexia	5	8.00	10.00	3.80	7.00		
	Phonological Alexia	7	28.00	27.71	4.49	7.00		
<i>Reading comprehension</i>	Global Alexia	8	49.50	46.75	14.33	19.75	9.14	0.009
	Deep Alexia	5	41.00	37.40	13.77	26.00		
	Phonological Alexia	7	61.00	60.48	4.89	10.00		

*Note- N= Number of participants, S.D – Standard deviation, p- value < 0.05*

Table 4.30

*Pairwise comparison of reading abilities between sub groups of alexia in English.*

<b>Tasks</b>	<i>Oral reading</i>	<i>r<sub>e</sub></i>	<i>Reading comprehension</i>	<i>r<sub>e</sub></i>
<b>GA vs PA</b>	<b>PA&gt;GA*</b>	<b>3.22</b>	PA>GA	-
<b>GA vs DA</b>	DA>GA	-	DA>GA	-
<b>DA vs PA</b>	PA>DA	-	<b>PA&gt;DA*</b>	<b>2.95</b>

*Note- GA- Global alexia, PA- Phonological alexia, DA- Deep alexia, (\*) refers to p- value < 0.05*

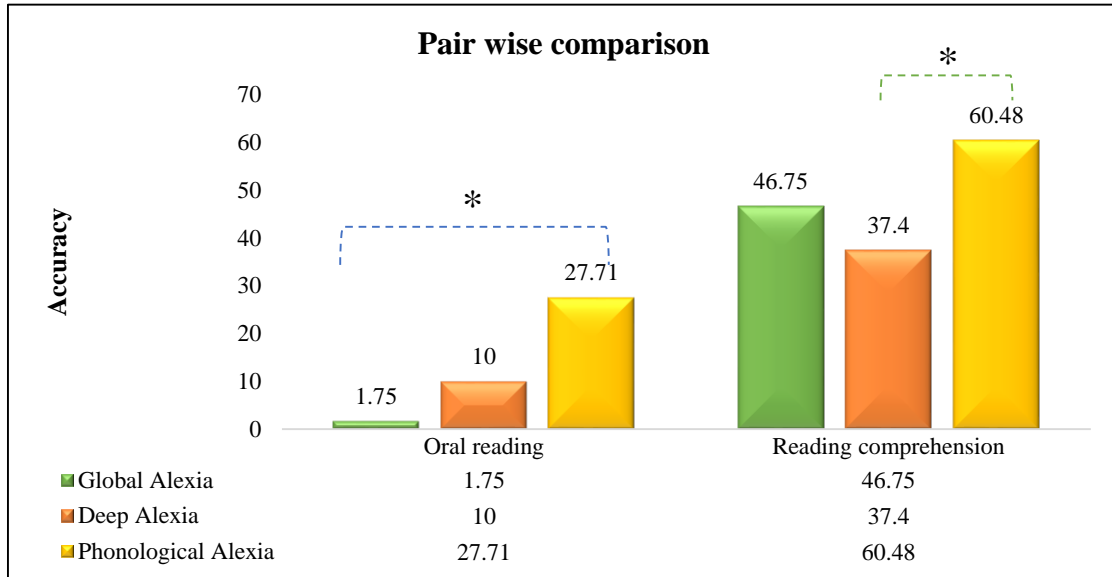
Kruskal Wallis H test analysis revealed significant difference across sub groups of alexia ( $\chi^2(2) = 16.90$ ,  $p = 0.000$ ,  $N = 20$ ) in oral reading abilities (Table 4.29). Specifically, oral reading abilities were found to be significantly better in phonological alexia compared to global alexia ( $|Z| = 12.50$ ,  $p = 0.00$ ,  $N = 15$ ) with large effect ( $r_e = 3.22$ ), alike in Kannada language (Table 4.30). Oral reading abilities were enhanced in phonological alexia than in deep alexia, and better in deep alexia compared to global alexia ( $p < 0.05$ ). Further, reading comprehension abilities were also found to be significantly deviant across sub groups of alexia ( $\chi^2(2) = 9.14$ ,  $p = 0.009$ ,  $N = 20$ ). Mann Whitney U post hoc analysis revealed superior performance in reading comprehension in phonological alexia compared to deep alexia ( $|Z| = 10.243$ ,  $p = 0.03$ ,  $N = 12$ ) with large effect ( $r_e = 2.95$ ). Overall, reading comprehension were predominantly better in phonological alexia compared to deep and global alexia in English language. The trend in reading abilities across sub groups of alexia in English language is depicted in Figure 4.17

In short, the oral reading and reading comprehension abilities were compared across sub groups of alexia (phonological, deep and global) in Kannada, and English languages. The Kruskal Wallis H test and adjusted Bonferroni' s pairwise comparisons were employed. In Kannada language, only oral reading abilities were found to be significantly deviant across sub groups of alexia. Precisely, pairwise comparison revealed oral reading abilities to be profound in phonological alexia compared to global and deep alexia. Statistical significance was noted between phonological alexia and global alexia. However, the reading comprehension abilities did not vary statistically

across sub groups of alexia. The mean scores revealed superior reading comprehension abilities in phonological alexia, followed by deep and global alexia.

Figure 4.17

Trend in reading abilities between sub groups of alexia with pairwise comparison in English



Note- X – axis indicates the domains (oral reading and reading comprehension); Y- axis denotes the accuracy in performance with mean performance bars. ----- indicates the significant pairwise comparison, \* p- value <0.05.

In English language, both oral reading and reading comprehension were significantly distinct across alexia sub groups. Specifically, oral reading was exponentially better in phonological alexia compared to deep and global alexia, alike Kannada language performance. Reading comprehension was found to be significantly better in phonological alexia compared to deep alexia.

Subsequent to understanding the variability in reading and linguistic abilities across sub groups of alexia in Kannada and English languages, the study further explored within alexia sub group distinctions across reading and linguistic abilities. The results are discussed in the following section.

### 4.7.3 Comparison of semantics, phonology, and syntax within each alexia sub-groups in Kannada and English languages.

This section delineates the within alexia sub group distinctions in linguistic abilities (semantics, phonology, and syntax) in Kannada and English languages. Friedman’s two-way analysis and adjusted Bonferroni’ s corrections were performed to observe the abovementioned distinctions. The findings are depicted in Table 4.31.

Table 4.31

Results of Friedman’s test and descriptive statistics of linguistic abilities within each alexia sub group in Kannada.

Tasks	Groups	Median	Mean	S.D	Interquartile range	$\chi^2(2)$	<i>p</i>
<i>Phonological Alexia</i> (N= 10)	Semantics	43.00	42.00	3.55	3.55	17.89	0.00
	Phonology	24.50	24.10	3.21	5.50		
	Syntax	29.00	28.40	5.56	5.25		
<i>Deep Alexia</i> (N=5)	Semantics	34.00	35.2	2.77	5.00	9.57	0.008
	Phonology	15.00	17.20	6.30	11.50		
	Syntax	26.00	24.60	4.44	8.50		
<i>Global Alexia</i> (N=5)	Semantics	35.00	35.00	3.93	6.00	10.00	0.007
	Phonology	11.00	11.00	3.00	6.00		
	Syntax	22.00	22.40	5.22	10.00		

Note- N= Number of participants, S.D – Standard deviation, *p* – refers to statistical *p* value.

#### *Phonological alexia*

In phonological alexia, linguistic abilities significantly varied ( $\chi^2(2) = 17.89$ ,  $p = 0.00$ , N= 10), wherein scores were highest in semantics (M= 43, IQR=3.55), followed by syntax (M= 29.00, IQR=5.25), and weakest in phonology (M=24.50, IQR=5.50) (Table 4.31). Adjusted Bonferroni’ s corrections revealed significantly better semantic abilities compared to phonology ( $|Z| = 1.85$ ,  $p = 0.000$ , N=10) with high effect size  $r_e = 0.58$ . Also, semantics abilities were prominent compared to syntax ( $|Z| = 1.15$ ,  $p = 0.030$ ) with medium effect size  $r_e = 0.36$ . However, syntax and phonology were not significantly deviant with

each other in phonological alexia. Overall, results indicated phonological abilities were modest and semantic abilities were much preserved in phonological alexia.

### *Deep alexia*

On observing the linguistic abilities in deep alexia, similar trend as in phonological alexia was noted. Semantics, phonology, and syntax significantly varied in deep alexia ( $\chi^2(2) = 9.57, p = 0.008, N = 5$ ). Here, semantics was robust, followed by syntax > phonology (Table 4.31). Phonological abilities were significantly poor compared to semantics ( $|Z| = 1.90, p = 0.008, N = 5$ ), with high effect size  $r_e = 0.85$ . Performance in semantics (M= 34.00, IQR=5.00) was better compared to syntax (M=26.00, IQR=8.50). Overall, phonological abilities were scantiest in deep alexia, and fair in syntax and semantics (Table 4.31).

### *Global alexia*

Performance in semantics, phonology, and syntax in global alexia revealed significant distinctions ( $\chi^2(2) = 10.00, p = 0.007, N = 5$ ). Alike phonological and deep alexia, semantic abilities were superior, followed by syntax and phonology. Phonological abilities were weakest in global alexia. Pairwise comparison revealed significantly better performance in semantics compared to phonology ( $|Z| = 2.00, p = 0.005, N = 5$ ), with high effect size  $r_e = 0.89$ . On the whole, phonological abilities were unexceptional in global alexia, with average semantic and syntactic skills. Results are depicted in Table 4.31.

Subsequent to observation in Kannada language, the linguistic abilities were analysed within phonological, deep and global alexia in English language. The descriptive statistics results indicated semantics was strongest in phonological alexia (M= 44.00, IQR=2.00), in deep alexia (M= 37.00, IQR=4.50), and even in global alexia (M= 37.00, IQR=4.75) compared to syntax and phonology within each alexia group.

Table 4.32

Results of Friedman's test and descriptive statistics of linguistic abilities within each alexia sub group in English.

Tasks	Groups	Median	Mean	S.D	Interquartile range	$\chi^2(2)$	<i>p</i>
<i>Phonological Alexia</i> (N= 7)	Semantics	44.00	43.42	1.39	2.00	14.00	0.001
	Phonology	26.00	24.71	3.45	7.00		
	Syntax	30.00	29.80	3.23	4.00		
<i>Deep Alexia</i> (N=5)	Semantics	37.00	36.80	2.48	4.50	8.84	0.015
	Phonology	19.00	17.60	5.94	9.50		
	Syntax	23.00	21.80	3.70	7.00		
<i>Global Alexia</i> (N=8)	Semantics	37.00	38.10	2.85	4.75	15.54	0.000
	Phonology	15.50	15.37	6.88	13.25		
	Syntax	24.50	23.50	5.12	8.50		

Note- N= Number of participants, S.D – Standard deviation, *p* – refers to statistical *p* value.

### *Phonological alexia*

Friedman's two-way analysis was applied on phonological alexia, linguistic abilities significantly varied ( $\chi^2(2) = 14.00$ ,  $p = 0.001$ ,  $N = 7$ ), wherein scores were highest in semantics, followed by syntax, and weakest in phonology (Table 4.32). Further, adjusted Bonferroni's corrections revealed significantly better semantic abilities compared to phonology ( $|Z| = 2.00$ ,  $p = 0.001$ ,  $N = 7$ ) with high effect size  $r_e = 0.75$ . However, semantics and syntax, and syntax and phonology were not significantly deviant with each other in phonological alexia. Overall, results indicated phonological abilities were scantiest and semantic abilities were well preserved in phonological alexia.

### *Deep alexia*

On observing the linguistic abilities in deep alexia, semantics, phonology, and syntax significantly varied ( $\chi^2(2) = 8.84, p = 0.015, N = 5$ ). Performance in semantics was robust, followed by syntax > phonology (Table 4.32). Phonological abilities were significantly poor compared to semantics ( $|Z| = 1.80, p = 0.013$ ), with high effect size  $r_e = 0.80$ . Syntax and semantics were equipotent in nature, with slight better performance in semantics. Overall, phonological abilities were scantiest in deep alexia, and fair abilities in syntax and semantics were observed (Table 4.32).

### *Global alexia*

Alike phonological and deep alexia, semantic abilities were superior, followed by syntax and phonology in global alexia (Table 4.32). Phonological abilities were weakest in global alexia. Performance in semantics, phonology, and syntax in global alexia revealed significant distinctions ( $\chi^2(2) = 15.54, p = 0.000, N = 8$ ) (Table 4.32). Pairwise comparison revealed significantly better performance in semantics compared to phonology ( $|Z| = 1.98, p = 0.000, N = 8$ ), with high effect size  $r_e = 0.70$ . On the whole, phonological abilities were modest in global alexia, with fair semantic and syntactic skills.

#### ***4.7.4 Comparison of oral reading and reading comprehension abilities within alexia sub- groups in Kannada and English languages.***

This section delineates within alexia sub group distinctions in reading abilities (oral reading and reading comprehension) in Kannada and English languages. The data was initially analysed for descriptive statistics and Wilcoxon sign rank test was performed to observe the within alexia group distinctions on reading abilities.

From Table 4.33, the median scores were compared between oral reading and reading comprehension abilities within each alexia group. The oral reading abilities were markedly weak in phonological alexia (M= 20.50, S. D= 3.24), deep alexia (M= 5.00, S.D=1.09), and global alexia (M= 0, S.D= 0.40) compared to silent reading comprehension abilities in Kannada language.

Table 4.33

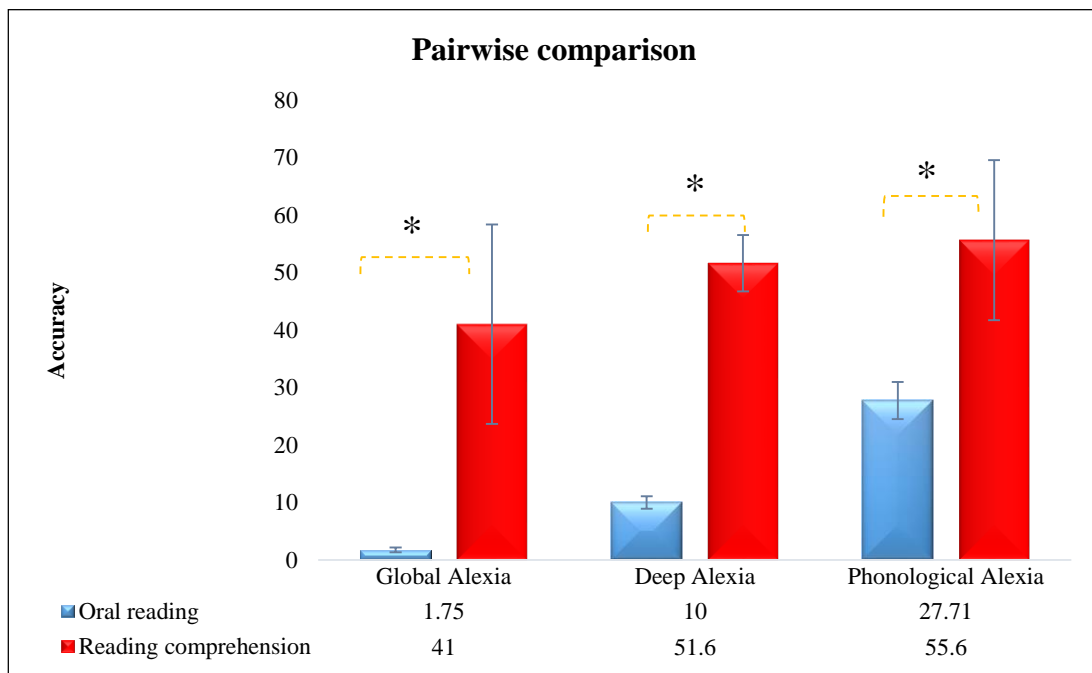
Results of Wilcoxon Sign Rank test and descriptive statistics of reading abilities in sub groups of Alexia in Kannada.

Tasks	Domains	Median	Mean	S.D	Pairwise comparison	Z	p	r <sub>e</sub>
Phonological Alexia (N=10)	Oral reading	20.50	20.50	3.24	OR<RC	2.80	0.005	0.88
	Reading comprehension	61.00	55.60	13.90				
Deep Alexia (N=5)	Oral reading	5.00	4.80	1.09	OR<RC	2.03	0.042	0.91
	Reading comprehension	51.00	51.60	4.92				
Global Alexia (N=5)	Oral reading	0	0.89	0.40	OR<RC	2.02	0.043	0.90
	Reading comprehension	37.00	41.00	17.36				

Note- N= Number of participants, S.D – Standard deviation, OR- Oral reading, RC- Reading comprehension, p-refers to statistical p value, r<sub>e</sub>- refers to effect size.

Figure 4.18

Trend in reading abilities within sub groups of alexia comparison in Kannada.



Note- X – axis indicates the domains (Oral reading and reading comprehension); Y- axis denotes the accuracy in performance with mean performance bars. ----- indicates the significant pairwise comparison, \* p- value <0.05.

In Kannada language, the oral reading abilities and reading comprehension were compared within each type of alexia (phonological, deep, and global) through Wilcoxon sign rank test. The results revealed significantly better reading comprehension abilities ( $p < 0.05$ ) compared to oral reading abilities in phonological, deep and global alexia with high effect size ( $r_e > 0.5$ ). Results are depicted Table 4.33. The trend in performance in reading abilities and pairwise comparison is depicted in Figure 4.18.

In similar manner, the performance of reading abilities was compared in each type of alexia in English language. From Table 4.34, the median scores were compared between oral reading and reading comprehension abilities within each alexia group. The oral reading abilities were markedly weak in phonological alexia (M= 28.00, S.D= 4.49), deep alexia (M= 8.00, S.D=3.80), and global alexia (M= 1.00, S.D= 1.50) compared to silent reading comprehension abilities in English.

Table 4.34

*Results of Wilcoxon Sign Rank test and descriptive statistics of reading abilities in sub groups of Alexia in English.*

Tasks	Domains	Median	Mean	S.D	Pairwise comparison	Z	p	$r_e$
<i>Phonological Alexia</i> (N=7)	Oral reading	28.00	27.71	4.49	OR<RC	2.36	0.018	1.04
	Reading comprehension	61.00	60.42	4.89				
<i>Deep Alexia</i> (N=5)	Oral reading	8.00	10.00	3.80	OR<RC	2.02	0.043	0.71
	Reading comprehension	41.00	37.40	13.72				
<i>Global Alexia</i> (N=8)	Oral reading	1.00	1.75	1.50	OR<RC	2.52	0.012	1.13
	Reading comprehension	49.50	46.75	14.33				

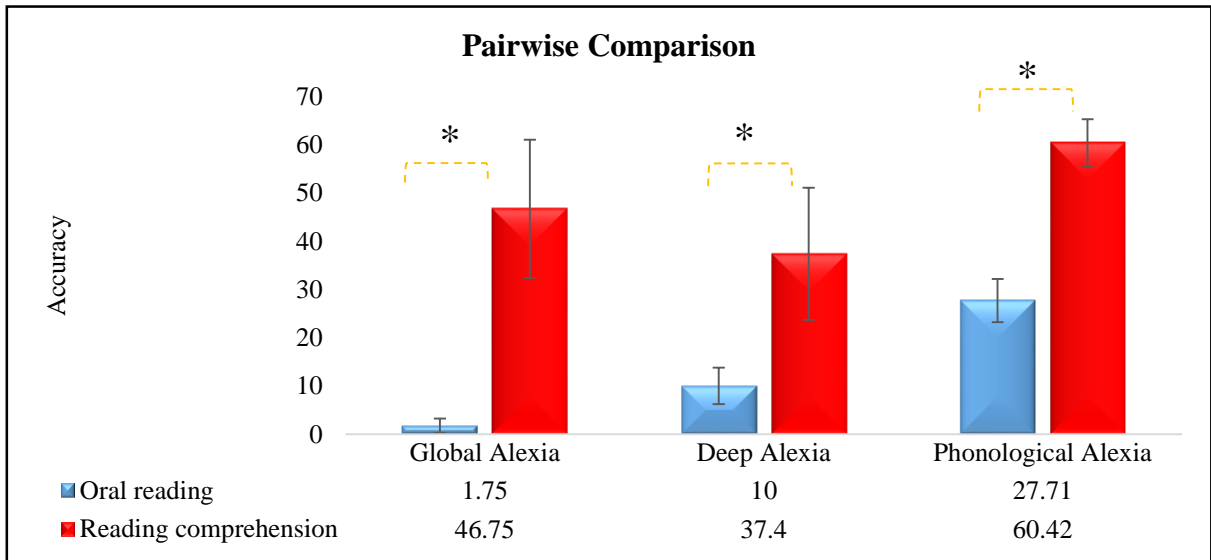
*Note- N= Number of participants, S.D – Standard deviation, OR- Oral reading, RC- Reading comprehension, p-refers to statistical p value,  $r_e$ - refers to effect size.*

Results of Wilcoxon sign rank test revealed statistically significant ( $p < 0.05$ ) poor oral reading abilities in all types of alexia compared to silent reading comprehension abilities. Results are illustrated in Table 4.34. The trend in performance in reading abilities and pairwise comparison is depicted in Figure 4.19.

Overall, the results of reading abilities in each type of alexia in Kannada and English languages indicated compromised oral reading abilities compared to reading comprehension abilities in all types of alexia.

Figure 4.19

Trend in reading abilities within sub groups of alexia comparison in English

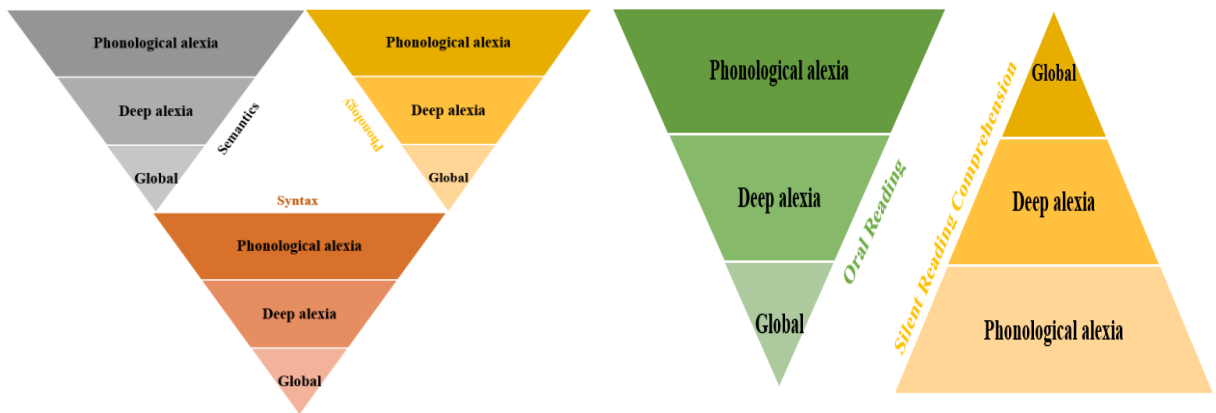


Note- X – axis indicates the domains (Oral reading and reading comprehension); Y- axis denotes the accuracy in performance with mean performance bars. ----- indicates the significant pairwise comparison, \*  $p$ - value  $< 0.05$ .

Overall the results of objective 5 intended to compare linguistic (semantic, phonology, and syntax) and reading abilities (oral reading and reading comprehension) in across and within the various types of alexia sub groups (phonological, deep, and global). The trend in linguistic abilities and reading abilities across different alexia type is illustrated in Figure 4.20. The trend in performance of various alexia sub groups in linguistic and reading abilities is depicted in Figure 4.21.

Figure 4.20

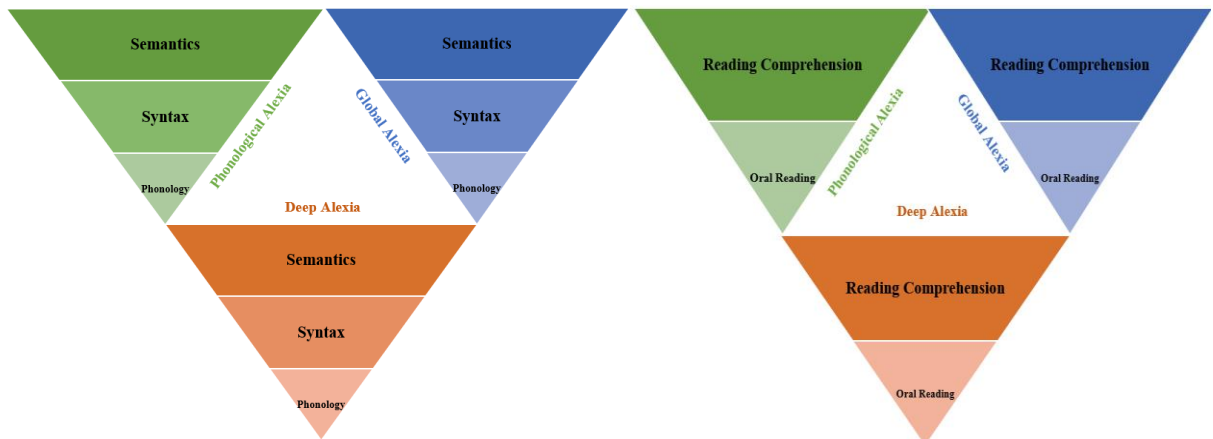
Illustration of strength of Linguistic and Reading abilities across various alexia sub- groups.



Note- The larger blocks denote strongest and smallest blocks denote weakest (based on means scores)

Figure 4.21

Illustration of strength of Linguistic and Reading abilities within each alexia sub groups.



Note- The larger blocks denote strongest and smallest blocks denote weakest (based on means scores)

In a nutshell, the study aimed to explore the relationship between linguistic and reading abilities in Kannada English bilinguals PWAs with alexia. Subsequently, the objectives of the study were analysed in detail in this chapter. The summary of outcomes of hypothesis in the study is described in the Table 4.35.

Table 4.35

*Summary of null hypothesis based on the objectives of the study*

<b>Objective</b>	<b>Hypothesis</b>	<b>Outcome measures</b>	<b>Statistical analysis</b>	<b>Null Hypothesis (Accepted/Rejected)</b>
<b>I.</b>	<b>There is no relationship between a few aspects of semantics and phonology (linguistic form) with oral reading abilities in bilingual PWAs in Kannada and English, separately</b>			
<i>i.</i>	There is no correlation between oral reading tasks with phonology, and semantics in Kannada.		Significant correlation between phonology and semantics with oral reading in Kannada.  Significant correlation with phonological and semantic sub tasks also with all types of oral reading in Kannada	Rejected
<i>ii.</i>	There is no correlation between oral reading tasks with semantics, and phonology in English.	Semantics, Phonology Oral reading in Kannada & English	Significant correlation between phonology and semantics with oral reading in English.  Significant correlation with phonological and semantic sub tasks also with all types of oral reading in English	Rejected

<b>2. There is no relationship between a few aspects of semantics, phonology, and syntax (linguistic) with silent reading comprehension in bilingual PWAs, in Kannada and English, separately.</b>				
<i>i.</i>	There is no correlation between silent reading comprehension tasks with semantics, syntax, and phonology in Kannada.	Semantics Phonology Syntax	Significant correlation between phonology, semantics and syntax with silent reading comprehension in Kannada. Significant correlation with phonological, semantic, and syntax sub tasks also with all types of reading comprehension in Kannada	Rejected
<i>ii.</i>	There is no correlation between silent reading comprehension tasks with semantics, syntax, and phonology in English.	Silent reading comprehension in Kannada & English	Significant correlation between phonology, semantics and syntax with silent reading comprehension in English. Significant correlation with phonological, semantic, and syntax sub tasks also with all types of reading comprehension in English.	Rejected
<b>3. There is no orthography effect (alpha syllabic vs alphabet system) on reading abilities of Kannada and English languages in PWAs.</b>				
<i>i.</i>	There is no difference in performance in reading abilities (oral reading and reading comprehension) between Kannada and English languages.	Oral reading Reading comprehension	There is significant difference in oral reading between Kannada and English. There is no significant difference in reading comprehension between Kannada and English	Rejected Accepted

<i>ii.</i> There is no difference in performance in reading abilities (oral reading and reading comprehension) within Kannada and English languages.	There is significant difference between oral reading and reading comprehension within Kannada and English	Rejected
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**4. There is no cross linguistic variations in linguistic abilities of Kannada and English languages in PWAs.**

---

<i>i.</i> There is no difference in performance in linguistic abilities (semantics, syntax, and phonology) between Kannada and English languages.	There is no difference in semantics, syntax and phonology between Kannada and English	Accepted
<i>ii.</i> There is no difference in performance in linguistic abilities (semantics, syntax, and phonology) within Kannada and English languages.	There is significant difference in semantics, syntax and phonology within Kannada and within English language performances	Rejected

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**5. There is no difference in a few aspects linguistic (semantics, syntax and phonology) and reading abilities (oral reading and reading comprehension) across and within the type of alexia in Kannada and English languages among bilingual PWAs.**

---

<i>i.</i> There is no difference in semantics, syntax, and phonology between alexia sub-groups in Kannada and English languages.	There is significant difference in semantics, syntax, and phonology between alexia sub-groups in both Kannada and English languages	Rejected
--	---	----------

<i>ii.</i> There is no difference in oral reading and reading comprehension abilities between alexia sub- groups in Kannada and English languages.	There is significant difference in oral reading and reading comprehension abilities between alexia sub- groups in Kannada and English languages.	Rejected
<i>iii.</i> There is no difference in semantics, syntax, and phonology within alexia sub-groups in Kannada and English languages.	There is significant difference in semantics, syntax, and phonology within alexia sub- groups in Kannada and English languages.	Rejected
<i>iv.</i> There is no difference in oral reading and reading comprehension abilities within alexia sub- groups in Kannada and English languages.	There is significant difference in oral reading and reading comprehension abilities within alexia sub- groups in Kannada and English languages.	Rejected

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# Predictor Model for Oral reading Abilities in Kannada and English

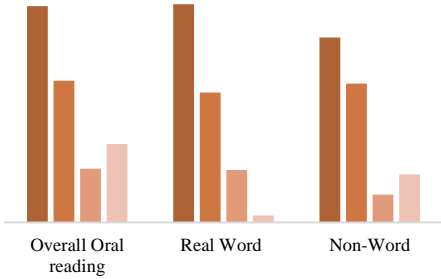
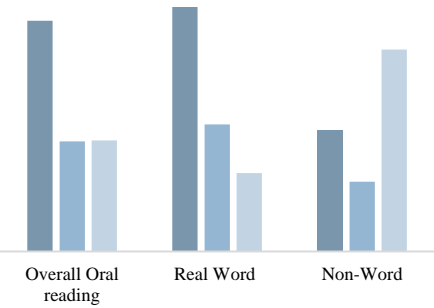
## Kannada Oral Reading

### Phonology

### Semantics

- Phonological Manipulation
- Real Word Rhyme Judgement
- Non Word Rhyme Judgement

- Auditory comprehension
- Picture Identification
- Auditory Judgement
- Picture Association



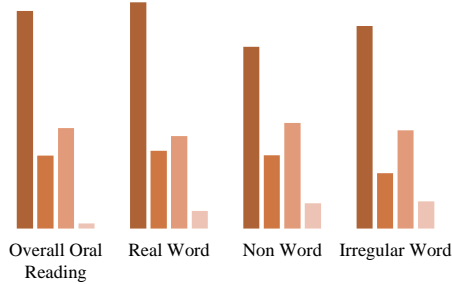
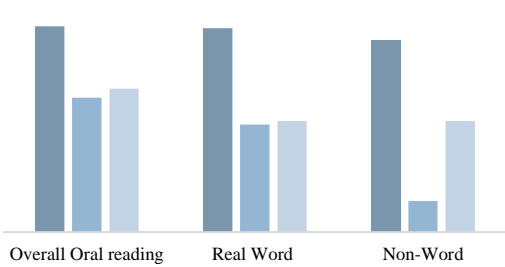
## English Oral Reading

### Phonology

### Semantics

- Phonological Manipulation
- Real Word Rhyme Judgement
- Non Word Rhyme Judgement

- Auditory Comprehension
- Picture Identification
- Picture Association
- Auditory Judgment

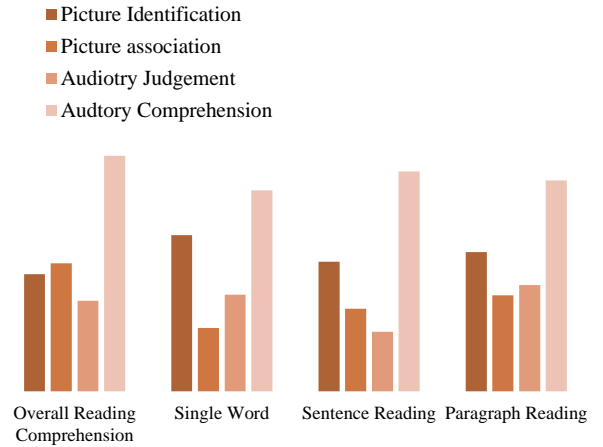
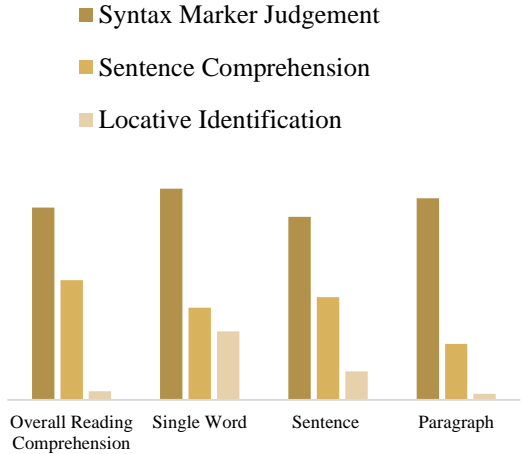
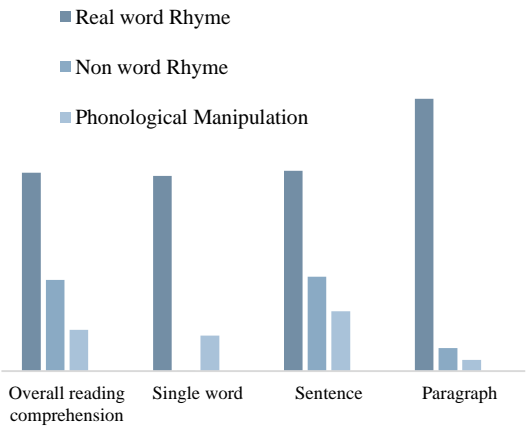


Note- The flow chart depicts the predictors of Oral reading abilities in Kannada & English languages through MLR analysis. Each bar graph is denoted by specific tasks of phonology, and semantics. The predictors are represented with  $\beta$  value deduced from MLR models. The double arrows denote strong relation, and single arrow denotes moderate relation.

# Predictor Model for Silent Reading Comprehension Abilities in Kannada and English

## Kannada Silent Reading Comprehension

## English Silent Reading Comprehension



Note- The flow chart depicts the predictors of Reading comprehension abilities in Kannada & English languages through MLR analysis. Each bar graph is denoted by specific tasks of phonology, semantics and syntax. The predictors are represented with  $\beta$  value deduced from MLR models. The double arrows denote strong relation, single arrow denotes moderate relation, and dotted lines denote weak relation.

## **CHAPTER V**

### **DISCUSSION**

Alexia is an acquired reading impairment secondary to brain insult. Most commonly, it is a consequence of left hemisphere injury, resulting in loss of ability to understand print or written scripts. Conversely, a similar left hemispheric brain insult is known to develop an impairment in spoken language, resulting in aphasia. Alexia and aphasia are known to co-exist, and researchers have been very keen in the recent past to examine the pathophysiological and clinical features they manifest to communicate. However, most of the research and rehabilitation concerning aphasia is focused on realizing and rehabilitating the spoken language abilities of PWAs rather than concentrating on their written language impairment (Knollman-Porter et al., 2015; Thiel et al., 2015). With the recent advances in technology, the dependency on the multimedia mode of communication, like the use of mobiles, computers, and laptops to text, email, or for any documentation, and so on has been exacerbated throughout the globe. Thus, PWAs themselves are concerned and express their desire to improve their written mode of communication to participate effectively in the era of technology. The acquired reading impairment or alexia is researched extensively in general, but in isolation. Often the researchers have neglected the association co-existing between spoken impairment and reading impairment, despite their common nature of pathophysiology. The perspective of looking into both spoken and reading impairment as associative may further enhance the quality of rehabilitation and even the assessment, to provide maximum independence to communicate for a PWA. Sadly, while treating aphasia, reading impairments are viewed as a separate entity from spoken impairment.

Disagreeing with the distinct view of spoken and written language, the connectionist model of single word processing known as the primary system hypothesis (PSH) (Patterson & Ralph, 1999) was proposed. According to the model, both spoken and written language are processed in synchrony through the activation of semantic, phonology, and orthographic units at the central level. A disruption in the connection between any of these modules may reflect varied types of reading impairments namely; deep, phonological, and global alexia, which are also known as central alexia. Henceforth, reading is a sophisticated process necessitating simultaneous activation of central

processes entailing linguistic domains, namely semantics, syntax, and phonology. PSH being a model explained based on the Western languages, specifically in the English language, seems inadequate to explain the processes entailed in Indian languages or any other alpha syllabary scripts per se. They fail to explain the inabilities in reading impairments owing to transparent or alpha-syllabary languages. Strongly believing in an underlying explanation from the Primary System Hypothesis (PSH), the study identified the need for examining the nature of language impairments and reading impairments and enumerating the relationship they share among each other in the Kannada- English bilingual context. Also, there are no attempts conducted in Indian languages to investigate the interdependence of language and reading processing involved in acquired reading impairment conditions with the support of neurocomputational models. In this line, the present study examined the performances of Kannada- English bilingual PWAs on linguistic domains (semantics, phonology, and syntax) and reading domains (oral reading, and reading comprehension) through a corpus of validated tasks in both Kannada and English languages. The tasks were entirely based on behavioral responses, administered after ensuring normal auditory-visual sensorium, cognition, and absence of apraxia of speech. The study intended to broadly look into the association between linguistic processing and reading processing. Also, the study aimed to delineate the cross-linguistic dissociations persisting across Kannada and English processing both in linguistic and reading aspects. Lastly, the study emphasized investigating the relation between types of alexia or degree of reading impairment and linguistic impairments in PWAs, exclusively in Kannada and English reading patterns. The detailed objectives and, sub-objectives are stated in Chapter III. The findings of the statistical analysis specific to each objective are discussed under the following headings below

#### 5.1. Relationship between linguistic abilities and oral reading in Kannada.

5.1.1 Influence of phonology on oral reading in Kannada.

5.1.2. Influence of semantics on oral reading in Kannada.

#### 5.2 Relationship between linguistic abilities and oral reading in English.

5.2.1 Influence of semantics on oral reading in English.

5.2.2 Influence of phonology on oral reading in English.

#### 5.3 Relationship between linguistic abilities and silent reading comprehension in Kannada.

- 5.3.1. Influence of phonology on reading comprehension of Kannada script.
- 5.3.2. Influence of syntax on reading comprehension of Kannada script.
- 5.4 Relationship between linguistic abilities and silent reading comprehension in English.
  - 5.4.1 Influence of semantics on reading comprehension in English.
- 5.5 Orthographic effects (alpha-syllabic vs alphabetic system) on reading abilities of Kannada-English bilingual PWAs.
  - 5.5.1 *Orthographic effects on reading abilities between Kannada and English in PWAs.*
  - 5.5.2 *Orthographic effects reading abilities within Kannada and English language performances.*
- 5.6. The linguistic abilities across and within Kannada and English in bilingual PWAs.
  - 5.6.1. *Cross-linguistic effects on linguistic abilities of Kannada- English bilingual PWAs.*
    - a. *Effect of Bilingualism on Semantics in PWAs.*
    - b. *Effect of Bilingualism on Phonology in PWAs.*
    - c. *Effect of Bilingualism on Syntax in PWAs.*
  - 5.6.2. *Linguistic abilities within Kannada and English language performances in PWAs.*
- 5.7. Reading and linguistic abilities in Bilingual PWAs across and within Alexia groups in Kannada and English.
  - 5.7.1. Linguistic abilities and reading abilities across sub-groups of alexia in Kannada and English languages of bilingual PWAs.
  - 5.7.2. Linguistic abilities (semantic, phonology, and syntax) and reading abilities within sub-groups of alexia in Kannada and English languages of bilingual PWAs.

### **5.1 Relationship between linguistic abilities and oral reading in Kannada.**

The section elucidates the connections and extent of relatedness between semantics, phonology, and syntax with oral reading abilities as per objective 1. Objective one aimed to examine the relationship between the linguistic abilities with oral reading abilities specific to the Kannada language. The performance of all twenty PWAs was analyzed over a comprehensive set of tasks tapping semantics, phonology, syntax, and oral reading processing. Semantics was investigated through a) picture association task, b) picture identification, c) auditory comprehension, and d)

auditory synonym judgment. Phonology was investigated through a) a real word rhyme judgment task, b) a non-word rhyme judgment task, and c) a phonology manipulation task. Syntax was observed through a) syntax marker (plural and tense) comprehension, b) sentence judgment task, and c) locative identification task. The oral reading abilities were addressed at two levels, a) real word reading, and b) non-word reading. The relationship between linguistic abilities and oral reading was analyzed in two folds. At first, a correlation analysis was performed to understand the relationship of semantics, phonology, and syntax with a) overall reading, b) real word reading, and c) non-word reading. Further, Multiple Linear Regression (MLR) analysis was performed on subtasks of semantics, phonology, and syntax with a) overall reading, b) real word reading, and c) non-word reading to determine the predictors of oral reading skills in Kannada language. The results of the investigation are discussed below.

#### ***5.1.1 Influence of phonology on oral reading in Kannada.***

The results of correlation analysis among linguistic domains revealed a highly significant relation between phonology and a) overall oral reading, b) real word reading, and c) non-word reading, suggesting an explicit influence of phonology on oral reading abilities of Kannada script among bilingual PWAs cohort. Compared to semantics and syntax, phonology seemed to share a strong correlation with oral reading abilities in Kannada. This indicates that oral reading skills are subserved directly by the extent of functioning of phonological aspects. The findings of the study agree with the preceding literature (Crisp & Lambon Ralph, 2006; Henry et al., 2012; Madden et al., 2018; Rapcsak, 2010). In general, oral reading abilities (single words) involve coordination of the semantic-phonologic reading pathway (Cherney, 2004), which is consistent with the neuropsychological models.

Specifically, owing to transparent orthography in Kannada script, there is a consistent relationship between letters and sounds. Hence individuals with phonological impairments may experience significant oral reading challenges. In Kannada, studies have shown that phonological processing significantly influences reading acquisition (Bishop & Snowling, 2004; Wagner et al., 1994) For instance, research by Nag, and Snowling (2011) found that poor readers of Kannada exhibited deficits in phonological processing, impinging their word decoding skills. They indicated

the core deficit in reading alpha-syllabary Kannada script is due to the phonological deficit (Nag & Snowling, 2011).

Another interesting factor contributing to the involvement of phonology in reading Kannada script could be the use of indirect strategy. Wimmer and Goswami (1994) proposed that while reading a transparent script (e.g., Kannada, German, Spanish), the readers use an indirect strategy to read, which involves letter-to-sound conversion while recognizing the words. This is opposed to the direct strategy used in English (or any opaque script) reading, who use whole-word recognition to read. Karanth (2004) in her experiment concluded that a skilled transparent script reader relies on grapheme to phoneme conversions. Hence, a transparent language like Kannada necessitates an active phonological process involving grapheme-to-phoneme conversions in the oral reading process, which is evident from the correlation pattern observed in the study.

Yet another factor contributing to strong phonology and oral reading relation in Kannada is the phonological alexia pattern in the cohort of the study. As per the objective five of the study, all 20 PWAs were analyzed for reading errors, and 55% of them (11/20) were categorized with phonological alexia, and 5/20 manifested deep alexia based on Kannada oral reading accuracy. Very clearly studies have proved reading errors are a direct consequence of phonological processing deficits in phonological alexia, and deep alexia which is even severe form of phonological variant per se (Beeson et al., 2010; Kendall et al., 2003). As a consequence of the presence of more than half of the cohort in the study manifesting phonological alexia traits and severe variants of alexia, the analysis of oral reading errors depicts phonological deficits predominantly by large concerning Kannada reading skills.

The reading errors in Kannada were further analyzed for correlation with phonology, and results revealed a strong positive phonological correlation with both real word reading and non-word reading. The findings support the principles of connectionist models, which emphasize that the orthography and phonology links are a reflection of phonological deficits evidenced through poor real word and non-word reading (Marshall et. al., 1987; Harm & Seidenberg, 1999; Woollams, 2014)). Similar observations were reported by Newcombe and Marshall (1985) who identified reading errors in real words as well as non-words. They attributed it to arise from a breakdown of

graphemic parsing (segmenting each letter in the word), even with conserved processing of letter-sound correspondences.

Interestingly, the real words were strongly correlated with phonology compared to non-words in Kannada oral reading. The probable reason for this could be the word familiarity effect (Patterson & Marcel, 1992). In the study, phonological composite scores highly correlated with real word reading as the phonological activation required for familiar patterns of real words is easier than the new activation of phonological strings for non-words. This finding is in consensus with the study by Madden et al., 2018.

The study investigated the phonological predictors of oral reading abilities in Kannada through three phonological tasks, a) real word rhyme judgment, b) non-word rhyme judgment, and c) phonological manipulation task. The phonological manipulation task depicted the strongest correlation with real word reading, which is consistent with the findings of experiments on acquired reading impairment (Rapcsak, 2009; Madden et al., 2018) and atypical developmental reading impairments (Wagner et al., 1994; Bishop & Snowling, 2004). Readers with poor phonological awareness and poor phonological short-term memory tend to manifest compromised phonological decoding abilities. The same is true for a strong correlation between phonological non-word rhyme judgment tasks and non-word oral reading in Kannada script. Non-word reading entails grapheme parsing, grapheme-to-phoneme conversion (decoding), and blending (Cherney, 2004), which all are the same processes necessitated in non-word rhyme judgment tasks as well. Similar observations were reported by Newcombe and Marshall (1985) who attributed reading errors in real words as well as non-words arise from a breakdown of graphemic parsing (segmenting each letter in the word), even with preserved phonological awareness. Thus, phonological manipulation is the linguistic precursor, thus proving to be a sensitive predictor of real word, and non-word reading skills.

### ***5.1.2. Influence of semantics on oral reading in Kannada.***

The results of correlation analysis among linguistic domains revealed a strong significant relation between semantics and a) overall oral reading, b) real word reading, and c) non-word reading, suggesting an explicit influence of semantics on oral reading abilities of Kannada script among PWAs. The finding is in consensus with previous works (Crisp & Lambon Ralph, 2006;

Madden et al., 2018). After phonology, semantics was observed to have a direct influence on the oral reading abilities of Kannada script.

From connectionist model views, there is evidence of the direct impact of semantics representations on oral reading abilities (Crisp & Lambon Ralph, 2006; Plaut, 1996). Through a number of case series experiments, oral reading accuracy is observed to be influenced by the individual's residual conceptual knowledge (semantics) of the target words in post-acquired reading impairment instances (Graham, Hodges, & Patterson, 1994, Crisp & Lambon Ralph, 2006).

The correlation analysis indicated that the extent of association of semantics with oral reading is penultimate to phonology. The study highlights the observations of Karanth (2004), who addressed orthographic-specific influence on reading abilities, and stated that while reading transparent orthographies (e.g., Kannada), readers do not depend on lexical reading as much as they do in reading opaque scripts (e.g., English) in typical reading process. The same was reported in reading Chinese, and Spanish transparent scripts (Goral, 2019; Weekes, 2005).

Specific to Kannada script, as stated earlier, it entails active grapheme-phoneme translation rapidly when a typically skilled reader is reading the text. Thus, a typical reader would engage himself in decoding the meaning more. However, for an individual with impaired reading processing, most of the attention of the reader is on reading through grapheme-phoneme conversion alone, and hence the ability to access the meaning of the word is limited (Cherney, 2004). Subsequently, semantic access is not active while reading aloud among acquired reading deficit individuals, though accessed later for meaning or comprehension. Thus, semantics is next strongly correlated to oral reading abilities after phonology owing to the results of the Kannada script in the study.

The pattern of correlation was stronger between semantic and real word reading compared to non-word reading (real word > non-word reading), which agrees with the literature (Cherney, 2004; Crisp & Lambon Ralph, 2006, Madden et al., 2018). The oral reading of familiar or real words involves active access to a visual word store with immediate verification of the meaning of the word being read (Cherney, 2004). On the contrary, while reading non- word, the focus is on accessing the phonological strings of unfamiliar combinations, hence negating the access to semantics or lexical nodes. In non- word reading process, orthographic- phonological loop is most active and the semantic

loop is bypassed (Cherney, 2004). Hence, the correlation of semantics is greater with real words than with non-word reading concerning the Kannada script.

On analyzing the semantic predictors of oral reading abilities through a) picture identification, b) picture association, c) auditory comprehension, and d) auditory synonym judgment tasks, the regression analysis revealed overall oral reading, real word reading, and non-word reading conditions significantly correlated with auditory comprehension and picture identification tasks. This indicated that while reading Kannada text aloud, individuals are actively accessing the auditory processing and relating to the conceptual knowledge of the words being read through auditory comprehension tasks. Also, this suggests that they are involved in analyzing the spontaneous feedback of words being read. The picture identification task seems to be a sensitive predictor of oral reading abilities in Kannada. This could be attributed to the alpha-syllabic nature of the language. The script is loaded with a cluster of graphemic specifications. Being an alpha-syllabic script, each consonant has a series of graphemic representations. The root of the grapheme remains constant, but depending on the vowel attached, the shape and phonics of the grapheme changes. Thus, the spatial layout of the script is high, resulting in visual complexity (Chengappa et al., 2004). To an extent, a small variation in the grapheme concerning vowel attached to the consonant/ root may vary the meaning of the word (e.g., vowel /a/- short and long (/baala/ (ಬಾಲ್) means tail, and /bala/ (ಬಲ್) means strength). Thus, due to this unique nature of the script, the reader has to visually perceive and identify the graphemes and blend them phonetically while reading. Thus, Kannada reading necessitates finer visual identification and visual discrimination to translate the grapheme to phoneme (Chengappa et al., 2004; Karanth, 2003; Ratnavalli et al., 2000). In this manner, the strong correlation between picture identification task and oral reading of Kannada script is well justified concerning the results of the study, indicating it as a sensitive semantic (linguistic) indicator of oral reading abilities in Kannada.

From the above discussions, the study indicated that Kannada oral reading abilities are invariably influenced by phonological processing more, followed by semantic processing in PWAs. The strong phonological activation during oral reading tasks may be attributed to a) the transparent

nature of Kannada orthography which involves active letter-to-sound translation, b) the indirect strategy used while acquiring and using transparent orthography as they do not recognize words as “whole”, c) majority of the cohort in the study manifested phonological and deep alexia, who reflected phonological deficits. The phonological abilities correlated strongly with non-word reading compared to real word reading conditions in Kannada. The real word reading strongly influenced by phonology may be attributed to a) issues in the grapheme parsing/blending despite intact letter-sound correspondence, b) word familiarity effect, wherein reading real words is easier to activate the already known strings of letter-sound as opposed to unfamiliar words. The phonological task which was sensitive predicting the oral reading functioning in Kannada was identified as the phonological manipulation task. The strong correlation of phonological manipulation task with oral reading could be attributed to a) poor phonological awareness, and b) poor short-term memory resulting in deficits in decoding the phonological strings in Kannada oral reading.

Further, the semantic domain was found to be the next highly correlated aspect with oral reading abilities after phonology. The study ascribes the reduced semantic association with oral reading compared to phonology to a) the transparent nature of Kannada script, which does not involve lexical reading overtly, b) phonological deficit is more prominent in stroke-induced acquired reading impairment, resulting in more tedious effort on grapheme-phoneme translation with limited access to semantics/ meaning per se. However, semantics is accessed in later stages of phonological decoding. Hence, there is a good positive correlation in this instance. The pattern of oral errors showed a high correlation between real word reading and semantics compared to non-word reading, suggesting a strong influence of semantic activation in reading real words and less in non-word in Kannada script reading. This was attributed to a) real word reading involves rapid access to visual word store leading to immediate access to meaning, b) non-word reading involves activation of unfamiliar letter strings, hence semantic access is skipped. The most sensitive semantic predictor of the oral reading abilities of Kannada was identified to be the auditory comprehension task and picture identification task. Auditory comprehension task is much sensitive to oral reading skills as it involves accessing auditory processing concerning to conceptual knowledge actively accessed while reading.

The transparent nature of Kannada script may involve visual discrimination and letter identification while reading aloud, thus association with picture identification task may be reasonable.

## **5.2 Relationship between linguistic abilities and oral reading in English.**

The study further intended to investigate the association between linguistic abilities and oral reading abilities among PWAs in the English language owing to objective one. The semantics, and, phonology of linguistic aspects were analyzed through comprehensive tasks as described in the previous section 5.1 for Kannada. Similarly, the oral reading abilities were analyzed across a) real word reading, b) non-word reading, and c) irregular word reading. Irregular word reading was not included in the reading task of Kannada attributing to the transparent orthographic nature of the script. The association was examined in two folds. First, the performances in semantics, and phonology were analyzed for correlation with oral reading conditions of English through bivariate correlation. Next, the subtasks of semantics and phonology were evaluated through multiple linear regression with all conditions of oral reading tasks to deduce the predictors of oral reading abilities of English.

The bivariate correlation between semantics, phonology, and oral reading conditions revealed oral reading abilities strongly correlating with semantics, followed by phonology. The results are discussed in the following sections below.

### ***5.2.1 Influence of semantics on oral reading in English.***

The oral reading abilities were found to be strongly correlated with semantics compared to phonology. The finding is in consensus with prior literature (Beeson et al., 2022; Cherney, 2004; Crisp & Lambon Ralph, 2006; Madden et al., 2018; Woollams, 2014). Thus, the results indicate that semantics processing at central linguistic level contributes immensely to oral reading skills, followed by phonology in English oral reading.

The finding is also in agreement with prior observations of the primary system hypothesis, which proved graded inhibition of semantic processing among semantic dementia individuals reflecting impairments in their spoken as well-written language processing (Beeson et al., 2022; Plaut, 1996; Ralph et al., 2002).

Oral reading in English involves reading through stored pronunciation, which entails activation of orthographic-semantic association/ link. Hence, they do not require activation of orthographic- phonological loop, instead directly access the orthographic-semantic loop and then access the phonological processor to read out loud the written words in general (Cherney, 2004; Madden et al., 2018; Ueno et al., 2014).

Owing to orthographic features of English script, studies on reading acquisition report that generally, individuals learn to read English through two strategies. One is through a direct style, involving whole word recognition. The second method is through indirect style, depending on word recognition through letter-to-sound conversion. English readers follow or prefer the direct style of reading due to the opaque nature of the script. While the inverse is in transparent orthography (Wimmer & Goswami, 1994; Karanth, 2003). This clearly indicates that less transparent language like English relies on lexical access, which underlines the activation of semantic connections. Thus, reading English scripts is more connected to semantic activations.

Traditionally, the specific influence of semantics on oral reading accuracy is appraised through the lexicality effect, which refers to reading real words, non-words, and irregular words owing to the English language (Beeson et al., 2022; Crisp & Lambon Ralph, 2006; Madden et al., 2018). The pattern of association between semantics and oral reading was gauged through correlation analysis. The strongest association was observed between semantics and real word reading> irregular word reading> non-word reading. The finding is in line with previous experiments on acquired reading impairments (Beeson et al., 2022; Cherney, 2003; Crisp & Lambon Ralph, 2006; Madden et al., 2018). This pattern is very much reasonable owing to the following reasons.

While reading real words, the reader spontaneously matches the visual word store at the lexicon level and then tries to match the meaning through semantic activation. Hence, while reading real (regular) words, the “whole word” reading strategy is performed though the phonological processor is activated (Cherney, 2005, Crisp & Ralph, 2006). Also, reading regular words may be underlined through the familiarity effect. As the words are frequently used or familiar to the reader, they directly tend to access the orthographic–semantic association and less access to the orthographic-phonological loop (Woollams, 2014). The need to actively convert letters to sounds is

not necessary for reading regular/ real words. Hence, weightage is more on the semantic system to read regular words. However, this is not the case in reading irregular word/novel words. Reading irregular words entails non-transparent letter-to-sound association found in opaque languages (e.g., English, French). Consequently, the reader needs to store the unusual pronunciation in their lexical buffer to read out loud visualizing the word. Again, like regular English word reading, “whole word” or “whole gestalt” (Karanth, 2002) reading is entailed in reading irregular words in English. This invariable necessitates the involvement of a semantic system to activate while reading the irregular words. However, in the case of acquired reading impairment conditions, the access to the semantic system is compromised due to a central deficit, resulting in dependency on the phonological loop to read the irregular words phonetically in correspondence to the grapheme. Thus, the semantic involvement in reading irregular words in acquired reading conditions is inhibited (Cherney, 2004; Lambon Ralph & Patterson, 2005) as evidenced in the study.

The non-word reading shows the least dependency on semantics compared to real words and irregular. While reading non-words, the reader tends to match the visual form to sound mapping, involved in reading letter strings. Thus, reading non-words involves the orthographic-phonological loop, bypassing the semantic loop (Cherney, 2004). Also, because these words are unfamiliar or novel to the individual, they automatically depend on reading through the phonological loop.

The regression analysis of semantic subtasks with a) overall oral reading, b) real word, c) non-word reading, and d) irregular word reading of the English language revealed the strongest correlation between auditory comprehension task and all the reading conditions. This indicated that the auditory comprehension task is the most sensitive semantic predictor of oral reading abilities in English script, which is in line with observations in previous literature (Beeson et al., 2022; Crisp & Lambon Ralph, 2006; Madden et al., 2018). The auditory comprehension task is known to tap the lexical knowledge with active auditory processing of the words at the central level. From former discussions, oral reading (real word, irregular word, non-word) is strongly influenced by semantics involving strong lexical access by large while reading English script. Hence, auditory comprehension tasks may serve as a strong predictor of oral reading tasks in English. The picture association and picture identification tasks are known to tap conceptual knowledge (Beeson et al., 2022) rather than

lexical knowledge. Also, the performance of PWAs on these picture-based tasks resulted in ceiling performance as the tasks were relatively easy and less taxing (Karanth, 2003). This portrayed the insensitivity to semantic deficits, hence are not closely associated with oral reading abilities based on the findings of the study.

### ***5.2.2 Influence of phonology on oral reading in English.***

The bivariate correlation analysis among linguistic skills and oral reading abilities revealed a strong correlation with phonological domains after semantics. A similar pattern of associative trend was reported in earlier experiments on acquired reading impairment cohorts (Beeson et al., 2022; Crisp & Lambon Ralph, 2006; Henry et al., 2012; Madden et al., 2018; Rapcsak, 2010). The pattern of correlation is different from the Kannada script. In Kannada reading, phonology manifested a strong correlation with oral reading followed by semantic influence. The opposite is observed while reading English script, indicating the restricted influence of phonology compared to semantics in English reading. This may be attributed to the gestalt reading strategy in reading the alphabetic script (Karanth, 2004), inferring minimal dependency on grapheme to phoneme translation unlike observed in transparent languages.

Specifically, the English script is highly irregular as in many instances there is no direct grapheme to phoneme transparency. In such instances, the brain processes the irregular patterns through lexical learning and stores the whole word as such. So by large both semantics and phonology are involved in reading English script, with more dependency on semantics.

Also, another factor that could be contributing to moderate participation of phonology in English oral reading is the method of English language acquisition. Unlike the present education system, earlier schools followed ‘rote learning’ rather than ‘phonic learning’. By default, the individual acquired English reading through rote memorization and less through phonic based, depending on semantic store majorly and less on phonology (Karanth, 2003). In general, the orthographic-phonological loop is disturbed usually post-stroke (Jefferies et al., 2007), resulting in inhibition of letter-to-sound translation. Thus, major control of semantics in English reading may be evidenced.

The regression analysis was performed to evince the phonological predictors of oral reading abilities in English. Among the real word rhyme judgment, non-word rhyme judgment, and phonological manipulation tasks, the results showed the strongest association with phonological manipulation (parsing and blending of sounds) and all conditions of oral reading (real word, non-word, and irregular word reading). The findings suggest that the phonological manipulation task is a sensitive phonological predictor of the central system of oral reading abilities concerning English script, which is well supported by earlier literature (Beeson et al., 2022; Crisp & Lambon Ralph, 2006; Henry et al., 2012; Rapcsak, 2010).

From prior literature on proficient readers, the phonological manipulation task has been the most sensitive task subserved by phonological functioning at central level. However, it is not practiced in everyday instances, phonological manipulation is a good indicator of both spoken and written language functioning (Beeson et al., 2010, Beeson et al., 2022; Crisp and Lambon Ralph, 2006; Henry et al., 2007; Rapcsak et al., 2009). Often it is proved that phonological manipulation deficits reflect poor phonological awareness and poor phonological short-term memory resulting in poor decoding abilities, which is agreed by both acquired reading impairment evidence (Rapcsak et al., 2009) and developmental cohorts (Bishop & Snowling, 2004; Wagner et al., 1994). Phonological manipulation task proves to be a good predictor for oral reading abilities owing to the results of the study. Also, the results of the study indicate that real-word rhyme judgment and non-word rhyme judgment were not sensitive phonological predictors of oral reading abilities. This was agreed upon by reports of Beeson and colleagues, 2022, stating these tasks tap only the phonological awareness which is not sufficient enough to tap higher phonological skills at central linguistic processing stage.

In summary, the results of objective one concerning oral reading abilities in English indicated strong dependency of oral reading abilities on semantics, followed by phonology owing to the performance of the PWAs cohort in the study. The deeper association of semantics with an oral reading of English may be attributed to a) graded semantic inhibition according to the primary system hypothesis, reflecting compromised reading performance, b) English script is opaque in nature and hence involves storing pronunciation through orthographic-semantic activation, and c) English readers learn to read through whole word recognition, depending more on semantic activations. The

pattern of association with semantics and oral reading revealed stronger semantic connections with real word >irregular> non-word. This pattern could be confirmed as a) real word reading entails matching visual stores in the lexicon leading to semantic activations, b) real word or regular words refer to familiar words involving orthographic semantic loop activity for rapid recognition from the store, c) irregular words also use orthographic – semantic loop activation due to opaque nature of the script, translation through phonological loop results in erroneous pronunciation, d) non – word involves recognizing novel strings of letters which are not available in the semantic store. Hence, reading real words has the maximum dependency on semantics, and non-word reading has the least semantic influence owing to English script.

Further, the results indicated a positive strong correlation with phonology, yet diminished compared to semantics with oral reading abilities of English. This may be ascribed to a) the use of gestalt reading in English, which necessitates weaker involvement of orthographic-phonological loop, b) English script being opaque, the irregular patterns are processed through semantics and not through phonology, c) English readers may have acquired literacy through whole word reading and not through the phonic system, and d) mostly in post-stroke conditions, phonological skills are impaired to a larger extent compared to semantics. Henceforth, due to these reasons, the study predicts that phonological involvement may be weaker in English reading compared to semantic based on the performance of the cohort.

Similar to the results of the Kannada regression analysis, the phonological manipulation task indicated to be a strong phonological predictor of oral reading abilities in English script. This may be attributed to poor phonological awareness and poor phonological short-term memory resulting in poor decoding skills while reading the text among acquired reading impairment condition. On the contrary, the rhyme judgment tasks proved not sensitive enough to tap oral reading skills as they did not reflect higher phonological processing.

Overall, the oral reading abilities of Kannada–English bilingual PWAs depicted a strong association with semantics and phonological aspects. In specific, the phonological manipulation task was the most sensitive phonological task in predicting the oral reading abilities in both Kannada and English. Auditory comprehension and picture identification tasks were convincing semantic

predictors of Kannada text oral reading, and English text reading was strongly associated with auditory comprehension alone.

Subsequent to determining the relations and predictors of oral reading abilities of Kannada and English languages from linguistic domains (semantics, syntax, and phonology), the study attempted to investigate the same for reading comprehension abilities in bilingual PWAs across Kannada and English languages in the following sections.

### **5.3 Relationship between linguistic abilities and silent reading comprehension in Kannada.**

The section elucidates the connections and extent of relatedness between semantics, phonology, and syntax with silent reading comprehension abilities as per objective two. The objective aimed to examine the relationship between linguistic abilities with silent reading comprehension abilities specific to the Kannada language. The performance of all twenty PWAs was analyzed against a comprehensive set of tasks entailed in semantics, phonology, syntax, and reading comprehension. Semantics was investigated through a) picture association task, b) picture identification, c) auditory comprehension, and d) auditory synonym judgment. Phonology was investigated through a) a real word rhyme judgment task, b) non- word rhyme judgment task, and c) a phonology manipulation task. Syntax was examined through a) syntax marker (plural and tense) comprehension, b) sentence judgment task, and c) locative identification task. The reading comprehension abilities were addressed at three levels a) single word reading, b) sentence reading, and c) paragraph reading. The relationship between linguistic abilities and reading comprehension was analyzed in two folds. At first, a correlation analysis was performed to understand the relationship of semantics, phonology, and syntax with a) single-word reading comprehension, b) sentence reading comprehension, and c) paragraph reading comprehension. Further, Multiple linear regression (MLR) analysis was performed on subtasks of semantics, phonology, and syntax with a) overall reading comprehension, b) single-word reading, and c) paragraph reading to determine the predictors of these reading comprehension conditions. The results of the investigation are discussed in detail below.

### ***5.3.1. Influence of phonology on reading comprehension of Kannada script.***

The correlation analysis among linguistic aspects with reading comprehension showed a strong positive correlation. The overall reading comprehension correlation was intense with phonology>syntax>semantics concerning Kannada script. This pattern indicates a maximum influence of phonological and syntax, followed by semantics in Kannada silent reading comprehension.

The strong phonological and syntactic association with the reading comprehension of the Kannada script may be attributed to the transparent nature of the script. Kannada being an alpha syllabic script entails close correspondence to written letters and speech output (Karanth, 2003). This was evidenced in oral reading tasks of Kannada reflecting a strong association with phonology in the previous objective of the study. Automatically, the visual recognition of words while reading comprehension is first triggered through the activation of phonological loops though the speech-motor system is inhibited. To identify the text/ letters, an orthographic-phonological loop is invariably activated. Evidence on developmental reading comprehension in Kannada suggests that early readers depend on phonological awareness and phonological manipulation which enhance in decoding of the words being read. A strong association was noted between phonological awareness, and reading fluency and comprehension in early Kannada readers (Prabhu et al., 2024). The phonological influence eventually fades away as the reader becomes more skilled manifesting dependency on integrated activation of syntax and semantics to comprehend the text in Kannada (Prabhu et al., 2024). In acquired reading impairment condition, as the central linguistic processes are impaired post-stroke, which leads to compromised processing speed and accuracy of reading text (Ravi & Chengappa, 2014). Through this evidence, it can be inferred that individuals with acquired reading impairments post-stroke probably rely on reading strategy followed by early readers of Kannada script. Wherein, they decode written text through orthographic- phonological loop, followed by syntactic segmentation and comprehension. Unfortunately, there is no direct literature support addressing the correlation between phonology, semantics, and syntax with reading comprehension exclusively in Kannada readers. However, the study attempts to delineate the probable processes occurring with shreds of evidence from developmental and post-stroke reading

impairment studies in the context of reading comprehension in Kannada. Hence, this indicates that future studies may focus on exploring the underlying central linguistic aspects of reading comprehension across skilled readers and acquired reading-impaired cohorts, particularly in transparent scripts.

The PWAs cohort in the study showed significantly varied correlation patterns across reading comprehension levels with phonology. Results indicated strongest phonological association with paragraph reading > sentence reading > single word reading. This suggested that with an increase in the length and complexity of reading text, the dependency on phonology was greater. Webster et.al (2022) found a significant correlation between reading comprehension and text complexity in PWAs, and they implied this to a breakdown in phonological decoding and syntactic parsing. As discussed previously, the reading comprehension task entails phonological decoding to recognize the words, followed by syntactic parsing to verify the morphological aspect, and then deducing the meaning of the text being read to comprehend.

Due to central linguistic deficits in PWAs, phonological processing is compromised by large, leading to marked deficits in decoding abilities of paragraph and sentence-level texts (Friesen & Frid, 2021). Also, the working memory involvement could be a key mediator in the reading comprehension process. While reading text, phonological strings of sound need to be blended for accurate word recognition. Disconnected phonological working memory hampers reading comprehension at the lexical level. The task becomes more taxing when loaded with more words (as in sentences, and paragraphs) to process the text, demanding a long span of attention and working memory on the individual to read longer sentences (either oral or silent). Owing to PWAs, compromised working memory capacity results as a contributing factor to silent reading comprehension difficulties (Meteyard et al., 2015; Purdy et al., 2019). Thus, poor phonological decoding abilities coupled with poor phonological working memory in PWAs may contribute to poor reading comprehension at sentence and paragraph levels. This is proposed through the Phonological Deficit Hypothesis (PDH) (Rack, 1994). The PDH posits that poor readers struggle with processing and retaining phonological information in working memory. This working memory deficit hinders the delivery of information at the speed and accuracy needed for higher-level processing.

Shankweiler and Crain (1986) suggest that challenges in processing complex syntactic structures as seen in sentence and paragraph reading should be understood as stemming from difficulties at the phonological level rather than the syntactic level. The extent of phonological influence in the study was observed to be equivalent in both sentence and paragraph reading, this could be because PWAs were trying to read familiar words and chose to scan through the text for keywords that they were able to comprehend (Knollman-Porter et al., 2015; Madden et al., 2018). Hence, paragraph and sentence reading are influenced by phonological processing at the central level in the PWAs of the study.

On the contrary, single-word reading comprehension evinced the least phonological influence. This may be predicted due to short phonological strings entailed at the word level, demanding the least load on phonological recognition and working memory to blend the strings. Word recognition is much faster at the word level compared to sentence and paragraph level. Also, as the task comprised of common familiar words to read and comprehend at the word level, the familiar strings of phonemes tend to be activated much immediately leading to whole word recognition, reducing the dependency of phonological activations. Yet another factor could be the nature of the task. The cohort of the study was instructed to read the word and match the corresponding picture out of four choices. So the PWAs had the context presented through the pictures, they had to just match the word and the picture, thereby reducing the load on phonological activation and even lexical knowledge.

The regression analysis was performed to predict the sensitive phonological task for reading comprehension in Kannada. Results indicated a strong correlation between the real word rhyme judgment task and overall reading comprehension, single-word reading comprehension, sentence reading, and paragraph reading comprehension. The rhyme judgment task defines the phonological awareness of the individual. In PWAs, even mild deficits in phonological judgment tasks reflects poor phonological awareness in them (Beeson et al., 2022). Thus, phonological awareness could be sufficient to recognize the word concerning reading comprehension task, unlike oral reading requiring higher phonological processes (phonological awareness and phonological manipulation).

Thereby, the rhyme judgment task may be considered a good phonological predictor of Kannada silent reading comprehension based on the results of the study.

### ***5.3.2. Influence of syntax on reading comprehension of Kannada script.***

Parallel to phonological aspects, syntax also manifested an equivalent association with reading comprehension abilities in Kannada. The results indicated that syntax has a direct influence on reading comprehension abilities of Kannada script. In general, it is quite proven that syntax is the mainstay of reading comprehension through developmental studies (Tiwari et al., 2017), and acquired reading impairment conditions (Meteyard et al., 2015; Ravi & Chengappa, 2014; Webster et al., 2023). Nag and Snowling (2011) identified a strong correlation between syntactic awareness skills and reading comprehension in language-impaired individuals. With agrammatism at its peak in PWAs, reading comprehension of written text becomes even more challenging.

Specific to the Kannada language, the syntactic structure is featured by Subject-Object-Verb (SOV) order, with the presence of extensive inflections, and postpositions that significantly affect majorly on the reader's ability to extrapolate meaning from reading the Kannada script. Thus, Kannada is referred to as an agglutinative language (Tiwari et al., 2017) due to the structural complexity in the morphosyntax of the language. Due to these inherent features of the language, reading comprehension of Kannada text is underlined by syntactic processing to a much larger extent compared to other languages (e.g., English).

On analyzing the magnitude of correlation between syntax and reading comprehension levels, a significant strong association was manifested with paragraph reading > sentence > single word reading. At the sentence level, individuals with aphasia often struggle to comprehend grammatically complex and reversible sentences, whether presented in spoken or written form (Webster et al., 2013). Reduced syntactic processing could be attributed to reduced speed of lexical activation contributing to impaired sentence reading comprehension in individuals with aphasia, consistent with the findings of previous studies by Thomson & Choy (2009), and Ravi & Chengappa, 2014. Caplan and Evans (1990) stated that difficulties in sentence-level reading comprehension tend to cause difficulties at paragraph level too. Yet another factor could be due to incomplete access to

word class information and delays in integrating words within a sentence among PWAs may result in longer processing and comprehension duration for sentences (Ravi & Chengappa, 2014). The most striking aspect could be the agglutinative nature of Kannada script (Tiwari et al., 2017). Due to the complex syntactic makeup of the language, sentence, and paragraph processing becomes competitive with higher syntactic parsing needed to deduce the meaning of the text being read.

The results of regression analysis signified syntactic marker judgment task as a sensitive syntactic predictor of reading comprehension abilities concerning Kannada language. The syntactic marker judgment task entailed the judgment of correct and incorrect tense forms and plural forms of the Kannada language. These tasks involve lexical knowledge and syntactic parsing to segment the words from their inflections and decode the meaning. For example, the plural form of /haṅḡu/(fruit) is /haṅḡu-gaḷu/. In Kannada /gaḷu/ is the plural form mostly used to depict plurals. Irregular patterns are also used in the language [e.g., /magu/ (baby)- /makkaḷu/ (babies)]. Likewise, tense markers of Kannada are also combined with complex inflections (e.g., /hogu/ (go)- /hogida/ (went for male), /hogidalu/ (went for female), /hoythu/ (went for animal/ object). Thus, Kannada entails complex morphosyntax. Studies on developmental language impairment suggest that deficits in syntax at the central linguistic level are reflection of poor processing of tense, agreement markers, and case markers (Tiwari et al., 2017). Naturally, processing these morphosyntactic units of sentences or paragraphs involves syntactic parsing. Among PWAs, syntactic parsing both in shorter text and richer text reading has evidenced deficits in syntax by large (Meteyard et al., 2015; Perfetti et al., 2007). Hence, based on the findings of the study, the syntactic marker judgment task may be deemed as a sensitive syntactic predictor of reading comprehension in the Kannada language.

From the above discussions, the study indicated that Kannada reading comprehension abilities are predominantly guided by phonological and syntactic processing, followed by semantic processing in PWAs. The strong phonological activation during reading comprehension tasks may be inferred from a) the transparent nature of Kannada orthography which involves active letter-to-sound translation alike oral reading process, b) reading comprehension demands word recognition as a first step and owing to transparency of the language it occurs through phonological activation first, c) deficits in phonological decoding results in poor word recognition, d) due to poor

phonological processing speed and accuracy evidenced in PWAs, phonological activation demands longer duration to decode. The extent of phonological influence across the reading comprehension levels manifested a strong effect on paragraph reading>sentence>single word in Kannada. The paragraph and sentence strongly inflected by phonology may be attributed to a) phonological breakdown in PWAs exacerbated with an increase in length and complexity leading to phonological decoding challenges, b) underlying central linguistic deficits sub serve poor phonological processing, c) poor working memory triggers limitations to hold larger strings of sounds to blend, and d) complex syntactic units in sentence and paragraph demands complex phonological decoding. On the contrary, single-word reading comprehension had the least phonological influence which could be presumed due to a) short phonological strings demanding less phonological activation and lesser working memory involvement to hold smaller strings, b) word familiarity effect which demands phonological activation, and c) due to picture based task, the phonological dependency will be minimum and semantic knowledge access is more to match with the concept already presented in the form of picture. The phonological task at a linguistic level which was sensitive to predicting reading comprehension abilities in Kannada is the real word judgment task. The strong correlation of real word judgment task with reading comprehension could be attributed to a) involvement of phonological awareness necessitated for word recognition in the reading comprehension process, unlike higher phonological activation required for reading orally. Hence rhyme judgment proved to be a strong predictor of Kannada reading comprehension abilities.

Further, the syntactic aspects were evidenced to manifest an equivalent correlation with silent reading comprehension abilities in Kannada. The study attributes syntax to share prominent influence along with phonology to a) involvement of syntactic awareness and syntactic parsing underlined for efficient reading comprehension of written text, b) specific to agglutinative nature of Kannada language, due to complex syntactic units it demands higher syntactic processing comparatively, and c) due to agrammatic prominently noticed in PWAs, syntactic processing comes more challenging in this cohort. The trend in syntactic association across the levels of reading comprehension manifested a clear definitive correlation with paragraph reading> sentence reading > single word reading. The study attributed this to a) underlying central processing deficits in PWAs

resulting in reduced speed of lexical activation, b) incomplete access to word class information in PWAs, and c) complex morphosyntax entailed in the language requires higher syntactic parsing. Further, the syntactic marker judgment task is observed to be a sensitive predictor of reading comprehension in Kannada. This task encompasses lexical knowledge and syntactic parsing. Kannada being a complex morphosyntactic language, compels syntactic parsing often to deduce the meaning. In the context of PWAs, due to central linguistic deficit post-stroke, processing tense, agreement markers, and case markers are inhibited. Thus, processing sentences and paragraphs through syntactic parsing is questionable. Poor syntactic parsing is reflected through syntax marker judgment tasks both at the linguistic level and at the written language level as per the results of the study.

#### **5.4 Relationship between linguistic abilities and silent reading comprehension in English.**

Akin to Kannada, the performance of PWAs in the study was investigated for correlation among linguistic abilities (phonology, syntax, and semantics) and silent reading comprehension abilities in the English language. Initially, the bivariate correlation analysis was employed individually among phonology, syntax, and semantics with a) overall reading comprehension, b) single-word reading comprehension, c) sentence reading comprehension, and d) paragraph reading comprehension. This was followed by multiple regression analysis to evince the linguistic predictors of reading comprehension across various levels through sub-tasks of semantics, syntax, and phonology. The results are discussed in detail in the following section.

##### ***5.4.1 Influence of semantics on reading comprehension in English.***

The correlation analysis among linguistic domains revealed a significantly strong association between semantics and overall reading comprehension abilities across all conditions compared to phonology and syntax in English language. The phonological and syntactic influence was almost equivalent and not significant as per the results. A similar pattern was observed in previous literature on PWAs (Madden et al., 2018). However, the finding was contrary to the pattern evinced in Kannada (syntax > phonology > semantics with reading comprehension).

The strong semantic interaction in silent reading comprehension in English may be attributed to oral reading pattern evidenced in the present study. Oral reading in English manifested the highest correlation with semantics followed by phonology underlined by the alphabetic nature of the language. Naturally, while silent reading comprehension, as discussed previously, first word recognition occurs followed by accessing lexical representation linking the linguistic knowledge persisting with the reader (Meteyard et al., 2015; Perfetti et al., 2007). Specific to English script word recognition is performed through gestalt recognition (whole word) (Karanth, 2003) due to irregularity in the grapheme to phoneme correspondence. In general, the orthographic-phonological loop is disturbed usually in post-stroke (Jefferies et al., 2007), resulting in the inhibition of letter-to-sound translation. Thus, major control of semantics in English reading may be observed. Also, efficient extrapolation of lexical meaning of text being read, and semantic activation is pivotal (Beck, Perfetti, & McKeown, 1982; Meteyard et al., 2015). Yet another major factor attributing to enhanced semantic influence on reading comprehension compared to phonology and syntax could be the pattern of language acquisition. English being the second language acquired in the cohort of the study, the linguistic proficiency was not native-like. The linguistic knowledge and syntactic parsing abilities specific to English may be compromised owing to less proficiency, and limited use in daily context. The cross-linguistic differences based on proficiency are discussed in much detail in the later objectives of the study.

In continuation, the pattern of semantic association with reading comprehension abilities revealed a strong semantic influence on single-word reading > paragraph reading > sentence reading. As predicted single-word reading correlated significantly with semantics owing to ease of comprehension at the word level in spoken and written modality in PWAs (Madden et al., 2018). This is also plausible due to the less cognitive load dedicated to the process.

Unexpectedly, the paragraph reading comprehension manifested a strong semantic association compared to sentences. This could be attributed to the nature of the task employed in the study. The PWAs were instructed to read the paragraph and match the picture respective to the theme or inference of the paragraph out of four foils. They were already presented with picture-based context to comprehend the text and match. So in this process, PWAs due to underlying central

linguistic and cognitive inabilities, might resort to identifying the target words in the paragraph and skim the text to closely match with the pictures presently (Madden et al., 2018). They may skip reading every word and sentence to sentence in the process. Automatically, the phonological and syntactic activations in the task will be limited, and dependency on lexical activation will be utmost. As word-level recognition is involved in the process by large, orthographic-semantic reliance is much more reasonable in this task, rather than reading complete paragraphs. Also, another reason could be the ease of accessibility to a mental schema with picture-based tasks. The representation of pictures with written text is referred to as ‘advance organizers’ (Bransford & Johnson, 1973). The advanced organizers aid in comprehending complicated text effectively. It is reported that they tend to activate the schema concerning the prior events and experiences (Ellis, 1993). With the prior knowledge, the reader can then utilize it to comprehend larger text with ease (Meteyard et al., 2015).

In general, linguistic abilities are among those known to be most affected in aphasia (Kertesz, 1982), which is likely to worsen the text comprehension difficulties in PWAs due to underlying linguistic impairments. Additionally, broader cognitive skills which interact with linguistic abilities, enable readers to construct meaning from the text they are reading (Meteyard et al., 2015; Perfetti et al., 2007). While semantics enriches the depth of comprehension, its influence might be less direct compared to phonology and syntax for basic reading tasks (Perfetti et al., 2007).

The regression analysis run to delineate the key predictors of reading comprehension abilities in English through subtasks of semantics a) auditory comprehension, b) auditory rhyme judgment, c) picture identification, and d) picture association task] was found to be the auditory comprehension task. The overall reading comprehension, sentence, and paragraph reading comprehension together were strongly predicted by auditory comprehension tasks with high variance in the model. Only the single-word reading comprehension task manifested a correlation with the picture identification task in the study.

The auditory comprehension task is known to be the most sensitive predictor of semantic functioning through spoken mode among PWAs. Similarly, in the present findings it is observed to be a much more important obvious semantic featured task for reading comprehension as well. This

indicates that both spoken comprehension and written comprehension are directly associated with each other, which agrees with the results of previous studies (Madden et al., 2018).

To sum up, the relationship between linguistic abilities and English silent reading comprehension abilities reveals a strong association between semantics and reading comprehension aspects. Phonology and syntax were observed to have equivalent contributions but not as significant as semantics in this context. The predominant semantic influence on English silent reading may be attributed to a) oral reading in English also showed similar trend of semantic influence, b) word recognition in English is majorly through semantic activation, c) irregularity in the script results in poor orthographic- phonological activation and enhance semantic activation for lexical store, d) reduced proficiency of English language in the present cohort and e) also due to reduced usage of language in daily activities. The pattern of semantic influence on reading comprehension across the levels showed a larger effect on single word > paragraph reading > sentence reading. Single-word reading entails reading through word recognition, and since most of the words were regular or familiar words, direct access to semantics is expected in single-word reading comprehension. Also, as the task included picture-matching activating, the cognitive load was less. However, paragraph reading showed an unexpectedly larger extent of semantic influence rather than phonology or syntax. This could be attributed to a) the nature of the task in the study, wherein picture based task reduces the processing load and the reader may tend to skim the words to analyze the meaning rather than reading complete sentences, b) favors ease of accessibility with use of picture-based task as the concept is readily presented to the reader, their mental schema easily matches the picture without actually reading the sentences in length. Hence, semantic involvement in English reading comprehension is dominated by phonological-syntactic activations. Probably, a more diverse set of tasks apart from picture-based tasks may aid in inferencing better influence of syntax and phonology in reading sentence and paragraph text. The auditory comprehension task was deemed to be the semantic predictor of reading comprehension in English. This posed to be a clear correlation with spoken language also being closely associated with auditory comprehension tasks. This indicates that both spoken and written comprehension tasks are sensitive to auditory comprehension at the central level.

The study further, attempted to understand the effects of orthographic specific influences on linguistic and reading abilities in the bilingual PWAs cohort of the study.

### **5.5. Orthographic effects (alpha-syllabic vs alphabetic system) on Reading abilities of Kannada- English bilingual PWAs.**

In this section, the study attempts to review the performance of bilingual PWAs on reading abilities between Kannada and English languages, and also within each language as per the objective three of the study. The reading abilities were gauged through levels of oral reading and reading comprehension in the Kannada and English languages. The PWAs in the study were bilingual Kannada-English individuals who acquired English language (L2) in their schooling. None were reported to be simultaneous bilinguals. Hence, Kannada was their native, first language acquired (L1) among all the PWAs, and English was their second language (L2), acquired successively. Kannada script entails an alpha-syllabary or syllabic orthographic system. English entails the properties of an alphabet orthographic system. Owing to the unique orthographic transparency of each script, the study addressed the orthographic effects on the performance of PWAs concerning their impairments post-stroke in reading processing. The results are discussed in detail under the following sub-headings.

#### *5.5.1 Orthographic effects on reading abilities between Kannada and English in bilingual PWAs.*

#### *5.5.2 Orthographic effects on reading abilities within Kannada and English language performances in PWAs.*

#### **5.5.1. Orthographic effects on reading abilities between Kannada and English in bilingual PWAs.**

The study attempted to understand the effect of orthography transparency (alpha- syllabic vs alphabetic) through performances in reading abilities of the bilingual PWAs. On comparing the overall reading quotient (RQ), the PWAs outperformed significantly in the Kannada language compared to the English language. The finding is in consensus with previous literature, wherein the variations are due to inherent linguistic features of the languages (L1 and L2) manifested dissociations in reading impairments among bilingual PWAs (Goral, 2019; Kuzmina et al., 2019; Weekes, 2012). This is underlined due to multiple factors.

The dissociations are reported in previous experiments on bilingual persons with alexia and attributes the differential reading impairments across languages coinciding with orthographic dependent features of each script (Goral, 2019; Meguro et al., 2003; Senaha & Parente, 2012).

Most predictably, Kannada was learned very early by all the PWAs in the cohort, and also as it is a very transparent language compared to English language (L2), all seemed to have performed better in their native L1 language on the reading tasks. In general, premorbid individual differences among bilingual speakers may contribute to dissociations in two languages (Plaut, 2003).

The type of orthography reflects the patterns of reading impairments across the languages in bilingual or multi-lingual PWAs (Chengappa et al., 2004). Due to the inherent transparent nature of Kannada script (alpha syllabic), the ease of reading is much enhanced as there is a one-to-one correspondence of grapheme to phoneme, as opposed to the opaque nature of English script (alphabetic). The irregularity in grapheme-phoneme correspondence of the script results in more irregular and severe patterns of reading errors in English (Karanth, 2003; Ratnavalli et al., 2000; Weekes, 2005).

On basis of neural network functioning, L1 and L2 processing is based on two types of processes. The assimilation process occurs when individuals learn to read an opaque L1 first followed by a more transparent L2. On the other hand, an accommodation process is involved when the individual learns an opaque L2 after learning a transparent L1 (Goral, 2019). Owing to the present scenario, all the PWAs learned L1 (Kannada) first and through the accommodation process acquired reading abilities in opaque L2 (English), wherein additional networks are believed to have facilitated L2 reading acquisition (Liu & Cao, 2016; Tan et al., 2003).

Yet another explanation for the varied patterns of reading impairment in Kannada and English languages could be explained based on the lexical routes involved in processing the scripts, Kannada language being a transparent language depends on sub-lexical (grapheme phoneme correspondence- GPC) route in a typical reading as the script is loaded with transparent grapheme translations. Whereas, English being an opaque language relies solely on the lexical route for more semantic-based processing of the script due to irregularity in the grapheme translations in typical readers. In PWAs, due inherent deficit in lexical route majorly, the Kannada language can still

depend on reading through the lexical route to read familiar or real words. However, for English script, both routes become inaccessible as it depend mostly on semantic processing (Goral, 2019; Karanth, 2003). Hence, in the present cohort, reading abilities in the Kannada language were much more resilient compared to the English language.

Alternatively, another factor that is believed to cause differential impairment in reading Kannada and English language is the underlying unique neural networks adapted to meet the specific orthographic demands of each language. Although the underlying system for spoken language processing is shared between the two languages of a bilingual individual, the written language processing may be reliant on distinct neurocognitive processes as it is more formally acquired (Goral, 2019). This is well justified by the results of the study, wherein the average performance in language quotient of all PWAs across L1 and L2 showed no differential impairment, but in terms of reading quotient there is deviation cross-linguistically.

The notion of a distinct neuronal network for orthographic-specific reading impairments is supported by previous observations on bilingual alexia. It is evidenced that processing transparent orthography (Kannada in this instance) is associated with left-temporal-occipital regions, and opaque scripts (English in this instance) are processed through frontal temporal activations (Goral, 2019; Kumar, 2014; Perfetti et al., 2007; Tan et al., 2003). Hence, it could be anticipated that neural networks for Kannada script processing may be well preserved or regained compared to English script. If both languages (Kannada and English) shared the same neural network for reading tasks of both distinct scripts, differential reading patterns would not be evidenced.

Henceforth, owing to all the above reasons, the study indicated the presence of orthographic effects on overall reading impairment in Kannada-English bilingual PWAs. Specifically, the performance in reading Kannada script was superior to reading abilities in English. These findings are in agreement with previous literature, indicating that more the opaque orthography, the larger reading deficits in bilingual alexia condition (Goral, 2019; Paulesu et al., 2001; Reis et al., 2020a; Ziegler et al., 2008).

Further, the study looked into differences in oral reading and reading comprehension skills across the two languages. Results revealed that oral reading fared better performance in Kannada

script compared to English script. However, the reading comprehension in both languages was noted to be comparable.

### **Oral Reading**

The oral reading abilities were well preserved or recovered in Kannada–English bilingual PWAs in the study. Very clearly, the distinctions in oral reading impairment evidenced are due to the strong interplay between orthographic features of the two languages, despite the central linguistic processes (semantics, syntax, and phonology) manifested parallel impairments cross-linguistically.

The type of orthography (transparent vs opaque) can be a major factor attributing to the dissociations in the oral reading tasks of Kannada and English scripts. Kannada being a transparent, alpha-syllabary script follows transparent GPC. Thereby, facilitating easier and enhanced activations for Kannada compared to irregular GPC patterns of the English language (Karanth, 2003; Ratnavalli et al., 2000; Weekes, 2005).

In general, considering the nature of orthography, typical readers are known to take longer time to process while reading opaque scripts, compared to a more transparent orthography (e.g., McClung & Pearson, 2019; Rau, Moll, Snowling, & Landerl, 2016; Schmalz, Beyersmann, Cavalli, & Marinus, 2016), suggesting the inherent processing challenges persisting in reading aloud the opaque orthography (e.g., English). It may depend on the pattern of acquisition during their development stage. In more transparent orthographies (e.g., Kannada), mastering a small set of grapheme-phoneme correspondences facilitates the reading of many words in a short time, even without prior exposure to them. In contrast, opaque orthographies (e.g. English) require individuals to learn and memorize a larger number of grapheme-phoneme pairings to read and write proficiently (Reis et al., 2020b).

In continuation to this notion, based on the orthographic depth hypothesis (Frost, Katz, & Bentin, 1987), scripts like English rely on deeper linguistic activations due to phonological irregularities in the GPC. Due to these irregularities, it is more cognitively taxing for the reader (McClung & Pearson, 2019). Thus, in acquired reading-impaired individuals, decoding English becomes challenging compared to transparent scripts. Transparent orthographies rely more on phonemic structures which is easily predictable due to close GPC with the print and speech form.

Consecutively, more varied and severe reading errors are observed in English oral reading performance compared to the Kannada language.

Enhanced oral reading in the Kannada language may be attributed to the pattern of reading acquisition. Kannada being the native language and first acquired, results in better recovery or preservations of reading abilities owing to longer use of language, better proficiency in the native language, and early acquired language in formal education (Karanth, 2003; Goral, 2019; Ratnavelli et al., 2009; Weekes et al, 2005). On the contrary, English being the second language acquired, is a non-native language with comparatively lesser usage in day-to-day activities concerning reading aloud. Due to these inherent individualistic factors, the average performance of the bilingual PWAs cohort could have fared better oral reading skills in Kannada over the English language in the current study.

Based on the processes involved in reading bilingual scripts, English (L2) would entail additional neural networks for processing the alphabet due to orthographic distinctions (more opaque) as per the explanations of the accommodation process (Liu & Cao, 2016; Tan et al., 2003) discussed earlier. So, probably the breakdown in the additional networks assigned for activation to read English script may be responsible for oral reading insufficiencies in the English language.

Dissociations specific to orthography could be triggered due to distinct neural area activations. The oral reading for transparent script entails temporo- parietal activations and for opaque scripts activations are perceived at fronto temporal regions. Probably, the recovery or the extent of lesions in the areas responsible for Kannada may be facilitating better performance among the Kannada-English PWAs on the whole (Goral, 2019; Kumar, 2014; Perfetti et al., 2007; Tan et al., 2003).

Thus, owing to the above-discussed reasons, cross-linguistic dissociations examined in oral reading abilities across Kannada versus English languages showed elevated performance in the Kannada language. However, the pattern of performance remained the same with reading comprehension across Kannada and English language.

## **Reading comprehension**

On comparing the performance in Kannada and English reading comprehension abilities, the PWAs in the cohort performed parallel in both languages. A similar pattern was reported in previous studies, wherein orthography type did not influence the reading comprehension abilities in transparent versus opaque orthography (Reis et al., 2020b).

The nature of tasks being administered on the PWAs in the study in both Kannada and English language may be responsible for equipotent performance cross-linguistically. The reading comprehension task was addressed across three levels, single-word, sentence, and paragraph reading comprehension through picture-matching tasks. Thereby, the ease of performing the task was much higher compared to oral reading which relied on verbal output. Also, the context and previous background knowledge activated through picture presentation may augment in retrieving the theme facilitating comprehension in written or print mode (Waller & Darley, 1978; Webster et al., 2018)).

To elaborate, as Kannada's oral reading abilities were noted to be superior to the English language, the same could be expected in reading comprehension. But the performance in English reading comprehension was parallel to Kannada which could be attributed to the contextual cues presented prior to the complete reading through picture choices. Secondly, due to the inherent irregularities in the GPC in English script, the PWAs may attempt to recognize familiar words and match the theme without trying to read complete sentences. The reader would skim the text and extrapolate the meaning based on the pictures. Additionally, apart from picture choices, the texts or sentences in the tasks were linguistically simple. Only the length was varied across the levels. Also, there was no time restriction imposed on the PWAs to respond, allowing them to re-read without time restrictions. Probably, including reading comprehension tasks with questions and answering or matching the gist of the paragraph to the theme in printed text form, or including advanced sentences, or imposing time restriction to respond would be more sensitive to tap the effect of cross-linguistic variations concerning reading comprehension.

Alternatively, reading comprehension is believed to entail constant interaction between recognizing the word form and meaning, which is bidirectional in nature according to the 'Reading Systems Framework' (Perfetti and Stafura, 2014). Comprehending written script involves combining

an individual's word knowledge and their mental mapping of the same based on their previous exposure (McClung & Pearson, 2019). Thereby, some may be able to perform better and some may not due to individualistic differences. In context to the cohort of the study, most of them (18/20) used English for official work in their premorbid phase. So probably, their word knowledge and exposure in English is aiding in equivalent performance to Kannada reading comprehension, unlike oral reading.

Contrary to previous views, studies have proved that spoken language comprehension is the predominant predictor of reading comprehension (Friesen & Frid, 2021; Garcia and Cain 2014; Landi 2010) rather than oral word reading ability, especially while comprehending the written text in second language in bilingual PWAs (Melby-Lervag and Lervag 2014). Clearly, it indicates that along with spoken language comprehension, reading comprehension recovers simultaneously in PWAs equally in both languages. These explanations and patterns are consistent in the present study, wherein reading comprehension across the two orthographies does not mimic oral reading patterns across two orthographies.

### ***5.5.2. Orthographic effects on reading abilities within Kannada and English language performances in PWAs.***

Post to analysing the orthographic effects between Kannada and English reading abilities, reading performances within Kannada and English were further analysed. The results of comparing reading abilities within Kannada and English languages showed significantly diminished performance in oral reading abilities compared to reading comprehension. The results are in consensus with both developmental dyslexia literature (Van Den Boer et al., 2022), and acquired reading impairment literature (Meteyard et al., 2015; Webster et al., 2022).

An impoverished oral reading skills compared to silent reading comprehension lies in the distinct nature of processing involved in the two, though both are subserved by a few common central linguistic processing. Reading aloud relies on visual word recognition, phonological decoding, and active speech-motor movements for verbal output. While, reading comprehension negates the involvement of verbal output, and depends more on word recognition, with syntactic and semantic processing to extrapolate the meaning (Meteyard et al., 2015; Webster et al., 2022). The extra time

required to read aloud the text due to the articulations involved in verbal output could influence the performance in reading aloud (Van Den Boer et al., 2022). Similar results were reported in eye-tracking experiments, wherein oral reading involved more processing time than silent reading comprehension in adults (Ashby et al. 2012).

Furthermore, reading comprehension imposes a relatively lower cognitive load compared to oral reading output. The study incorporated tasks such as single-word, sentence, and paragraph comprehension, which involved activities like matching written words, sentences, and paragraphs to corresponding pictures. These tasks provided a semantic context, allowing participants to infer meaning with the support of the images presented in the foils. Thus, owing to the aforementioned reasons, oral reading abilities were much compromised compared to silent reading comprehension in both Kannada and English languages.

To summarize, as per the objective three, the study examined the effects of orthography (alpha-syllabic vs alphabetic) on reading abilities by comparing performances between Kannada and English language reading. The dissociation between Kannada and English reading was seen in overall reading abilities across Kannada and English language, which indicated orthographic-dependent features attributing to this effect. Specifically, the overall reading abilities manifested better performance in Kannada (L1) compared to English (L2). The findings could be attributed to a) Kannada (L1) being learnt much earlier than English (L2) b) transparency of the language c) premorbid individualistic factors like family background, use of language in written mode, proficiency in language for reading, work environment, and nature of routine demanding the use of written language use, d) Kannada being more transparent has closer connections to grapheme to phoneme correspondence, making it easy to read compared to irregular patterns in English, e) additional networks involved in processing L2 to read may not be functioning adequately post stroke based on accommodation process, f) due to impaired lexical processing needed for English reading, the semantic processing for English reading is inaccessible, g) distinctive neural cognitive process may be involved in reading two languages varying in transparency of scripts, h) proved by distinct neural bases, wherein transparent scripts are processed through left temporo- occipital region and opaque scripts are processed by fronto temporal region, i) more opaque orthography demand higher

order cognitive abilities, which is inadequate in post stroke PWAs. Thereby, in consensus with previous literature, these could be the probable factors attributing to elevated performance in Kannada reading abilities in bilingual PWAs with reading deficits.

Specifically, the study analysed the performance in reading abilities through oral reading tasks and silent reading tasks across Kannada and English languages. The oral reading abilities were distinct across the languages, wherein PWAs fared better scores in oral reading abilities in Kannada compared to English language. The study ascribed to a) strong interplay of orthographic features of the two languages despite of equipotent central linguistic processing in the two languages, b) Kannada has closer correspondence with grapheme and phoneme combinations, easing the oral reading process in Kannada language, c) more time is reported to process opaque scripts, d) as English needs memorization of grapheme – phoneme sequences due to irregularities, the pattern of reading acquisition during developmental stage could have contributed difficulty in reading English, e) orthographic depth hypothesis suggests that's English relies on deeper linguistic activations due to irregularities, adding to severe reading errors in English oral reading abilities in the cohort, f) Kannada reading could have been easy during development acquisition stage due to transparency, g) additional neural network responsible for reading English may have been impaired, h) and also due to distinct neural networks involved in reading process. Thus, all these factors could have contributed to better oral reading in the Kannada language and poor oral reading in English concerning the results of the study.

However, the silent reading comprehension across both Kannada and English languages indicated parallel performance in both languages. The findings suggested that there is no influence of orthography type on the reading comprehension abilities of bilingual PWAs in the study. The study presumed the factors attributing to this could be a) tasks being picture-based, yielded better performance through easier recognition of theme in reading comprehension as it did not demand oral response, b) English reading comprehension could have been comparable as readers would have skimmed through the familiar words only unlike reading complete sentences to match the picture respective to the text, c) texts in the sentences and paragraphs framed were much simpler linguistically in concern to PWAs, d) no time restriction posed, e) most of the PWAs in the cohort

were using English language officially in the premorbid stage at work though most report use of spoken English was comparatively limited, so probably their word knowledge and exposure could have been better for English written language comprehension, and f) many studies have proved alike spoken language comprehension, reading comprehension recovers better and simultaneous compared to oral reading skills in PWAs. Owing to all the above reasons, the study assumes these factors could have aided in comparable performance in Kannada and English silent reading comprehension abilities in the bilingual PWAs cohort in the study.

In continuation, the study examined the reading abilities within each language and results demonstrated poor oral reading abilities compared to reading comprehension abilities in both languages. This pattern of performance in reading abilities were attributed to a) the distinct nature of processing involved in the two tasks (oral reading and reading comprehension), though they are subserved by few common central linguistic processes, b) oral reading demands visual word recognition, phonological decoding and active speech motor movements, whereas reading comprehension negates the need of oral response, depending more on word recognition, syntactic, and semantic processing, and c) due to picture based tasks involved in reading comprehension tasks, the cognitive load was much condensed, aiding better response in reading comprehension.

Further, the study attempted to address the cross-linguistic effects on linguistic abilities in Kannada – English bilingual PWAs.

#### **5.6. The linguistic abilities across and within Kannada and English in bilingual PWAs.**

In this section, the study attempts to review the performance of bilingual PWAs on linguistic abilities between Kannada and English languages, and also within each language as per the objective four of the study. The linguistics abilities were evinced through the subtasks of semantics, syntax, and phonology in Kannada and English, in isolation. Owing to the unique linguistic properties of each language, the study addressed the linguistic effects on the performance of PWAs concerning their impairments post-stroke in central language processing. The results are discussed in detail under the following sub-headings.

*5.6.1. Cross-linguistic effects on linguistic abilities of Kannada- English bilingual PWAs.*

*a. Effect of Bilingualism on Semantics in PWAs.*

*b. Effect of Bilingualism on Phonology in PWAs.*

*c. Effect of Bilingualism on Syntax in PWAs.*

*5.6.2. Linguistic abilities within Kannada and English language performances in PWAs.*

***5.6.1. Cross-linguistic effects on Linguistic abilities of Kannada-English bilingual PWAs.***

On analyzing the performance of the bilingual PWAs cohort on linguistic aspects through subtasks of semantic, syntax, and phonology across Kannada and English, equivalent performance was observed in the study. The overall language performance was computed to Linguistic Quotient (LQ). On comparing the LQ of Kannada and English, no significant deviation was noted between the two. Similarly, the specific linguistic abilities, namely, semantics, phonology, and syntax manifested parallel performance in Kannada and English languages. Thereby, the results indicated no cross-linguistic effects (L1 vs L2) on these linguistic domains post-stroke. The results are in consensus with previous reports on bilingual PWAs (De Letter et al., 2021; Lahiri et al., 2021; Alladi et al., 2016; Kuzmina et al., 2019)

In general, the patterns of language impairments in multilingual/ bilingual PWAs vary broadly post-stroke. In some cases, the impairments are parallel (e.g., De Letter et al., 2021), wherein all languages are affected to the same extent, while in other instances, the deficits are distinct (e.g., Lahiri et al, 2021). One language may be more affected than the others. This pattern of distinction may arise from the intricate structure of the multilingual language system, shaped by a complex interaction of factors such as the age of acquisition of each language, frequency of language usage, premorbid proficiency, and the linguistic similarity between the languages (Kuzmina et al., 2019). These factors are referred to as Ribot's law or Pitre's law, which was supported by a study on multilingual PWAs (Albert and Opler (1978), who found both parallel and non-parallel language impairments in their cohort. Lahiri et al, 2021, reported factors like higher education level and younger age of L2 acquisition as positive predictors for PWAs' recovery from chronic aphasia.

Equipotent language quotient (LQ) in L1 (Kannada) and English (L2) among the PWAs in the study may be attributed to the age of second language acquisition. All the PWAs in the cohort were early bilinguals who started learning second language before seven years of age, but successively. And studies have proved that the early bilinguals manifest comparable language abilities post-stroke (De Letter et al., 2021; Kuzmina et al., 2019; Rylková & Kytarová, 2022).

Right hemisphere advantage, including the use of non-verbal abilities, could be another primary factor for parallel recovery in both languages in bilingual PWAs (e.g., Basso et al., 1989; Forkel et al., 2014; Heiss et al., 1999; Pettit & Noll, 1979; Turkeltaub et al., 2012). Based on this principle, reorganization of language across the hemispheres of the brain is a crucial factor contributing to language recovery in bilingual PWAs (Lahiri et al., 2021).

Studies have demonstrated bilingual advantage associated with the involvement of higher cognitive performance which is favourable in coping with two language activations (Bialystok, 2011, 2015). This, in turn, was attributed to cognitive reserve among PWAs (Alladi et al. 2016, Lahiri, 2021). Cognitive reserve is presumed as a “protective” factor in PWAs manifesting better recovery and parallel functioning in both languages on a bilingual PWA (Alladi et al., 2016).

Yet another factor contributing to equivalent performance in both languages may be attributed to shared cognitive and neural representations for both Kannada (L1) and English (L2) languages in the PWAs of the study. This comes with prepositions from previous literature (Costa et al., 2012; Miozzo et al., 2010; Nadeau, 2019), where it is assumed that aphasia affects all languages spoken pre-morbidly in similar ways. According to the Shared Bilingual Neural Substrate (SBNS) hypothesis, bilingual individuals who acquire a second language (L2) early in life as noted in the present study, rely on a common neural network with shared lexical-semantic and syntactic representations for both languages in the brain (Costa et al., 2012; Miozzo et al., 2010; Nadeau, 2019). This hypothesis aligns with cognitive neuropsychological models of typical bilingual language processing (Gollan and Kroll, 2001; Faroqi-Shah and Waked, 2010) and supports the notion that linguistic differences between pre-morbidly spoken languages may not be significant in post-stroke bilingual PWAs (De Letter et al., 2021; Kuzmina et al., 2019).

In specific to the nature of tasks administered in the study to assess the linguistic sub-domains, the tasks were picture-based, and auditory comprehension based involving identification, discrimination, and judgment responses. Thereby, there was absolutely no reliance on verbal output to perform these linguistic tasks. This was ensured to reduce the load on the PWAs to respond which could be diminished by the underlying speech-motor deficits. This further ensured that they could respond based on the conceptual knowledge persisting across semantic, phonology, and syntactic processing specific to Kannada (L1) and English (L2). Due to the least dependency on the verbal output, they were probably able to respond equipotent in both languages. Yet, these tasks are much more sensitive to tapping the semantic, phonological, and syntactic processing at the central level based on the previous experiments (Beeson et al., 2022; Brookshire et al., 2014; Crisp & Lambon Ralph, 2006; Friesen & Frid, 2021; Henry et al., 2012; Madden, 2016)

However, there are contradicting reports of unparalleled recovery or deficit in each language in bilingual PWAs, wherein mostly no bilingual advantage, or a slight advantage in the cognitive test performance, or differences observed only in specific subgroups of bilinguals are reported (Dick et al., 2019; Lahiri et al., 2021; Lehtonen et al., 2018; Rosselli et al., 2016).

Further, the study observed the cross-linguistic effects on subdomains of linguistic domains and noted no significant variations in semantics, syntax, and phonology of (Kannada) L1 versus English (L2) among the PWAs of the study.

#### **a. Effect of Bilingualism on Semantics in PWAs.**

The study evinced comparable performance in Kannada (L1) and English (L2) in semantic processing among the bilingual PWAs of the study. This is supported with the notion of shared neural networking for both L1 and L2. Based on the neural model of semantic cognition (Ralph et al., 2017), the bilingual language control coincides with the neural network of both languages, wherein the linguistic conflicts are modulated by prefrontal areas and the language selection by posterior areas of the brain (Abutalebi & Green, 2008; Calabria et al., 2018). Prior research on this line has agreed upon the same notion (e.g., Abutalebi and Green, 2008).

Parallel semantic control in a bilingual context is supported by a few behavioral and neuroimaging studies (Travis et al., 2015). They found an equal extent of word priming in

semantically related contexts in cross-language priming tasks regardless of language complexity. Similar results were reported on picture naming tasks loaded on semantic processing, reflecting parallel semantic control irrespective of the language used (Goldrick et al., 2012).

Comparable semantic control across languages has been supported by studies investigating semantic deficits in bilingual patients with neurodegenerative disorders. The results revealed equal impairments across languages, suggesting that semantic processing functions independently of language (Mendez, 2019); Hernández et al., 2011).

The shared conceptual/ semantic control across languages is well supported by the bilingual models of production and comprehension in spite of as linguistic variations of the L1 and L2 (Bilingual Interaction Activation model: Dijkstra and van Heuven, 2002; Inhibitory Control Model: Green, 1986; Revised Hierarchical Model: Kroll and Stewart, 1994). Moreover, the semantic control in speech-based semantic activation tasks (picture naming, verb retrieval, etc.) poses different processes in a bilingual context. The speech production tasks entail exclusive language-specific lexical-semantic representations (Kroll et al., 2015; Branzi et al., 2018). Based on RHM (Revised Hierarchical Model) (Kroll & Stewart, 1994), the semantic lexicon for L1 is presumed to be larger than L2, indicating stronger semantic connections in L1 compared to L2. The same is agreed upon by the ICM model (Inhibitory Control Model) (Green, 1986) which predicted stronger semantic connections with the dominant language among the two. Yet, this was not the case in the present study, as none of the semantic tasks were loaded with speech production, and all tapped the conceptual knowledge pertaining to each language, thus equal semantic competency was observed across Kannada and English languages in PWAs in the study.

#### **b. Effect of Bilingualism on Phonology in PWAs.**

Alike semantic performance, phonological competency was equally affected or retained in both languages of the bilingual cohort of the study. Equipotent performance in phonological processing of Kannada and English languages can be attributed to the nature of tasks administered in the study. The phonological tasks, namely the real word rhyme judgment task and non-word rhyme judgment tasks employed in the study, except for the phonological manipulation task demanded comprehension-based responses. It is believed that by 5- 9 months post-stroke, the phonological

comprehension is much spontaneously restored and strong among PWAs (Robson et al., 2019). Consecutively, regardless of language, they performed at the same levels in both languages in the study.

Yet another reason for equipotent performance in phonological abilities in Kannada and English languages may be attributed to well preserved cognitive control system, which could have influenced positively in L2 performance. This can be predicted as more than 80% of the PWAs recruited in the study had higher qualification and were working pre-morbidly. These factors could have aided in better cognitive reserve. Subsequently, better cognitive functioning and faster recovery in phonological processing may be anticipated among the PWAs of the study (Hillis & Tippett, 2014; Watila & Balarabe, 2015).

Contrary to the previous views, it could depend on the residual phonological functional framework accessible for the acoustic phonological processing post-stroke. Wherein, neuroplasticity of acoustic phonological processing is deemed to be limited for recovery of comprehension (Robson et al., 2019; De Letter et al., 2021). Thereby, concerning the present study results, probably limited phonological processing ability is responsible for comparable responses in both Kannada and English languages. The results clearly showed the poorest performance in the phonological domain of both languages compared to semantics and syntax in both Kannada and English languages.

In terms of the assimilation process, ideally the L2 phonology is processed via L1 connections in the premorbid phase. Post-stroke due to underlying phonological deficit at the central level, the assimilation process is affected, in turn resulting in sub-standard performance in both L1 and L2 of PWAs (Eviatar, Leikin & Ibrahim, 1999). In this case, the Kannada (L1) phonological loop is damaged and invariably could affect English (L2) phonological activations.

### **c. Effect of Bilingualism on Syntax in PWAs.**

Similar to the trend in performance in semantics and phonology, syntax was also equally competent or deficient in both Kannada and English languages among the PWAs of the study. This could be attributed to strong deficit in processing syntactic aspects of the language post-stroke, referred as agrammatism. Agrammatism is a collective of both sentence production deficits and comprehension deficits (Berndt et al., 1996).

Schwartz et al. (1987) offered an alternative explanation for asyntactic comprehension, suggesting that individuals with agrammatic aphasia experience a mapping deficit. According to the Mapping Hypothesis, asyntactic comprehension does not result from an inability to perform syntactic analysis or parse sentences. Instead, it arises from difficulties in mapping thematic roles onto the constituents that have already been parsed (Linguistic Theory and Aphasia, 2020). Owing to the tasks included in the study concerning syntax, all tapped the comprehension of grammatical aspects of the language, thereby the overall deficit in syntactic comprehension in both languages may be responsible for comparable performance in L1 and L2.

Another reason that could be attributed to equally affected or retained syntax in the bilingual PWAs is the limited functioning of higher-order cognitive processing precluding the syntactic comprehension of the language. Active short-term memory functioning is necessary to maintain, retrieve, and manipulate the words and the order of syntactic units for efficient comprehension of syntactic tasks (Caplans et al., 2007). On the whole, due to the underlying deficit in higher order cognitive functioning, leads to limited processing of morpho-syntactic knowledge in agrammatic PWAs. This, in specific to the present study may be the reason for equally compromised syntax processing in Kannada and English. Also, as both these languages entail very distinct morphosyntax, there are high chances of linguistic conflicts at the central level to distinguish the syntactic rules and either activate or suppress the L1 or L2 linguistic connections.

### ***5.6.2. Linguistic abilities within Kannada- English language performances.***

Subsequent to comparing the linguistic abilities cross-linguistically, the same was analyzed within each language, Kannada and English. The subdomains of linguistic aspects (semantics, syntax, and phonology) were examined within Kannada and the English languages. Of specific interest, the study was keen on understanding the extent of recovery or deficit in the linguistic abilities within each language in these bilingual PWAs.

The performance in semantics, syntax, and phonology depicted clear distinctions among each other with a large effect. Specifically, PWAs manifested predominant performance in semantics, followed by syntax, and the poorest scores in phonology in the Kannada language. A

similar pattern was noticed in the English language as well. Overall, these findings indicate varied recovery or preserved linguistic abilities at the central level in PWAs.

Addressing the first concern, semantic abilities were noted to be superior and phonology was the poorest. In general, recovery in aphasia post-stroke varies considerably. Mostly it is very individualistic. Some recover spontaneously in the early phases of stroke with the greatest regain in function within the initial few weeks of post-stroke onset (Fridriksson et al., 2012). The degree of spontaneous recovery is linked to stroke severity and related factors, including the size and location of the insult (Fridriksson et al., 2012). Other stroke-related factors, such as the preservation and activation of specific brain regions, are likely to influence the effectiveness of aphasia recovery.

Focusing on the pattern, semantics showed stronger links compared to phonology and syntax. The findings collaborated with the perspective that accessing the semantic system leads to the processing of phonological information first, suggesting that there are greater chances for phonological access impairment than semantic access (Howard & Gatehouse, 2006; Meier et al., 2016).

Considering the pathophysiological distinctions reflecting the linguistic process at the central, phonology is most extensively affected (Hillis, 2002). Phonological processes, including phonological awareness, phonological short-term memory, and speech production, are facilitated by the dorsal pathway in the perisylvian region (Beeson et al., 2022; Hickok & Poeppel, 2007; Saur et al., 2008). In contrast, semantic processing is broadly distributed across the left anterior inferior frontal gyrus (pars orbitalis) and the angular gyrus. These regions are mainly supplied by the left middle cerebral artery, with some contributions extending from the right hemisphere (Beeson et al., 2022; Binder et al., 2009). Thereby, very clearly the semantic processing is well sustained by much wider regions in the brain compared to phonology processing areas. In other words, the areas facilitating phonological processing are more fragile and susceptible to extensive damage. Subsequently, the extent and chances of phonological deficits are much higher and more severe than semantics and even syntax, which is compensated through other undamaged pathways.

Another contributing factor could be the nature of the task employed in the study. The semantic tasks were picture association, picture identification, auditory synonym judgment task, and

auditory comprehension task. All these addressed the conceptual and lexical knowledge respective to the languages and were entirely based on comprehension level rather than retrieval. Eventually, the cognitive load on the individual is moderate, suppressing higher cognitive demands. This notion is supported by previous literature, wherein it is proposed that semantic control required for information retrieval is subserved by contextual cognitive demand (Ralph et al., 2017), which depends on the processes triggered by the tasks. PWAs tend to manifest access deficits and not storage deficits as in semantic dementia. Thereby, specific to aphasia due to stroke, is featured by the semantic network activation with semantic memory being intact (Jefferies and Lambon Ralph, 2006; Rogers et al., 2017). Henceforth, semantic abilities in PWAs are broadly activated due to the vast spread of networks through multiple means and much resistant to complete damage in post-stroke conditions.

These findings (semantics outperforming phonology) are believed to be influenced by the interaction of two key components at the cognitive-linguistic level. This may stem from the role of cognitive functioning in facilitating lexical processing and the differing cognitive demands of tasks supported by these systems (Swamy & Goswami, 2024). Undoubtedly, cognitive functioning in PWAs is disturbed, consequently impacting lexical processing.

Moreover, there is inherent task variability across semantic and phonology subdomains. Tasks like minimal pair judgment (rhyming and non-rhyming), blending, and segmentation require higher efforts and multiple processing, which cognitively involve working memory, attention, and judgment aspects (Crisp & Lambon Ralph, 2006; Meier et al., 2016). Thereby, the phonological tasks were more taxing than the semantic tasks. Semantic tasks entailed picture-based identification and association, with auditory sentence judgment and comprehension tasks. All relied on simple judgment skills and auditory processing. The focus was to avoid lexical access and tap the conceptual aspects of semantic processing. Overall, owing to underlying functions relied on tasks, and based on cognitive load, the semantic subdomain fared better results than phonological tasks.

Concerning the severity of deficits and recovery patterns in left post-stroke PWAs, very evidently it is reflected through underlying deficits or functioning of semantics, syntax, and phonology at the central level. The basic premise of aphasia classification is explained in parallel to

the expression of the central linguistic processing. For example, global aphasia is categorized by marked mutism with slightly better-spoken language comprehension skills (Goodglass & Kaplan, 1983) which is indicative of extensive phonological deficit and better semantic processing abilities. In anomic aphasia, the mild variant of aphasia is marked by word retrieval issues (Goodglass & Kaplan, 1983; Ralph et al., 2002). The major deficit is in the phonological and some syntactic processing abilities proven by many experiments (e.g., Kendall et al., 2013; Ralph et al., 2002). Thereby, the most severe to mild variant of aphasia reflects better semantic processing and poor phonological processing. The phonological aspects are the most severely affected and always the last to be recovered in post-stroke PWAs (Sheppard & Sebastian, 2021). In continuation to this notion, Meier et al.,(2016) opined that the manifestation of semantic and phonological processes are unique and independent of each other in PWAs. PWAs with varying levels of aphasia severity generally demonstrate relatively preserved abilities to perform various semantic tasks, which can be leveraged to bootstrap semantic processing in therapeutic settings. However, marked difficulties in phonological tasks irrespective of severity. Overall, the findings of the study are in support of previous literature explanations, wherein semantics is better functional compared to phonology in PWAs.

Further, much severe deficits in syntax compared to semantics may be ascribed to phonological processing influence on syntax. Phonological deficits inherently impact syntactic processing. Recent treatment studies support this relationship, indicating that strengthening phonological skills improves the production of accurate information units in discourse (Silkes et al., 2021) and enhances the grammatical and morphological framework of sentences (Beeson et al., 2022). Sentence processing is a complex mechanism that requires the reader or listener to identify the sentence structure and integrate its components to understand the overall meaning within a limited timeframe. Most PWAs, particularly those with non-fluent variants, commonly exhibit prominent agrammatic features. The fluent variants exhibit paragrammatism, which also showcases adequate syntactic processing deficits. These challenges include difficulty in understanding sentence structures, identifying violations in sentence structure, and comprehending sentences with

disruptions in noun-verb phrases (Bhat & Chengappa, 2003). Consequently, the study found that syntactic abilities were also impaired compared to semantic skills.

To recapitulate, objective four was framed to analyze the linguistic abilities between and within Kannada and English language performances in bilingual PWAs. The results of cross-linguistic variations on linguistic subdomains (semantics, syntax, and phonology) revealed equipotent performance in both Kannada (L1) and English (L2). This indicated that bilingual PWAs processed central linguistic functions parallel irrespective of language as per the pattern noted in the study. In general, the L1 and L2 language recovery pattern in bilingual PWAs post-stroke may be influenced by multiple factors like age of language acquisition of each language, frequency of language use in their daily routine, premorbid language proficiency, linguistic similarities between the two languages, higher education level, and so on.

Overall equivalent performance in both Kannada and English language on linguistic abilities may be attributed to a) early age of L2 (English) language as all started learning L2 before 7yrs, b) right hemisphere advantage to process L2 post-stroke, c) higher cognitive functioning flexibility reported in bilinguals which could have aided in better activations at central linguistic processing for both languages and cognitive reserve would have served as a protective factor for the same, d) shared cognitive and neural representation for both languages according to Shared Bilingual Neural Substrate hypothesis proposes that same lexical-semantic and syntactic representation is involved to process linguistic aspects of any two languages at the central level, e) all tasks focused on picture and auditory based responses, neglecting the need of verbal output, thereby more emphasis was on conceptual knowledge to tap the central linguistic processing. Thus, these could be the general possibilities for comparative performance in both Kannada and English central linguistic processes among bilingual PWAs as per the findings of the study.

In specific, the study explored the effect of bilingualism on semantic processing in bilingual PWAs post-stroke. Results evinced parallel performance in Kannada and English on semantic processing which could be attributed to a) parallel semantic control in bilinguals coincides with shared neural network for both languages based on neural model of semantic cognition, b) the same was proved through behavioral and neuroimaging experiments, which showed equal cross-linguistic

priming on semantic priming experiments, c) equipotent performance in semantic processing was reported in bilingual cohorts with neurodegenerative conditions, d) all the tasks of semantic sub domain were comprehension based rather than retrieval, which tapped the conceptual and lexical knowledge independent of language used. Similarly, phonological processing was analysed for bilingual influence in post-stroke PWAs, and results manifested comparable performance in both Kannada and English language. Thus, it indicated parallel central phonological processing in PWAs post-stroke regardless of the languages known. The probable factors attributing to this pattern could be a) the comprehension based nature of tasks included in the study, which neglected verbal responses, and studies have proved phonological comprehension is much stronger and spontaneous in PWAs post-stroke, b) higher-order cognitive capacity is facilitated in bilingual individuals, thus post-stroke it could have aided in equal phonological activations, c) limited residual phonological functioning due to stroke could have limited their performance in both languages, d) inadequate assimilation process post-stroke could have influenced the L2 (English) phonological activations with inherent L1 (Kannada) phonological loop breakdown, thereby phonological processing is affected in both languages. Lastly, the influence of bilingualism on syntactic processing in bilingual post-stroke PWAs showed equipotent performance in Kannada and English language. The study attributes the findings to a) agrammatism is prominent in PWAs which is regardless of the languages known, b) mapping deficits in PWAs, and c) limited higher-order cognitive functioning due to post-stroke which is pre-requisite in syntactic processing, which further hampers maintaining or retrieve or manipulate words in the syntactic order. Hence, owing to the aforementioned reasons, the bilingual PWAs tend to perform parallel in both languages on linguistic aspects at the central level.

Further, the study addressed the linguistic distinctions within the languages (Kannada and English) to understand language-specific variations among bilingual PWAs. First, on investigating the linguistic abilities within Kannada and English language, the PWAs manifested clear deviations parallel in both languages. Predominant performance was noted in semantics and the poorest in phonological aspects in both languages. In general, recovery in aphasia is individualistic, yet the degree of spontaneous recovery matters with the extent and site of lesion, preservation, and activation of specific brain regions and the influence of previous treatments. In specific, semantics was noted

to be stronger and phonology much weaker among the cohort in the study. This trend could be attributed to a) semantic access usually proceeds phonological information at the central linguistic processing, due to wide spread of activation it is much resistant to damage, b) phonology is most extensively affected pathophysiologically as it is restricted to dorsal perisylvian regions and much fragile to insult, c) whereas semantic activations are much wide spread across anterior inferior frontal gyrus and angular gyrus, supplied by left middle cerebral artery which extends to right hemisphere also, d) all the semantic task were picture based comprehension tasks which addressed conceptual and lexical knowledge and thus reducing the overall cognitive load, e) phonological tasks demanded multiple processing like working memory, attention and judgment function to perform in minimal pair judgment task, blending and segmentation tasks, and f) the aphasia classification also reflects poorest phonological abilities in most severe aphasia like Global aphasia and even in the mildest form of Anomic aphasia, with much better semantic processing abilities in these variants. Thus, clearly, from various literature support and experiments, the PWAs manifest better semantic abilities, and phonology is the most vulnerable and strongly compromised aspect of central linguist processing irrespective of language exposure, and the findings conclude the same. The syntactic abilities were much affected compared to semantics, which was attributed to a) poor phonological processing invariably affecting the syntactic functioning in PWAs, b) treatment studies have proved enhancing phonological skills has triggered better performance in syntax processing and strengthen grammar and morphological structures, c) and most PWAs evidently manifest either agrammatism or paragrammatism depending on the type of aphasia, suggestive of clear syntactic processing in them. Therefore, due to the aforementioned reasons the study presumes the strongest semantic processing, followed by syntax, and poorest in phonological processing in the bilingual PWAs cohort concerning the linguistic abilities.

Further, the study attempted to analyse the manifestation of linguistic and reading abilities across and within various alexia sub groups. The results are discussed in the following sections below.

## **5.7. Reading and linguistic abilities in Bilingual PWAs across and within Alexia groups in Kannada and English.**

This section explains the reading and linguistic performances of 20 Kannada–English bilingual PWAs across the subgroups of Alexia respective to Kannada and English language profiling as per the objective five which was the secondary objective of the study. All the PWAs were sub-grouped into alexia profiles (Phonological, deep, and global alexia) individually in Kannada and English languages depending on their reading accuracy in oral reading tasks in each language. The details of sub-grouping are depicted in Table 4.16 of Chapter four. The study observed distinct alexia patterns in the PWAs, wherein few manifested different alexia profiles in Kannada and English, and few showed the same pattern in both languages. Based on the previous discussions of the previous objectives, distinct alexia profiling in each language is a clear consequence of orthographic-specific features (alphabetic versus alpha syllabary). The study was curious to examine the distinctions in alexia profiling in each language among bilingual PWAs as there is limited literature support for understanding reading deficits in acquired language impairments in bilingual context and especially in Indian bilingual PWAs. The PWAs' premorbid reading skills with current interests and their desire to read dominate the extent of intervention required in these skills. Traditionally, a brief screening of acquired reading impairment is performed along with the profiling of the spoken language deficits in PWAs during routine investigations. This merely serves the identification or presence of reading impairments in the PWAs among a multitude of other spoken language impairments. However, to frame an effective treatment regime for the bilingual PWAs, profiling their reading skills specific to the language known to them is warranted to learn the precise breakdowns at various levels of the reading process and the extent of reading impairment. Also, the orthographic-specific factors need to be understood while intervening with acquired reading impairments in bilingual PWAs. Thus, the objective was framed to address these notions. The results of the objective four are discussed under the following subheadings:

5.7.1. Linguistic and reading across sub-groups of alexia in Kannada and English languages of bilingual PWAs.

5.7.2. Linguistic abilities (semantic, phonology, and syntax) and reading abilities within sub-groups of alexia in Kannada and English languages of bilingual PWAs.

***5.7.1. Linguistic abilities and reading abilities across sub-groups of alexia in Kannada and English languages of bilingual PWAs.***

The study analysed the performances of all PWAs in each alexia subgroup (phonological, deep, and global) and investigated the influence of linguistic aspects, namely semantics, syntax, and phonology, exclusively in Kannada and English languages.

The linguistic performance in semantics, syntax, and phonology was compared across alexia subgroups (phonological, deep, and global) in Kannada and English languages. In both Kannada and English subgroups of Alexia, the semantic abilities were found to be significantly prominent in phonological alexia compared to deep and global alexia. Phonological skills were also renowned in phonological alexia followed by deep and global alexia. Syntactic abilities were also evidenced to be best in phonological alexia compared to other types of alexia. However, statistical significance was not noted in the syntactic abilities across subgroups of alexia. Overall, the performance in semantics, phonology, and syntax was superior in phonological alexia, followed by deep and weakest in global alexia in both Kannada and English languages. The finding is in consensus with previous literature on alexia in PWAs (Madden et al., 2018).

The results indicate that the severity of semantic and phonological abilities reflect the severity of alexia profiles or acquired reading impairments. In both Kannada and English alexia profiles, semantic abilities were well preserved in phonological alexia, moderately affected in deep alexia, and most severely impaired in global alexia. This was clearly evidenced by maximum reading errors in global alexia, followed by deep alexia, and milder errors in phonological alexia on comparing the reading patterns across real words and non-words of Kannada and English languages.

Phonological alexia is characterized by the ability to read aloud real words, mostly high-frequency words that have a stored orthographic representation and are part of their reading vocabulary and visual word memory (Cherney, 2004; Crisp & Lambon Ralph, 2006; Madden, 2016). Although, the reader tends to struggle reading aloud non-words (e.g., "powe") and even low-

frequency words (e.g., “bizzare”). They cannot sound out letters to form the word because their letter-sound conversion is impaired. Common errors include visual mistakes, such as reading "cat" instead of "bat," where the target word is misread as a visually similar word. Individuals with phonological alexia often report difficulty reading complex text, such as books and newspapers (Cherney, 2004). Understanding these specific features of phonological alexia suggests that their semantic abilities are well preserved as the real/ regular high-frequency words oral reading are finer compared to non-word or low-frequency words, which is evidenced in the present study as well. The real word reading is processed through the store orthographic representation and visual word memory, implying their limited reliance on phonology for reading real/ regular high-frequency words. The issue arises while reading non-words and low frequency words which rely mostly on orthographic- phonological loops (Patterson & Marcel, 1992; Crisp & Ralph, 2006). Non-word reading does not involve semantic processing (Crips & Ralph, 2006). This suggests that words are more likely to be read correctly than non-words because their meaning enhances phonological activation, whereas non-words lack meaning and therefore do not receive this boost. Thereby, the semantic abilities in phonological alexia are uninterrupted, although phonology is hampered as evidenced by non-word reading errors exhibited by PWAs in the study.

Alternate to this notion, in phonological alexia severely impaired phonological representations alone can result in semantic errors and imageability effects (non-word reading impairment) in reading (Ralph et al., 2002; Patterson & Lambon Ralph, 1999). This may stem from disrupted phonological-semantic interactions or an increased reliance on semantic representations as a compensatory mechanism in language processing. If this is accurate, the continuum could be reduced to a single phonological dimension, potentially explaining why severe cases exhibit impairments in both semantic and phonological assessments (Crisp & Ralph, 2006). The more severe forms are evidenced in deep and global alexia conditions. At the phonological alexia level, the phonological-semantic interactions may be interrupted to a milder extent.

Deep alexia is characterized by reading errors in real words and a total inability to read aloud non-words. Reports suggest individuals with deep alexia frequently make semantic errors, often substituting target words with synonyms, antonyms, or related subordinate terms (Cherney, 2004).

These reading errors are a reflection of the marked inability to apply grapheme to phoneme correspondence rules and disruptions in lexical-semantic processing (Coltheart, 2000; Crisp & Lambon Ralph, 2006; K. E. Patterson, 1981). In turn, suggests semantic-phonological disjunctions. Wherein, real word/ regular word reading is underlined by semantic processing to access the semantic store, and non-word reading is subserved by phonological processing. Studies have suggested that the severity-based reading continuum between phonological and deep dyslexia is driven by two key factors: phonological and semantic impairments (Crisp et al., 2011; Crisp & Lambon Ralph, 2006).

A mild form of phonological dyslexia emerges when phonological impairment is present with minimal semantic deficits (Crisp & Ralph, 2006). In deep alexia, the phonological impairment is accompanied by semantic deficits or disrupted phonological-semantic interactions, wherein imageability effects (non-word reading) and semantic errors become more pronounced. These effects are in consensus with the results of the study, wherein both semantic and phonological aspects were significantly affected in deep alexia compared to phonological alexia. Significant phonological and semantic breakdown is evidenced through marked inability to read non- word and the presence of semantic errors in real word reading by deep alexia cohorts of both Kannada and English alexia profiles.

Consequently, in global alexia, overall central linguistic processes are obstructed resulting in extreme semantic and phonological impairments, which clearly reflects a pronounced inability to read aloud words (less than 10%) in both languages of PWAs in the study. The results showed significantly diminished semantic and phonological abilities in the global alexia cohort compared to the deep alexia cohort. The results suggested that both the orthographic-semantic loop and orthographic- phonological loop for reading real words and non-words, respectively are hampered, resulting in poor overall reading-aloud skills.

Overall, the variants of alexia are understood in terms of a continuum, with real word and non-word reading abilities varying in a graded manner. The extent of reading impairment relies on the degree of direct phonological, and semantic activations reserved in PWAs post-stroke rather than mere presence or absence of these activations (Crisp et al., 2011). At the severe end, PWAs with

global alexia manifest severe overall reading deficit, and PWAs with deep alexia could correctly read only a limited number of simple non-word stimuli. Both global and deep alexia conditions demonstrated diminished linguistic abilities at the central processing level. In contrast, at the milder end, PWAs with phonological alexia performed superior on semantics, syntax, and phonology, although their non-word reading remained below the typical range.

Along similar lines, reading abilities were analyzed across alexia profiles in Kannada and English languages. Results indicated both oral reading and reading comprehension skills were superior among PWAs with phonological alexia, followed by deep and global alexia. As expected, phonological alexia being the milder variant of alexia is underlined by milder semantic and phonological deficits as discussed prior, thereby oral reading and reading comprehension also were minimally diminished in phonological alexia compared to deep and global alexia. Yet another reason could be due to semantic-phonological interplay in deep and global alexia (Crisp et al., 2011; Crisp & Lambon Ralph, 2006). By the extent of impairment, the semantic and phonological activations are extensively hampered in deep and more in global alexia. Owing to this, oral reading and reading comprehension are also affected more intensely in deep and global alexia as evidenced in the results of the study.

#### ***5.7.2. Linguistic abilities and reading abilities within sub-groups of alexia in Kannada and English languages of bilingual PWAs.***

The linguistic performance in semantics, syntax, and phonology were compared within each alexia subgroups (phonological, deep, and global) in Kannada and English languages to understand the extent of linguistic influence on reading profiles at the central level. In both Kannada and English reading profiles, the semantic abilities were found to be significantly prominent in all alexia subgroups (phonological alexia, deep, and global alexia). Phonological skills were the most diminished in every alexia variant. Syntactic and phonological abilities were equipotent in all reading profiles. Results suggest that reading deficits are most reliant on impaired phonology in all types of alexia, and semantics abilities are much more resistant to influence the reading abilities irrespective of language concerning the performance of PWAs on reading tasks in the present study.

In general, the semantic loop facilitates the reading of both regular and irregular words. However, since it primarily operates as a whole-word pathway, it does not encode many of the regular patterns between orthography and phonology. As a result, word frequency and age of acquisition both may influence the strength of neural connections playing a key role in determining resistance to network damage or interference (Brookshire et al., 2014). This was evidenced in the results of objective three, wherein, all PWAs manifested superior semantic abilities compared to phonological abilities in both Kannada and English linguistic aspects. The resistance to semantic network damage may be substantiated by wide distribution across the left anterior inferior frontal gyrus (pars orbitalis) and the angular gyrus. These regions are primarily supplied by the left middle cerebral artery, with some contributions even extending from the right hemisphere (Beeson et al., 2022; Binder et al., 2009). Thereby, semantic abilities tend to be much more resilient to damage across different alexia severities. Also, the semantic tasks in the study entailed picture-based identification and association, with auditory sentence judgment and comprehension tasks. All relied on simple judgment skills and auditory processing. The focus was to avoid lexical access and tap the conceptual aspects of semantic processing. Overall, owing to underlying functions relied on tasks, and based on cognitive load, the semantic subdomain fared better results than phonological tasks.

In contrast, phonology was severely diminished in all types of alexia compared to semantics and syntax. Primarily, it is well evidenced by the pattern of reading errors demonstrated by subgroups of alexia. Though phonological alexia is the milder version of alexia, the reading errors are dominated by non-word reading errors and phonological errors. The severity escalates with the surge in reading difficulties in both non-word and real words across deep and global alexia, wherein the latter posing the severe form of alexia. Many studies have proved reading errors are a direct consequence of phonological processing deficits in phonological alexia, and deep alexia which is even severe form of phonological variant per se (Louis, 2001; Kendall, 2003; Beeson, 2010). In general, the orthographic-phonological loop is disturbed usually post-stroke (Jefferies et al., 2006), resulting in inhibition of letter-to-sound translation. Evidently, orthographic-phonological loops are responsible for these varied patterns of reading impairments.

Specifically, non-word reading accuracy is the most commonly used measure of direct orthographic to phonological activation. Non-words cannot rely on lexical-semantic knowledge. While accuracy in non-word reading may be extremely poor or at floor level in phonological-deep dyslexia, this does not necessarily indicate a complete loss of direct phonological activation. These patients sometimes produce phonologically related errors (either words or non-words) when reading non-word targets, suggesting some degree of phonological activation through sub-lexical orthography to phonology translation. Even omission errors do not necessarily mean phonological activation is entirely absent (Crisp & Lambon Ralph, 2011).

Along the severity continuum, both word and non-word reading accuracy gradually shift. This pattern aligns with findings from our previous study (Crisp & Lambon Ralph, 2006) and further supports the idea that phonological-deep-global alexia stems from a diminished ability to activate the impaired phonological system (Patterson & Marcel, 1992; Patterson et al., 1996).

Further, the study examined the oral reading and reading comprehension within each type of alexia (phonological, deep, and global alexia) in Kannada and English reading profiles. The results indicated in all types of alexia, oral reading was significantly impoverished compared to reading comprehension in both Kannada and English reading profiles. The results are in line with previous literature (Cherney, 2004; Madden et al., 2018). The findings may be attributed to the distinct nature of processing involved in the two, although both oral reading and reading comprehension are subserved by a few common central linguistic processing. Reading aloud relies on visual word recognition, phonological decoding, and active speech-motor movements for verbal output. While, reading comprehension negates the involvement of verbal output, and depends more on word recognition, with syntactic and semantic processing to extrapolate the meaning (Meteyard et al., 2015; Webster et al., 2022). The extra time required to read aloud the text due to the articulations involved in verbal output could influence the performance in reading aloud (Van Den Boer et al., 2022). Similar results were reported in eye-tracking experiments, wherein oral reading involved more processing time than silent reading comprehension in adults (Ashby et al., 2012).

The study specifically included tasks assessing single-word, sentence, and paragraph comprehension. These tasks involved activities such as matching written words, sentences, and

paragraphs to corresponding pictures, providing a semantic context that helped infer meaning with the support of images presented in the foils. Thus, owing to the aforementioned reasons, oral reading abilities were much compromised compared to silent reading comprehension in both Kannada and English languages.

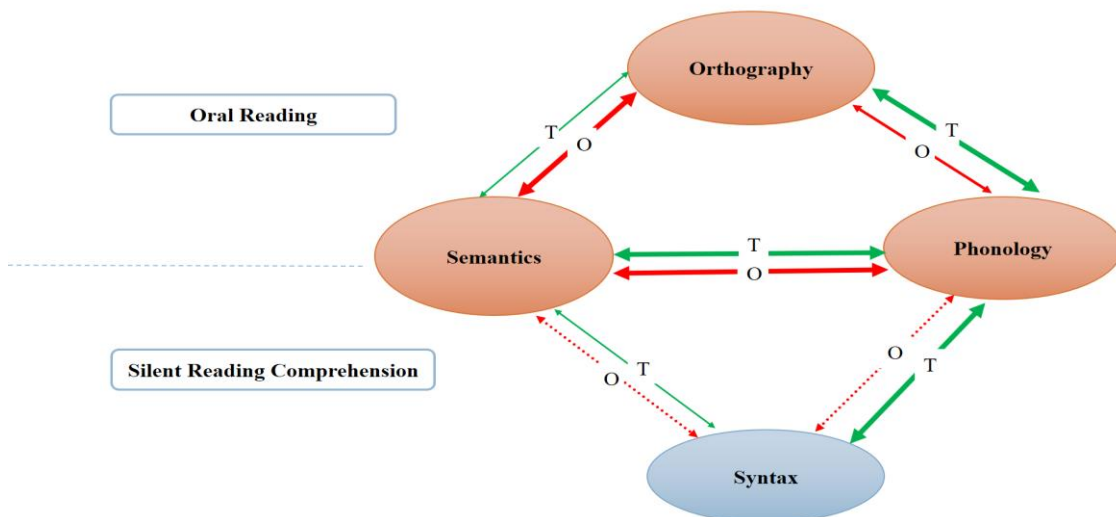
In a nutshell, in the context of the Primary System Hypothesis, the results of the study align with the explanations of Crisp and Ralph (2006). As expected, the impaired oral reading abilities are a clear reflection of semantic and phonologic impairments. *Phonological alexia*, is characterized by poor non-word reading compared to relatively intact real word reading (lexicality reading effect), is purported to result from a high degree of phonological impairment. Crisp and Ralph's explanation contrasts with Coltheart and colleagues' dual-route theory, which attributes deficits to a damaged indirect, sub-lexical reading pathway and a selectively impaired grapheme to phoneme rule system. Phonological alexia is most sensitive to the lexical status of the letter string. A significant deficit emerges when processing unfamiliar letter strings or non-words. *Deep alexia*, is commonly accepted as a severe form of phonological alexia (Crisp & Ralph, 2006; Woollams et al., 2022). According to PSH, it arises from some semantic impairment, in addition to severe phonological impairment. This perspective varies from the classic view of deep alexia resulting from damage to both lexical and sub-lexical reading-specific routes. Finally, *global alexia* is linked with severe underlying semantic and phonological impairment, which is thought to account for the abolished reading ability that defines the severe reading profile.

Based on the findings of linguistic and reading abilities of PWAs with alexia, the study proposes a model that illustrates the interrelationship between central linguistic abilities including phonological, semantic, and orthographic influence on Kannada and English oral reading abilities, and how these abilities contribute to reading disturbances in both languages. Likewise, the model demonstrates the injunctions between central linguistic abilities and silent reading comprehension in Kannada and English languages. With bilingual learners becoming increasingly common in multilingual contexts like India, understanding the shared and language-specific contributors to improve reading efficiency among acquire reading impaired individuals post stroke is essential for effective intervention.

*Rationale:* While previous studies have extensively examined reading development in English (e.g., Beeson et al., 2022; Henry et al., 2012; Madden et al., 2018; Purdy et al., 2019), there is a relative lack of research on how linguistic abilities in an agglutinative language like Kannada interact with English in the context of bilingual reading impairment context. Kannada and English differ significantly in their orthographic depth, morphological structure, and phonological systems, which provides a unique opportunity to examine cross-linguistic transfer and language-specific predictors of efficient reading. This model aims to deepen our understanding of how linguistic skills in two typologically distinct languages interact in the intervening reading abilities. Findings from this study can inform bilingual reading abilities, assessment design, and intervention planning in Kannada-English biscriptal acquired reading impaired with aphasia. Future studies need to verify the same among acquired reading impaired biscriptal PWAs in different transparent and opaque language systems (e.g., Hindi- English, Telugu- English, Malayalam- English, Tamil- English, etc.) owing to diverse languages spoken in India. Figure 5.1 depicts the acquired reading impairment model for Kannada- English biscriptal PWAs.

*Figure 5.1*

Acquired Reading Impairment Model for Transparent and Opaque Biscriptal PWAs



Note- The schematic representation of acquired reading impairment for transparent-opaque biscriptal individuals denoting the influence of central linguistic domains on oral reading and reading comprehension specifically in Kannada (transparent) and English (opaque) languages based on the principles of Primary System Hypothesis. The weighted arrow denotes strong relation, thin arrows denote moderate relation, and dotted arrow denotes weak relation.

## CHAPTER VI

### SUMMARY AND CONCLUSIONS

Alexia is an acquired reading impairment resulting from a lesion to the dominant hemisphere. The reading impairments are reflected in the partial or complete impairment of oral reading and reading comprehension abilities of written text or print (Cherney, 2004). Reading difficulties following left-hemisphere damage are usually linked to linguistic impairments and may appear either as isolated symptoms or as part of an aphasia syndrome. Thus, alexia co-occurs with aphasia (Cherney, 2004; Riley & Kendall, 2013; Madden, 2016).

Acquired language disorders manifest in various ways, including difficulties with speech production and comprehension, reading and text understanding, writing, object naming, interpreting gestures, and gesture production (Cherney, 2004). Aphasia is an acquired language disorder that is complex and marked by linguistic deficits, also paired with written language impairments of varying degrees (Madden, 2016). However, the prevalence of aphasia-related alexia, its subtypes, and the factors influencing its occurrence remain unclear. These aspects are central as they may influence aphasia rehabilitation goals. On this note, Brookshire and colleagues (2014) reported evidence that 68% of PWA exhibit the presence of alexia suggesting that reading impairment always accompanies aphasia. This indicates that there is a strong likelihood of the neural network for the spoken language being affected post-stroke also disrupts the network for reading aloud. The severity of this co-occurring impairment likely depends on the location and extent of the lesion. These distributed language networks are thought to deteriorate gradually rather than completely fail when damaged (Brookshire et al., 2014).

Given the highly interconnected nature of the language network, impairment and recovery in one component can influence other parts of the system. In PWAs, a strong relationship has been observed between reading performance and other linguistic abilities (Balani & Bickerton, 2023). In this notion, nearly three decades ago primary system hypothesis (PSH) was put forth stating that the performance of spoken language and written form is a consequence of interaction between the cognitive systems (Beeson et al., 2022; Patterson & Ralph, 1999). The model demonstrated that reading ability depends on the functioning of concept (semantics), sound processing (phonology),

and visual processing (orthographic) (Beeson et al., 2022; Patterson & Ralph, 1999; Plaut, 1996). The individual's reading status depended on the individual's primary language system. Thus, the reading profiles were proposed and proved through the primary systems. The primary system, also known as the triangular model, consists of three interconnected pathways: semantics-phonology, phonology-orthography, and orthography-semantics, all triggering language processing. This model operates through a division of labor, enhancing the efficiency of the language system. Most importantly, this suggests that reading impairments stem from disruptions in one or more of these modality-independent primary systems (Ralph & Patterson, 2005; Patterson & Ralph, 1999; Woollams, 2014). Consecutively, the reading patterns were explained based on the impairment or disjunctions in the pathways according to the primary system.

*Normal reading* ability relies on intact semantic and phonological processing. *Surface alexia*, characterized by difficulty reading irregularly spelled words while maintaining relatively preserved reading of regularly spelled words (the regularity effect), is thought to result from an underlying semantic impairment. *Phonological alexia*, marked by difficulty reading non-words while relatively preserving real word reading (the lexicality effect), is believed to stem from severe phonological impairment (Patterson & Ralph, 1999). Deep alexia, widely regarded as a severe form of phonological alexia (Crisp et al., 2011; Crisp & Lambon Ralph, 2006; Friedman, 1996), is thought to result from both severe phonological impairment and some degree of semantic impairment. Lastly, global alexia is believed to stem from profound semantic and phonological deficits, leading to the complete loss of reading ability characteristic of the syndrome.

Just as oral reading is impaired in acquired alexia secondary to stroke, reading comprehension also shares its role in the deficits, although the severity and pattern of deficit may vary among them. Alike oral reading and reading fluency deficits, reading comprehension is a common feature noted in PWAs (Kelly et al., 2015). Reading comprehension in PWAs has been evaluated at the word, sentence, and paragraph levels. However, there is limited understanding of the relationships between these levels and how lexical and syntactic challenges affect every day reading (Webster et al., 2022). Text or discourse comprehension, which involves understanding

multiple sentences, requires both lexical recognition and comprehension as well as the processing of sentence syntax (Chesneau & Ska, 2015).

The types of reading impairments are highly variant among different types of aphasia. Identification of impaired components of reading and writing is a crucial factor in remediating these difficulties. The manifestation of varied reading patterns in different types of aphasia, there are yet many more factors contributing to the extent of reading impairment in PWAs. One of the prime factors apart from the pathophysiology of brain insult is the orthographic maps of the individuals' language, which is crucial. In a diverse country like India, the country is abundant with a wide range of rich scripts and a multitude of languages spoken across the country. It is one of the largest functionally multilingual countries in the world (Annamalai, 2001). Especially, bilingualism is widespread in India, with approximately 450 distinct languages spoken across the country (Ethnologue, 2020).

Reading difficulties are widely influenced by the transparency of the script, prompting research into the specific characteristics of alexia across different orthographies (Landerl et al., 2022). For example, in more transparent orthographies (e.g., Indian scripts, Italian, Arabic), reading difficulties tend to manifest prominently in reading fluency rather than accuracy, as observed in studies on Italian (Reis et al., 2011) and Spanish (Suárez-Coalla & Cuetos, 2015) compared to opaque orthographies. However, most of the experiments on alexia in adults are centered on English speakers, which limits the extension of the findings to languages with less opaque orthographies (Reis et al., 2020). Further, the need for bilingual studies increased with the spurt in bilingualism across the globe.

A significant underpinning in bilingual readers is that a bilingual individual must acquire reading skills separately for each of their languages, particularly when the languages utilize distinct orthographic systems (Goral, 2019). The extent to which these mechanisms operate depends largely on the orthographic differences between L1 and L2.

The present study found that the research on acquired alexia in bilingual individuals has largely focused on single-case studies, often exploring how different types of alexia present across various orthographic systems. A review of previous works of literature reveals two main areas of

debate: first, the extent to which a language's orthographic characteristics shape the nature of reading impairments, and second, how differences between orthographies influence the neural networks involved in reading (Goral, 2019).

Many bilingual alexia studies attempted to understand the influence of orthographic transparency on acquired bilingual alexia individuals and they opined that orthography type alone determines the manifestation of alexia (e.g., Laganaro & Overton Venet, 2001). While some studies suggest an influence of orthographic transparency on acquired reading impairments, others highlight the confounding role of language proficiency (Goral, 2019). Overall, there is no conclusive evidence for a direct relationship between orthography type and alexia subtype.

Some researchers propose that the differential impairment of two languages in bilingual PWAs is due to variations in activation and inhibition levels rather than differences in the extent of language damage (e.g., Goral, 2019; Kuzmina et al., 2019). According to this view, the apparent disparities between the two languages result from a disrupted control mechanism rather than a more severe impairment in one language (Abutalebi & Green, 2008). While this hypothesis has gained broader acceptance, it remains possible that the neural system supporting spoken language processing is shared across both languages in bilinguals.

Given the prevalence of multilingualism and bilingualism in India, a few pioneering researchers in the field have observed and documented distinctions unique to the Indian cross-linguistic context. In specific interest of the study, the study focuses on Dravidian languages, which entail alpha-syllabic orthography. This system is significantly more transparent than English orthography. Kannada is a Dravidian language, with a phonetically regular script.

Considering the complex orthographic features of Kannada and the extent of oral language impairment in individuals with acquired reading difficulties, this study emphasizes the importance of distinguishing concurrent language processes associated with reading impairments. This approach supports the primary system hypothesis (PSH) and underscores the need for further exploration of the reading mechanisms in Indian language orthographies (Swamy & Goswami, 2024). Specifically, the present study aimed to investigate the distinctions observed in Kannada-English bilingual PWAs with alexia following a stroke. If such distinctions are identified, the author attempts to explain them

using reading models tailored specifically for Kannada-English bilinguals, building on the foundational understanding provided by the literature discussed in the study.

Adhering to the research gaps analyzed, the study aimed to examine the relationship between linguistic abilities (linguistic form) and reading abilities (orthographic form) in bilingual PWAs across Kannada and English languages. The orthographic language refers to the written language aspects like oral reading and reading comprehension. The non-orthographic language refers to the linguistic processing aspects like semantics, syntax, and phonology. To address the reading and linguistic abilities of bilingual PWAs, a series of specific behavioral tasks were designed and systematically validated in Kannada and English languages. The study entailed single-group comparisons and correlation design. Also, the sub-grouping of alexia types was formed based on the oral reading errors. The reading and linguistic distinctions were compared within and between the types of Alexia. The independent variables in the study were the languages used (Kannada & English) and the type of alexia (phonological alexia, deep alexia, and global alexia) of PWAs. The dependent variables considered in the study were measures of semantics, phonology, and syntax (linguistic abilities) along with measures of oral reading and reading comprehension (reading abilities). Adhering to the ethical guidelines, the study recruited twenty Kannada-English bilingual PWAs with reading and language impairments post-stroke through a convenient sampling method. All were native speakers of Kannada (L1) and had acquired English (L2), during their formal schooling. Abiding by strict inclusion and exclusion criteria set in the study, a total of 15 males and 5 females diagnosed with aphasia through WAB whose average age was 43.5 years (S. D= 15.99; range= 20-68), and who had an average of 16 years of formal education (S. D= 1.77; range= 12-18) with an average of 35 months post-stroke onset participated in the study.

All the bilingual PWAs were examined for linguistic abilities and reading abilities of Kannada-English through a set of validated behavioral tasks compiled through a few standardized test batteries. The linguistic abilities were gauged through tasks of semantics, phonology, and syntax. The reading abilities were gauged through oral reading and silent reading tasks, exclusively in Kannada and English languages. A binary scoring system was employed to mark the responses of all the behavioral tasks. The data computed was analyzed for descriptive and inferential statistics

respective to the objectives of the study. The results of the analysis specific to the objective are summarized below.

- Objective 1: Relationship between semantics, and phonology (linguistic form) with oral reading abilities in bilingual PWAs in Kannada and English.
  - Correlation analysis: In Kannada language, manifested the strongest correlation with phonology, followed by semantics with oral reading abilities. However, in the English language oral reading abilities correlated strongly with semantics, followed by phonology.
  - Multiple linear regression (MLR) analysis: In Kannada, the semantic predictors of all the oral reading conditions (overall oral reading, real word reading, and non-word reading) are auditory comprehension and picture identification tasks. The phonological predictors of oral reading abilities in Kannada is the phonological manipulation task for overall reading, real word oral reading conditions. The non-word rhyme judgment task was found to be the predictor of non-word oral reading ability in the Kannada language.
  - In English, the semantic predictor of all the oral reading conditions is the auditory comprehension task alone. The phonological predictor of overall oral reading, real word reading, non-word reading, and irregular oral reading conditions is the phonological manipulation task.
- Objective 2: Relationship between semantics, phonology, and syntax (linguistic) with silent reading comprehension in bilingual PWAs in Kannada and English.
  - Correlation analysis: In the Kannada language, silent reading comprehension correlated strongest with syntax, followed by phonology and semantics. However, a contrasting correlation pattern was noted in English. The correlation was maximum with semantics, followed by phonology, and least with syntax. The extent of phonological influence across the reading comprehension levels manifested a strong effect on paragraph reading=sentence>single word in Kannada.

- Multiple linear regression (MLR) analysis: In Kannada, the syntactic predictors of all the silent reading comprehension conditions (overall reading comprehension, single-word reading comprehension, sentence reading comprehension, and paragraph reading comprehension) were the syntactic marker comprehension tasks. The phonological predictor was noted to be the real word rhyme judgment task.
- In English, the semantic predictor of all four levels of reading was the auditory comprehension task commonly. The picture association task and picture identification task were also found to be the predictors for single-word reading comprehension.
- Objective 3: To understand the orthography effect (alpha syllabic vs alphabetic system) in reading abilities of Kannada and English languages in PWAs.
  - Between L1 –L2: The performance in reading abilities revealed enhanced performance in the Kannada language (L1) compared to English (L2) in the overall reading quotient. Where oral reading also showed cross-linguistic dissociations (L1 better than L2). However, reading comprehension was found to be parallel in both languages. Overall, the cross-linguistic effect or orthographic transparency effect was demonstrated in reading processes across both languages (L1 better than L2).
  - Within L1 & L2: In both Kannada and English languages, the oral reading abilities were predominantly poor compared to reading comprehension.
- Objective 4: To understand cross linguistic variations in linguistic abilities of Kannada and English languages of PWAs.
  - Between L1- L2: The performance of linguistic abilities by all PWAs showed equivalent performance across both the languages (L1 vs L2), wherein semantics, phonology, and syntax were equipotent in both Kannada and English languages.
  - Within L1 & L2: In both Kannada and English languages among the linguistic abilities, the semantics was predominantly better compared to syntax and phonology, wherein all three significantly varied with each other.

- Objective 5: The linguistic and reading abilities across and within the type of alexia in Kannada and English languages among bilingual PWAs.
  - Linguistic abilities between alexia sub-groups in Kannada and English: The performance in semantics, phonology, and syntax was superior in phonological alexia, followed by deep and weakest in global alexia in both Kannada and English languages.
  - Reading abilities between alexia sub-groups in Kannada and English: In Kannada, the oral reading abilities were robust in phonological alexia and poorest in global alexia. Reading comprehension in Kannada did not show variability between subgroups of alexia. In English, both oral reading and silent reading abilities were significantly better in phonological alexia and merest in global alexia.
  - Linguistic abilities within alexia sub-groups in Kannada and English: In both Kannada and English the semantic abilities were strongest and phonological abilities were the weakest.
  - Reading abilities within alexia sub-groups in Kannada and English: In both Kannada and English oral reading abilities were significantly poor compared to silent reading comprehension.

## **6.1 Implications of the study.**

Validating the principles of the primary system hypothesis, the results of the study efficiently demonstrate the inherent connections between central linguistic abilities and acquired reading deficits in PWAs post-stroke. In other words, the findings support a unified language model, encompassing both spoken and written language, highlighting the interaction between semantics, phonology, syntax, and reading abilities in bilingual PWAs. The study identifies some of the salient clinical implications implied from the results of the study.

### ***6.1.1 Implications of Oral Reading Abilities in PWAs with Alexia***

Reading impairments are commonly observed in post-stroke survivors, leading to difficulties in oral reading and comprehension, along with a reduced reading speed (Knollman-Porter et al.,

2015; Madden, 2016; Beeson, 2022). Different types of alexia are central, and co-existing with spoken language impairment in PWAs. Reading being a complex neuropsychological process involves sensory (visual), semantic, morpho-syntactic, and phonological processing. In the instance of acquired reading impairment post-stroke, the results of the study imply shared neural processing with linguistic abilities across various types of alexia (phonological, deep, and global). Wherein, the results of the study demonstrated a specific extent of phonological and semantic influence on oral reading abilities in PWAs with alexia post-stroke.

Traditionally, a brief screening of acquired reading impairment is performed along with the profiling of the spoken language deficits in PWAs during routine investigations. This merely serves the identification or presence of reading impairments in the PWA among a multitude of other spoken language impairments. However, to frame an effective treatment regime for the individual, a comprehensive evaluation is warranted to learn the precise breakdowns at various levels of the reading process.

The findings of the study indicate the importance of a detailed analysis of oral reading abilities across various contexts like real word, non – word and irregular word reading becomes vital in the routine assessment procedures because the reading errors serve as the main source to categorize the individual with reading impairment into specific types the alexia (phonological, deep and global). Also, understanding the influence of linguistic underpinning (phonological and semantic) may augment efficient treatment for improving both spoken and written language impairments in the PWA groups.

### ***6.1.2. Implications of Oral Reading Abilities in PWAs with Alexia***

Just as oral reading is impaired in acquired alexia secondary to stroke, reading comprehension also shares its role in the deficits, although the severity and pattern of deficit may vary among them. Alike oral reading and reading fluency deficits, reading comprehension is a common feature noted in PWAs (Kelly et al., 2015). Reading comprehension in PWAs has been evaluated at the word, sentence, and paragraph levels. However, there is limited understanding of the relationships between these levels and how lexical and syntactic challenges affect everyday

reading (Webster et al., 2022). Text or discourse comprehension, which involves understanding multiple sentences, requires both lexical recognition and comprehension as well as the processing of sentence syntax. Specifically, reading comprehension tasks reflect the individuals' ability to retrieve semantic meaning from script/print, along with phonological and syntactic processing. The findings of the study have affirmed the inherent influence of phonology, syntax, and semantics in silent reading comprehension among PWAs with alexia.

Traditionally, the subtasks of reading comprehension are categorically aligned, starting with single-word level comprehension, followed by sentence level (e.g., comprehending written commands) and paragraph (e.g., responding to questions about a paragraph read). They even include recognition of letters (upper/lower case) and shapes as basic components (Cherney, 2004). There are numerous tests designed for assessing reading comprehension for PWAs but as subtasks in the comprehensive spoken language assessments. Nevertheless, in these reading subtasks in comprehensive aphasia batteries like in the Western Aphasia Battery (WAB) or Boston Diagnostic Aphasia Examination (BDAE), very scarce information is deciphered with fewer items tested, resulting in inadequate information to apprehend milder reading issues.

Thus, owing to these shortcomings in the present assessment regimes designed for PWAs, a comprehensive assessment of both linguistic and reading aspects of PWAs is necessary for their routine intervention. The tasks and sub-tasks employed in the study may serve as an appropriate exemplar for developing such a comprehensive dedicated assessment tool concerning PWAs.

### ***6.1.3. Implications of orthographic-specific investigations in PWAs with Alexia***

Besides the manifestation of varied reading patterns in different types of aphasia, there are yet many more factors contributing to the extent of reading impairment in PWA. In the Indian context, one of the prime factors apart from the pathophysiology of brain insult is the orthographic maps of the individuals' language, which is crucial. Especially, in a diverse country like India, the country is abundant with a wide range of rich scripts and a multitude of languages spoken across the country. The expression of written language impairment is largely influenced by the script and

orthographic structure of a given language (Goral, 2019). Hence, investigating acquired reading impairments specific to the orthography of the individual's native language is the prime need.

Reading difficulties are widely influenced by the transparency of the script, prompting research into the specific characteristics of alexia across different orthographies (Landerl et al., 2022). Presently, there is a wide range of assessment protocols developed exclusively for PWAs in various language contexts (Hindi, Kannada, Malayalam, Tamil, and so on). Yet, all these assessments focus primarily on overall linguistic disturbances, and scarcely on written language impairments, which is highly the need of the hour as most individuals are literate and depend mostly on written communication modes like emails, newspapers, and social media. The PWAs express their interest in improving written communication also to participating in the community. The majority of PWAs are literate and have a professional background before the stroke episode. Thus, the observations of the study indicate the orthographic-specific distinctions in reading impairments with underlying central linguistic competency concerning Kannada-English bilingual PWAs. The specific observations from the study may be applied in planning intervention of PWAs with reading impairments in Kannada-English languages.

#### ***6.1.4. Implications of bilingual investigations in PWAs with Alexia***

In a diverse country like India, the country is abundant with a wide range of rich scripts and a multitude of languages spoken across the country. It is one of the largest functionally multilingual countries in the world (Annamalai, 2001). Especially, bilingualism is widespread in India, with approximately 450 distinct languages spoken across the country (Ethnologue, 2020). Bilingual individuals must acquire reading skills separately for each of their languages, particularly when the languages utilize distinct orthographic systems (Goral, 2019). Furthermore, reading difficulties are widely influenced by the transparency of the script, prompting research into the specific characteristics of alexia across different orthographies (Landerl et al., 2022). Kannada being a transparent script and English being an opaque script, manifest distinct deficits in spoken and written combination post-stroke. The extent to which these mechanisms operate depends largely on the orthographic differences between L1 and L2. Also, a manifestation of these deficits depends on

premorbid language proficiency, educational background, family support, socioeconomic status, use of language, and many more individualistic factors.

With this notion, the study efficiently attempted to unravel the distinctions in linguistic and reading impairments exclusive in the Kannada and English languages of bilingual PWAs. The findings of the study suggest the salience of developing bilingual comprehensive assessment concerning linguistic and reading processing to augment efficient intervention of bilingual PWAs. The study also demonstrates the distinctions specific to orthographic nature (transparency) which is often overlooked in the interventions of bilingual PWAs. The clinician may benefit from the protocol administered in the study to render treatment in the same population. Additionally, the findings of the study indicate the deviances in the degree of impairment in both Kannada and English languages and varied types of reading errors in each language. These observations provide valuable insight into understanding the severity of reading errors specific to Kannada- English bilingual context among post-stroke PWAs and apply the inferences in their intervention.

In a nutshell, the findings of the study highlight the significance of routinely assessing reading abilities and providing integrated treatment for both written and spoken language impairments in PWAs. The results support recent alexia/agraphia interventions (e.g., Beeson et al., 2010; Beeson, Rising, DeMarco, Foley, & Rapcsak, 2018; Brookshire et al., 2014; Johnson, Ross, & Kiran, 2017) that address not only orthographic skills but also phonology and/or semantics to enhance written language processing. Furthermore, this study suggests that evaluating performance on semantic and phonologic tasks can aid in diagnosing alexia, rather than relying solely on single-word oral reading accuracy and error types, which is a common clinical practice. The importance of orthographic-specific and bilingual observations of the study in reading impairments of Kannada English bilingual PWAs suggests the development of more comprehensive protocols specific to the linguistic contexts of the region in the assessment of the PWAs, and also, apply the implications of the observations in the treatment rendered. Although the attempts were preliminary, the study demonstrates few strengths.

## 6.2. Strengths of the Study

- ✓ The attempts of the study are novel in terms of addressing the linguistic and orthographic abilities in bilingual contexts among PWAs.
- ✓ The study focused on explaining the core linguistic deficits affecting reading impairments in a bilingual context using the principles of the primary systems hypothesis model.
- ✓ A few pioneers in the field observed and reported the distinctions specific to the Indian cross-linguistic context (Chengappa et al., 2004; Karanth, 1981, 2002; Ratnavalli et al., 2000; Ravi & Chengappa, 2014). These studies were conducted among bilingual and multilingual individuals who knew languages such as Hindi, Kannada, Telugu, and English. All these investigations were on bilingual/ multilingual acquired alexia individuals primarily based on single-case studies, often examining how different types of alexia prevail across various orthographic systems. The present study is novel in terms of addressing the research gaps specific to orthographic-specific distinctions in the Kannada vs English language concerning reading impairments in a bilingual group of PWAs, unlike single case designs.
- ✓ Analysis of oral reading accuracy and demarcating them into subgroups of alexia is a novel attempt owing to the Indian context, unlike previous studies, sub-grouped the alexia based on Western language reading errors.
- ✓ Observation of oral reading accuracy (real word, non-word, irregular words) and silent reading comprehension (single word, sentence level, and paragraph level) and computing the reading quotient from this is an important attempt in the study. Most of the routine assessments follow a brief screening of acquired reading impairment along with the profiling of the spoken language deficits in PWAs, which is insufficient for efficient intervention of the PWAs with alexia.
- ✓ Orthographic-specific distinctions in Kannada-English reading profiles in PWAs post-stroke are one of the salient observations owing to the Indian bilingual context. These insights may aid in understanding the orthographic distinctions in other bilingual contexts of India (E.g., Hind- English, Malayalam- English, Tamil- English, etc.)

- ✓ The study designed a comprehensive assessment of both linguistic and reading abilities in Kannada-English PWAs. The behavioral tasks and sub-tasks employed in the study may serve as an appropriate exemplar for developing such a comprehensive dedicated assessment tool for their routine intervention concerning bilingual PWAs of native speakers of other languages.
- ✓ The analysis of linguistic predictors of oral reading and reading comprehension abilities exclusive to Kannada and English languages is another significant attempt of the study. Understanding underlying linguistic deficits in terms of phonology, semantics, and syntax may aid in planning treatment strategies specific to reading impairments. Also, the knowledge of the sub-tasks of phonology, semantics, and syntax predicting or directly influencing reading impairments may contribute to framing the specific tasks in the assessment protocols and also in planning treatment strategies. For example, the phonological predictor of oral reading abilities was the phonological manipulation task, and the rest were not significant in the Kannada language. In this instance, the focus can be more on assessing and treating phonological manipulation to intervene in reading abilities in PWAs with alexia in Kannada.

### **6.3. Limitations of the study**

- ✗ The study focused entirely on non-verbal linguistic tasks which restricted the involvement of verbal expression to reduce the load on PWAs. The inclusion of naming and repetition tasks of spoken language abilities may aid additional information on their influence on oral reading abilities.
- ✗ The impact of additional psycholinguistic variables, including word imageability, concreteness, and part of speech, specifically the inclusion of function words and bound morphemes on reading performance was not investigated.
- ✗ The silent reading comprehension tasks included picture-based reading at all levels. Due to this, the task complexity was much lower and the responses could have been simplified accordingly.

- ✘ The influence of aphasia type and severity in each language of bilingual PWA were not analyzed in the study. Integrating a broader sample across various types of aphasia and severity could have aided in more specific findings concerning aphasia type and severity.
- ✘ The study employed a purposive sampling method, limiting the inferential generalizability of the results to a broader population. Future research with a representative sample will be necessary to ensure the generalization of the findings.
- ✘ The study lacks internal validity as the samples were not recruited randomly from the population.

#### **6.4. Future Directions**

The present work has been preliminary in addressing the acquired reading impairments in post-stroke PWAs in bilingual context and marks to be novel in its attempts to examine the different patterns of reading impairments from underlying central linguistic breakdowns based on the principles of primary system hypothesis. The findings of the study offer multiple possibilities to extend the research on similar lines of the study. Primarily, future experiments may attempt to include a sample representation of the population randomly on a large scale, to improve the inferential generalizability. Further, address the randomized sample of PWAs by categorizing them into different types of aphasia and examine the linguistic and reading abilities in the subgroups of aphasia. Interesting results may be expected in future studies when each PWA's site and extent of the lesion are also considered and analyzed to see how these factors reflect on the individual's linguistic and reading impairments.

In terms of the protocol framed in the study, future research may additionally include spoken language tasks like naming and repetition along with non-verbal linguistic tasks which may further pave the way to understanding much complex influence of speech motor abilities subserving the oral reading abilities in PWAs with alexia post-stroke. The oral reading abilities may be analyzed across different psycholinguistic factors like word imageability, word concreteness, functional words, etc., which possibly aid in better understanding in the selection of the type of words to start intervening in reading abilities post-stroke. A few other task-specific modifications could be the inclusion of

complex reading comprehension stimuli, along with the inclusion of question and answer paragraphs that may be more sensitive to tap the influence of central linguistic processing, rather than picture-based reading comprehension tasks which taps only the conceptualization.

Lastly, and most importantly future researchers may look into language-specific linguistic and reading aspects in the other bilingual speakers of PWAs with alexia. The insights of the study may applied and future studies may extend their findings based on the language-specific distinctions observed in other Indian bilingual contexts cautiously considering the shortcomings of the study. Owing to the intricate linguistic features of other Indian languages, a few more remarkable findings may be expected. Further, this may facilitate developing protocols and treatment plans fostering both spoken language and reading impairments to enhance the performance of PWAs more independently in the present technological advancing phase.

To conclude, the study strongly scaffolds the principles of primary systems approaches in Kannada–English bilingual PWAs with alexia post-stroke, which first of the kind. Originally PSH was designed to explain reading and acquired alexia, the primary systems approach views reading difficulties as disruptions in broader cognitive processes rather than isolated reading skills. This study further demonstrates that performance on reading-related tasks reflects the functioning of core semantic, phonological, and syntactic processing mechanisms. Research on language and reading rehabilitation in bilingual PWA is still in its budding stage. The author hopes these findings inspire researchers and clinicians to further explore the nature of acquired written language deficits and, importantly, to consistently assess both spoken and written language abilities in PWAs to understand the orthographic-specific features. This approach may help identify shared underlying deficits that could be effectively targeted through therapeutic interventions. However, the conclusions should be interpreted with caution concerning the limitations of the study, and underscoring the need for further experiments with larger, more diverse samples across different bilingual contexts to gain deeper insights.

## REFERENCES

- Abutalebi, J., Cappa, S. F., & Perani, D. (2001). The bilingual brain as revealed by functional neuroimaging. *Bilingualism: Language and Cognition*, 4(2), 179–190. <https://doi.org/10.1017/S136672890100027X>
- Abutalebi, J., & Green\*, D. W. (2008). Control mechanisms in bilingual language production: Neural evidence from language switching studies. *Language and Cognitive Processes*, 23(4), 557–582. <https://doi.org/10.1080/01690960801920602>
- Alladi, S., Bak, T. H., Mekala, S., Rajan, A., Chaudhuri, J. R., Mioshi, E., Krovvidi, R., Surampudi, B., Duggirala, V., & Kaul, S. (2016). Impact of Bilingualism on Cognitive Outcome After Stroke. *Stroke*, 47(1), 258–261. <https://doi.org/10.1161/STROKEAHA.115.010418>
- Allevato, E. (2019). A Project-based Approach to Examine University Teachers Attitudes towards Visually Impaired Students. *Scholarly Journal of Psychology and Behavioral Sciences*, 2. <https://doi.org/10.32474/SJPBS.2019.02.000137>
- Annamalai, E. (2001). Managing multilingualism in India: Political and linguistic. In *Managing multilingualism in India: Political and linguistic manifestations* (p. 239). Sage. <https://searchworks.stanford.edu/view/4568537>
- Ashby, J., Yang, J., Evans, K. H. C., & Rayner, K. (2012). Eye movements and the perceptual span in silent and oral reading. *Attention, Perception, & Psychophysics*, 74, 634–640.
- Balani, A. B., & Bickerton, W.-L. (2023). *Acquired reading impairment following brain injury*. <https://doi.org/10.1080/23279095.2023.2165923>
- Barry C. (1988). Accounts of oral reading in deep dyslexia. *Springer Verlag*, 119-171.
- Barry, C., & Richardson, J. T. E. (1988). *Accounts of oral reading in deep dyslexia* (H. A. Whitaker, Ed.). Springer-Verlag. <https://oro.open.ac.uk/50121/>
- Basavaraj, V., & Venkatesan, S. (2009). *Ethical Guidelines for Bio-behavioral Research Involving Human Subjects*. All India Institute of Speech and Hearing. Mysuru, India.
- Basso, A., Gardelli, M., Grassi, M. P., & Mariotti, M. (1989). The role of the right hemisphere in recovery from aphasia. Two case studies. *Cortex*, 25(4), 555–566. [https://doi.org/10.1016/S0010-9452\(89\)80017-6](https://doi.org/10.1016/S0010-9452(89)80017-6)
- Beaton, A. A., & Davies, N. W. (2007). Semantic errors in deep dyslexia: Does orthographic depth matter? *Cognitive Neuropsychology*, 24(3), 312–323. <https://doi.org/10.1080/02643290701251957>
- Beeson, P. M., Rising, K., Kim, E. S., & Rapcsak, S. Z. (2010). A treatment sequence for phonological alexia/agraphia. *Journal of Speech, Language, and Hearing Research: JSLHR*, 53(2), 450–468. [https://doi.org/10.1044/1092-4388\(2009/08-0229\)](https://doi.org/10.1044/1092-4388(2009/08-0229))
- Beeson, P. M., Rising, K., Sachs, A., & Rapcsak, S. Z. (2022). Common predictors of spoken and written language performance in aphasia, alexia, and agraphia. *Frontiers in Human Neuroscience*, 16, 1025468. <https://doi.org/10.3389/fnhum.2022.1025468>

- Beck, I. L., Perfetti, C. A., & McKeown, M. G. (1982). The effects and uses of word knowledge in reading comprehension. *Journal of Educational Psychology*, 74(4), 506–521. <https://doi.org/10.1037/0022-0663.74.4.506>
- Behrmann, M., & Bub, D. (1992). Surface dyslexia and dysgraphia: Dual routes, single lexicon. *Cognitive Neuropsychology*, 9(3), 209–251. <https://doi.org/10.1080/02643299208252059>
- Behrmann, M., Nelson, J., & Sekuler, E. B. (1998). Visual complexity in letter-by-letter reading: Pure alexia is not pure. *Neuropsychologia*, 36(11), 1115–1132. [https://doi.org/10.1016/S0028-3932\(98\)00005-0](https://doi.org/10.1016/S0028-3932(98)00005-0)
- Béland, R., & Mimouni, Z. (2001a). Deep dyslexia in the two languages of an Arabic/French bilingual patient. *Cognition*, 82(2), 77–126. [https://doi.org/10.1016/s0010-0277\(01\)00148-2](https://doi.org/10.1016/s0010-0277(01)00148-2)
- Béland, R., & Mimouni, Z. (2001b). Deep dyslexia in the two languages of an Arabic/French bilingual patient. *Cognition*, 82(2), 77–126. [https://doi.org/10.1016/s0010-0277\(01\)00148-2](https://doi.org/10.1016/s0010-0277(01)00148-2)
- Benson, D. F., & Ardila, A. (1996a). *Aphasia: A clinical perspective* (pp. viii, 441). Oxford University Press.
- Benson, D. F., & Ardila, A. (1996b). *Aphasia: A Clinical Perspective*. Oxford University Press.
- Berndt, R. S., Mitchum, C. C., & Haendiges, A. N. (1996). Comprehension of reversible sentences in 'agrammatism': A meta-analysis. *Cognition*, 58(3), 289–308.
- Bialystok, E. (2011). Coordination of executive functions in monolingual and bilingual children. *Journal of Experimental Child Psychology*, 110(3), 461–468. <https://doi.org/10.1016/j.jecp.2011.05.005>
- Bialystok, E. (2015). Bilingualism and the development of executive function: The role of attention. *Child Development Perspectives*, 9(2), 117–121. <https://doi.org/10.1111/cdep.12116>
- Binder, J. R., Desai, R. H., Graves, W. W., & Conant, L. L. (2009). Where is the semantic system? A critical review and meta-analysis of 120 functional neuroimaging studies. *Cerebral Cortex*, 19(12), 2767–2796. <https://doi.org/10.1093/cercor/bhp055>
- Bishop, D. V. M., & Snowling, M. J. (2004). Developmental dyslexia and specific language impairment: Same or different? *Psychological Bulletin*, 130(6), 858–886. <https://doi.org/10.1037/0033-2909.130.6.858>.
- Bolger, D. J., Perfetti, C. A., & Schneider, W. (2005). Cross-cultural effect on the brain revisited: Universal structures plus writing system variation. *Human Brain Mapping*, 25(1), 92–104. <https://doi.org/10.1002/hbm.20124>
- Bransford, J. D., & Johnson, M. K. (1973). Consideration of some problems of comprehension. In W. G. Chase (Ed.), *Visual information processing* (pp. 383–438). New York: Academic Press.

- Branzi, F. M., Calabria, M., Gade, M., Fuentes, L. J., & Costa, A. (2018). On the bilingualism effect in task switching. *Bilingualism: Language and Cognition*, 21(1), 195–208. <https://doi.org/10.1017/S136672891600119X>
- Brookshire, C. E., Conway, T., Pompon, R. H., Oelke, M., & Kendall, D. L. (2014). Effects of Intensive Phonomotor Treatment on Reading in Eight Individuals With Aphasia and Phonological Alexia. *American Journal of Speech-Language Pathology*, 23(2). [https://doi.org/10.1044/2014\\_AJSLP-13-0083](https://doi.org/10.1044/2014_AJSLP-13-0083)
- Brookshire, C. E., Wilson, J. P., Nadeau, S. E., Gonzalez Rothi, L. J., & Kendall, D. L. (2014a). Frequency, nature, and predictors of alexia in a convenience sample of individuals with chronic aphasia. *Aphasiology*, 28(12), 1464–1480. <https://doi.org/10.1080/02687038.2014.945389>
- Brookshire, C. E., Wilson, J. P., Nadeau, S. E., Gonzalez Rothi, L. J., & Kendall, D. L. (2014b). Frequency, nature, and predictors of alexia in a convenience sample of individuals with chronic aphasia. *Aphasiology*, 28(12), 1464–1480. <https://doi.org/10.1080/02687038.2014.945389>
- Brookshire, R. H., & Nicholas, L. E. (1984). Comprehension of directly and indirectly stated main ideas and details in discourse by brain-damaged and non-brain-damaged listeners. *Brain and Language*, 21(1), 21–36. [https://doi.org/10.1016/0093-934X\(84\)90033-6](https://doi.org/10.1016/0093-934X(84)90033-6)
- Brunswick, N. (2010). *The functional neuroanatomy of reading* (P. Cornelissen, P. Hansen, M. Kringelback, & K. Pugh, Eds.). 80vq8. <https://doi.org/10.1093/acprof:oso/9780195300369.003.0004>
- Calabria, M., Costa, A., Green, D. W., & Abutalebi, J. (2018). Neural basis of bilingual language control. *Annals of the New York Academy of Sciences*, 1426(1), 221–235. <https://doi.org/10.1111/nyas.13879>
- Caplan, D., & Bub, D. (1990). Psycholinguistic assessment of aphasia. *Miniseminar presented at the annual convention of the American Speech and Hearing Association*, Seattle, WA.
- Cao, F. (2016). Neuroimaging studies of reading in bilinguals. *Bilingualism: Language and Cognition*, 19(4), 683–688. <https://doi.org/10.1017/S1366728915000656>
- Caplan, D., Waters, G., DeDe, G., Michaud, J., & Reddy, A. (2007). A study of syntactic processing in aphasia I: Behavioral (psycholinguistic) aspects. *Brain and Language*, 101(2), 103–150. <https://doi.org/10.1016/j.bandl.2006.11.003>
- Castles, A., & Coltheart, M. (1993). Varieties of developmental dyslexia. *Cognition*, 47(2), 149–180. [https://doi.org/10.1016/0010-0277\(93\)90003-E](https://doi.org/10.1016/0010-0277(93)90003-E)
- Chechlacz, M., Rotshtein, P., Bickerton, W.-L., Hansen, P. C., Deb, S., & Humphreys, G. W. (2010). Separating neural correlates of allocentric and egocentric neglect: Distinct cortical sites and common white matter disconnections. *Cognitive Neuropsychology*, 27(3), 277–303. <https://doi.org/10.1080/02643294.2010.519699>
- Chengappa, S., Bhat, S., & Padakannaya, P. (2004). Reading and writing skills in multilingual/multiliterate aphasics: Two case studies. *Reading and Writing*, 17(1), 121–135. <https://doi.org/10.1023/B:READ.0000013832.65765.d7>

- Cherney, R. (2004). Aphasia, Alexia, and Oral Reading. *Topics in Stroke Rehabilitation*, 11(1), 22–36. <https://doi.org/10.1310/VUPX-WDX7-J1EU-00TB>
- Chesneau, S., & Ska, B. (2015). Text comprehension in residual aphasia after basic-level linguistic recovery: A multiple case study. *Aphasiology*, 29(2), 237–256. <https://doi.org/10.1080/02687038.2014.971098>
- Chaitra, S., & Goswami, S.P. (2009). *Manual for Adult fluent aphasia* (Unpublished Master's Dissertation). University of Mysuru, Mysuru, India.
- Coltheart, M. (2000). Deep Dyslexia Is Right-Hemisphere Reading. *Brain and Language*, 71(2), 299–309. <https://doi.org/10.1006/brln.1999.2183>
- Coltheart, M. (2006). Acquired dyslexias and the computational modelling of reading. *COGNITIVE NEUROPSYCHOLOGY*.
- Coltheart, M., Curtis, B., Atkins, P., & Haller, M. (1993). *Models of reading aloud: Dual-route and parallel-distributed-processing approaches*. ProQuest. <https://www.proquest.com/openview/2bbfe7e31ebe73bc7d76e75c4611c690/1?pq-origsite=gscholar&cbl=60975>
- Coltheart, M., Patterson, K., & Marshall, J. C. (1980). Max Coltheart, Karalyn Patterson, John C. Marshall eds. 1980. Deep Dyslexia. *Linguisticae Investigationes*, 4(2), 418–420. <https://doi.org/10.1075/li.4.2.10ada>
- Coltheart, M., Rastle, K., Perry, C., Langdon, R., & Ziegler, J. (2001). DRC: A dual route cascaded model of visual word recognition and reading aloud. *Psychological Review*, 108(1), 204–256. <https://doi.org/10.1037/0033-295x.108.1.204>
- Coslett, B., & Turkeltaub, P. E. (2016). Acquired Dyslexia. In *Neurobiology of Language* (pp. 791–803). Academic Press. <https://doi.org/10.1016/B978-0-12-407794-2.00063-8>
- Crisp, J., & Lambon Ralph, M. A. (2006). Unlocking the Nature of the Phonological–Deep Dyslexia Continuum: The Keys to Reading Aloud Are in Phonology and Semantics. *Journal of Cognitive Neuroscience*, 18(3), 348–362. <https://doi.org/10.1162/jocn.2006.18.3.348>
- Crisp, J., Howard, D., & Ralph, M. A. L. (2011). More evidence for a continuum between phonological and deep dyslexia: Novel data from three measures of direct orthography-to-phonology translation. *Aphasiology*, 25(5), 615–641. <https://doi.org/10.1080/02687038.2010.541470>
- Dancey, C. P., & Reidy, J. (2004). *Statistics Without Maths for Psychology: Using SPSS for Windows*. Prentice Hall.
- DeDe, G. (2013). Reading and Listening in People With Aphasia: Effects of Syntactic Complexity. *American Journal of Speech-Language Pathology*, 22(4), 579–590. [https://doi.org/10.1044/1058-0360\(2013/12-0111\)](https://doi.org/10.1044/1058-0360(2013/12-0111))
- Dehaene, S., Cohen, L., Sigman, M., & Vinckier, F. (2005). The neural code for written words: A proposal. *Trends in Cognitive Sciences*, 9(7), 335–341. <https://doi.org/10.1016/j.tics.2005.05.004>

- Dejerine J. (1891). Sur un cas de cécité verbal avec agraphie, suivi d'autopsie. *Mémoires de La Société de Biologie.*, 3, 197–201.
- Dell, G. S., Schwartz, M. F., Martin, N., Saffran, E. M., & Gagnon, D. A. (1997). Lexical access in aphasic and nonaphasic speakers. *Psychological Review*, 104(4), 801–838. <https://doi.org/10.1037/0033-295X.104.4.801>
- De Letter, M., Cocquyt, E.-M., Cromheecke, O., Criel, Y., De Cock, E., De Herdt, V., Szmalec, A., & Duyck, W. (2021). The Protective Influence of Bilingualism on the Recovery of Phonological Input Processing in Aphasia After Stroke. *Frontiers in Psychology*, 11, 553970. <https://doi.org/10.3389/fpsyg.2020.553970>
- Dick, A. S., Garcia, N. L., Pruden, S. M., Thompson, W. K., Hawes, S. W., Sutherland, M. T., Riedel, M. C., Laird, A. R., & Gonzalez, R. (2019). No evidence for a bilingual executive function advantage in the ABCD study. *Nature Human Behaviour*, 3(7), 692–701. <https://doi.org/10.1038/s41562-019-0609-3>
- Diringer, D. (1968). *The alphabet: A key to the history of mankind : Diringer, David, 1900-1975 : Free Download, Borrow, and Streaming.* <https://archive.org/details/alphabetkeytohis0002diri>
- Dijkstra, T., & van Heuven, W. J. B. (2002). The Bilingual Interactive Activation (BIA) model: A retrospective and current issues. *Bilingualism: Language and Cognition*, 5(1), 1–17. <https://doi.org/10.1017/S1366728902003012&#8203>.
- Douglas, C. M., A. Peck, E., & G. Geoffrey, V. (2021). *Introduction to Linear Regression Analysis* (6th ed.). Wiley. <https://www.wiley.com/en-us/Introduction+to+Linear+Regression+Analysis%2C+6th+Edition-p-9781119578727>
- Druks, J., Aydelott, J., Genethliou, M., Jacobs, H., & Weekes, B. (2012). Progressive dyslexia: Evidence from Hungarian and English. *Behavioural Neurology*, 25(3), 185–191. <https://doi.org/10.1155/2012/702792>
- Dundas, E. M., Plaut, D. C., & Behrmann, M. (2014). An ERP investigation of the co-development of hemispheric lateralization of face and word recognition. *Neuropsychologia*, 61, 315–323. <https://doi.org/10.1016/j.neuropsychologia.2014.05.006>
- Ellis, H. D. (1993). *Perception and memory: The influence of prior knowledge*. Lawrence Erlbaum Associates.
- Eviatar, Z., Leikin, M., & Ibrahim, R. (1999). Phonological processing of second language phonemes: A selective deficit in a bilingual aphasic. *Language Learning*, 49(1), 121–141. <https://doi.org/10.1111/1467-9922.00072>
- Fridriksson, J., Richardson, J. D., Fillmore, P., & Cai, B. (2012). Left hemisphere plasticity and aphasia recovery. *NeuroImage*, 60(2), 854–863. <https://doi.org/10.1016/j.neuroimage.2011.12.057>
- Farah, M.J., Stowe, R.M., & Levinson, K.L. (1996). Phonological dyslexia: Loss of a reading-specific component of the cognitive architecture? *Cognitive Neuropsychology*, 13(6), 849-868. doi: 10.1080/026432996381836
- Faroqi-Shah Y., Waked A. N. (2010). Grammatical category dissociation in multilingual aphasia. *Cogn. Neuropsychol.* 27, 181–203. 10.1080/02643294.2010.509340

- Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). *Statistical power analyses using GPower 3.1: Tests for correlation and regression analyses\**. *Behavior Research Methods*, 41(4), 1149–1160. <https://doi.org/10.3758/BRM.41.4.1149>
- Field, A. (2005b). Non-parametric tests. In *Discovering statistics using SPSS* (3rd ed., pp. 550). SAGE Publications
- Forkel, S. J., Thiebaut de Schotten, M., Dell'Acqua, F., Kalra, L., Murphy, D. G., Williams, S. C., & Catani, M (2014). Anatomical predictors of aphasia recovery: A tractography study of bilateral perisylvian language networks. *Brain*, 137(7), 2027-2039.
- Friesen, D. C., & Frid, B. (2021). Predictors of Successful Reading Comprehension in Bilingual Adults: The Role of Reading Strategies and Language Proficiency. *Languages*, 6(1), Article 1. <https://doi.org/10.3390/languages6010018>
- Fridriksson, J., Richardson, J. D., Fillmore, P., & Cai, B. (2012). Left hemisphere plasticity and aphasia recovery. *NeuroImage*, 60(2), 854–863. <https://doi.org/10.1016/j.neuroimage.2011.12.057>
- Friedman, R. B. (1996). Recovery from Deep Alexia to Phonological Alexia: Points on a Continuum. *Brain and Language*, 52(1), 114–128. <https://doi.org/10.1006/brln.1996.0006>
- Friesen, D. C., & Frid, B. (2021a). Predictors of Successful Reading Comprehension in Bilingual Adults: The Role of Reading Strategies and Language Proficiency. *Languages*, 6(1), 18. <https://doi.org/10.3390/languages6010018>
- Friesen, D. C., & Frid, B. (2021b). Predictors of Successful Reading Comprehension in Bilingual Adults: The Role of Reading Strategies and Language Proficiency. *Languages*, 6(1), Article 1. <https://doi.org/10.3390/languages6010018>
- Frost, R., Katz, L., & Bentin, S. (1987). Strategies for visual word recognition and orthographical depth: A multilingual comparison. *Journal of Experimental Psychology: Human Perception and Performance*, 13, 104–115. <https://doi.org/10.1037/0096-1523.13.1.104>
- Funnell, E. (1996). Response biases in oral reading: An account of the co-occurrence of surface dyslexia and semantic dementia. *The Quarterly Journal of Experimental Psychology A: Human Experimental Psychology*, 49A(2), 417–446. <https://doi.org/10.1080/027249896392711>
- Garcia, J. Ricardo, and Kate Cain. 2014. Decoding and reading comprehension: A meta-analysis to identify which reader and assessment characteristics influence the strength of the relationship in English. *Review of Educational Research* 84: 74–111.
- Geva, E., & Wiener, J. (2014). *Psychological Assessment of Culturally and Linguistically Diverse Children and Adolescents: A Practitioner's Guide*. 978-0-8261-2349-7. <https://doi.org/10.1891/9780826123497>
- Goldrick, M., Runnqvist, E., & Costa, A. (2014). Language switching makes pronunciation less nativelike. *Psychological Science*, 25(4), 1057–1064. <https://doi.org/10.1177/0956797613520014>

- Gollan T. H., Kroll J. F. (2001). Lexical access in bilinguals, in *A Handbook of Cognitive Neuropsychology: What Deficits Reveal About the Human Mind*, ed. Rapp B. (New York, NY: Psychology Press; ), 321–345.
- Goodglass, H., & Kaplan, E. (1983). *BDAE- Boston Diagnostic Aphasia Examination*. <https://www.proedinc.com/Products/11850/bdae3-boston-diagnostic-aphasia-examinationthird-edition.aspx>
- Goodglass, H., Kaplan, E., & Weintraub, S. (1983). *Boston Naming Test*. Philadelphia: Lea & Febiger.
- Jackendoff, R. (1972). *Semantic interpretation in generative grammar*. Cambridge, MA: MIT Press.
- Goswami, S. P., Jayashree, C. S., Samasthitha, S., & Navitha, U. (2012). Field testing of manual for adult: Non-fluent aphasia therapy in Kannada (MANAT-K). *Journal of All India Institute of Speech and Hearing*, 31, 97–108
- Goral, M. (2019). *Acquired Reading Disorders in Bilingualism*. 592–607. <https://doi.org/10.1002/9781119387725.ch29>
- Graham, N. L., Hodges, J. R., & Patterson, K. (1994). Reading, spelling, and phonological processing in acquired dyslexia. *Cortex*, 30(3), 413–429.
- Green, D. W. (1986). *Control, activation, and resource: A framework and model for the control of speech in bilinguals*. In J. F. Kroll & A. M. B. de Groot (Eds.), *Handbook of bilingualism: Psycholinguistic approaches* (pp. 148–176). Oxford University Press.
- Green, D. W. (2009). The Neurocognition of Recovery Patterns in Bilingual Aphasics. In J. F. Kroll & A. M. B. D. Groot (Eds.), *Handbook of Bilingualism: Psycholinguistic Approaches* (p. 0). Oxford University Press. <https://doi.org/10.1093/oso/9780195151770.003.0029>
- Harm, M. W., & Seidenberg, M. S. (1999). Phonology, reading acquisition, and dyslexia: Insights from connectionist models. *Psychological Review*, 106(3), 491–528. <https://doi.org/10.1037/0033-295X.106.3.491>
- Hashimoto, K., & Uno, A. (2016). Cognitive neuropsychological analysis of differential reading and spelling disorder mechanisms in a patient with aphasia. *Neurocase*, 22(3), 294–299. <https://doi.org/10.1080/13554794.2015.1137950>
- Hegde, M. N. (2022). *A Coursebook on Aphasia and Other Neurogenic Language Disorders, Fifth Edition*. Plural Publishing.
- Heiss, W. D., Kessler, J., Thiel, A., Ghaemi, M., & Karbe, H. (1999). Differential capacity of left and right hemispheric areas for compensation of poststroke aphasia. *Annals of Neurology: Official Journal of the American Neurological Association and the Child Neurology Society*, 45(4), 430–438. [https://doi.org/10.1002/1531-8249\(199904\)45:4<430::AID-ANA3>3.0.CO;2-P](https://doi.org/10.1002/1531-8249(199904)45:4<430::AID-ANA3>3.0.CO;2-P)
- Henry, M. L., Beeson, P. M., Alexander, G. E., & Rapcsak, S. Z. (2012). Written Language Impairments in Primary Progressive Aphasia: A Reflection of Damage to Central Semantic

- and Phonological Processes. *Journal of Cognitive Neuroscience*, 24(2), 261–275. [https://doi.org/10.1162/jocn\\_a\\_00153](https://doi.org/10.1162/jocn_a_00153)
- Hernández, M., Costa, A., Fuentes, L. J., Vivas, A. B., & Sebastián-Gallés, N. (2011). The effects of bilingualism on toddlers' executive functioning. *Journal of Experimental Child Psychology*, 108(3), 567–579. <https://doi.org/10.1016/j.jecp.2010.10.009>
- Hickok, G., & Poeppel, D. (2007). The cortical organization of speech processing. *Nature Reviews Neuroscience*, 8(5), 393–402. <https://doi.org/10.1038/nrn2113>
- Hillis, A. E., & Caramazza, A. (1992). Not everything is the same: Some things are worse than others. A response to Tesak. *Brain and Language*, 43(3), 519–527. [https://doi.org/10.1016/0093-934x\(92\)90116-v](https://doi.org/10.1016/0093-934x(92)90116-v)
- Hillis, A. (2002). *New Techniques for Identifying the Neural Substrates of Language*. Psychology Press.
- Hillis, A. E., & Tippett, D. C. (2014). Phonological processing in individuals with aphasia. *Journal of Communication Disorders*, 47(1), 1–13. <https://doi.org/10.1016/j.jcomdis.2013.11.002>
- Howard, D., & Nickels, L. (2005). Separating input and output phonology: Semantic, phonological, and orthographic effects in short-term memory impairment. *Cognitive Neuropsychology*, 22(1), 42–77. <https://doi.org/10.1080/02643290342000582>
- Howard, D., & Gatehouse, C. (2006). Distinguishing semantic and lexical word retrieval deficits in people with aphasia. *Aphasiology*, 20(9–11), 921–950. <https://doi.org/10.1080/02687030600782679>.
- Ibrahim, R. (2009). Selective deficit of second language: A case study of a brain-damaged Arabic-Hebrew bilingual patient. *Behavioral and Brain Functions: BBF*, 5, 17. <https://doi.org/10.1186/1744-9081-5-17>
- IBM Corp. (2019). *IBM SPSS Statistics for Windows* (Version 26.0) [Computer software]. IBM Corp.
- Jefferies, E., & Lambon Ralph, M. A. (2006). Semantic memory and the brain: The unity and diversity of semantic cognition. *Current Opinion in Neurobiology*, 16(2), 177–183. <https://doi.org/10.1016/j.conb.2006.03.004>
- Jefferies, E., Patterson, K., & Lambon Ralph, M. A. (2007). The neural basis of semantic cognition: the interaction of the anterior temporal lobes and the semantic system. *NeuroImage*, 37(4), 1205–1214. <https://doi.org/10.1016/j.neuroimage.2007.06.014>.
- Johnson, R., & Raphail, A.-M. (2016). *Untangling letter confusability and word length effects in pure alexia: Cognitive Neuropsychology: Vol 32, No 7-8*. <https://doi.org/10.1080/02643294.2015.1113945>
- Karanth, P. (1980). Linguistic profile test in Kannada. *Journal of AIISH*, 5, 11–14.
- Karanth, P. (1981). Pure alexia in a Kannada-English bilingual. *Cortex; a Journal Devoted to the Study of the Nervous System and Behavior*, 17(2), 187–198. [https://doi.org/10.1016/s0010-9452\(81\)80040-8](https://doi.org/10.1016/s0010-9452(81)80040-8)

- Karanth, P. (2002). The search for deep dyslexia in syllabic writing systems. *Journal of Neurolinguistics*, 15(2), 143–155. [https://doi.org/10.1016/S0911-6044\(00\)00022-1](https://doi.org/10.1016/S0911-6044(00)00022-1)
- Karanth, P. (2003). *Cross-Linguistic Study of Acquired Reading Disorders* (Vol. 24). Kluwer academy. [https://www.researchgate.net/publication/313999805\\_Cross\\_Linguistic\\_Study\\_of\\_Acquired\\_Reading\\_Disorders](https://www.researchgate.net/publication/313999805_Cross_Linguistic_Study_of_Acquired_Reading_Disorders)
- Katz, L., & Frost, R. (1992). The reading process is different for different orthographies: The orthographic depth hypothesis. In *Orthography, phonology, morphology, and meaning* (pp. 67–84). North-Holland. [https://doi.org/10.1016/S0166-4115\(08\)62789-2](https://doi.org/10.1016/S0166-4115(08)62789-2)
- Kelly, K.-P., Wallace, S. E., Hux, K., Brown, J., & Long, C. (2015). Reading experiences and use of supports by people with chronic aphasia. *Aphasiology*, 29(12), 1448–1472. <https://doi.org/10.1080/02687038.2015.1041093>
- Kendall, D. L., Brookshire, C., Oelke, M., & Nadeau, S. (2013). *Phonomotor rehabilitation of anomia in aphasia* [Clinical Aphasiology Paper]. <http://aphasiology.pitt.edu/2487/>
- Kendall, D. L., Conway, T., Rosenbek, J., & Gonzalez-Rothi, L. (2003). Phonological rehabilitation of acquired phonologic alexia. *Aphasiology*, 17(11), 1073–1095. <https://doi.org/10.1080/02687030344000355>
- Kertesz, A. (1982). *Western Aphasia Battery*. New York: Grune & Stratton.
- 28(6), 766–769. <https://doi.org/10.1080/02687038.2014.894959>
- Kiran, S., & Thompson, C. K. (2019). Neuroplasticity of Language Networks in Aphasia: Advances, Updates, and Future Challenges. *Frontiers in Neurology*, 10, 295. <https://doi.org/10.3389/fneur.2019.00295>
- Knollman-Porter, K., Wallace, S. E., Hux, K., Brown, J., & Long, C. (2015). Reading experiences and use of supports by people with chronic aphasia. *Taylor & Francis*, 29(12), 1448–1472. <https://doi.org/10.1080/02687038.2015.1041093>
- Kroll, J. F., & Stewart, E. (1994). Category interference in translation and picture naming: Evidence for asymmetric connections between bilingual memory representations. *Journal of Memory and Language*, 33(2), 149–174. <https://doi.org/10.1006/jmla.1994.1008>
- Kroll, J. F., Dussias, P. E., Bice, K., & Perrotti, L. (2015). Bilingualism, mind, and brain. *Annual Review of Linguistics*, 1, 377–394. <https://doi.org/10.1146/annurev-linguist-030514-124937>
- Kruthi, H. R., & Goswami, S. P. (2011). *Manual for reading, writing and arithmetic for persons with aphasia in Kannada* (Unpublished Master’s Dissertation). All India Institute of Speech and Hearing, Mysuru.
- Krueger, R. A., & Casey, M. A. (2015). *Focus groups: A practical guide for applied research* (5th ed.). SAGE Publications.
- Keulen, S. (2014). Alexia: Diagnosis, treatment and theory by Leff, A., & Starrfelt, R. *Aphasiology*,
- Kumar, U. (2014). Effect of orthography over neural regions in bilinguals: A view from neuroimaging. *Neuroscience Letters*, 580, 94–99. <https://doi.org/10.1016/j.neulet.2014.07.053>

- Kumar, B. R., Dudala, S. R., & Rao, A. R. (2013). Kuppaswamy's socio-economic status scale—a revision of economic parameter for 2012. *International Journal of Research & Development of Health*, 1(1), 2-4.
- Kumar, U. (2014). Effect of orthography over neural regions in bilinguals: A view from neuroimaging. *Neuroscience Letters*, 580, 94–99. <https://doi.org/10.1016/j.neulet.2014.07.053>
- Kümmerer, D., Hartwigsen, G., Kellmeyer, P., Glauche, V., Mader, I., Klöppel, S., Suchan, J., Karnath, H.-O., Weiller, C., & Saur, D. (2013). Damage to ventral and dorsal language pathways in acute aphasia. *Brain: A Journal of Neurology*, 136(Pt 2), 619–629. <https://doi.org/10.1093/brain/aws354>
- Kuzmina, E., Goral, M., Norvik, M., & Weekes, B. S. (2019). What Influences Language Impairment in Bilingual Aphasia? A Meta-Analytic Review. *Frontiers in Psychology*, 10. <https://doi.org/10.3389/fpsyg.2019.00445>
- Laganaro, M., & Overton Venet, M. (2001). Acquired alexia in multilingual aphasia and computer-assisted treatment in both languages: Issues of generalisation and transfer. *Folia Phoniatrica et Logopaedica: Official Organ of the International Association of Logopedics and Phoniatrics (IALP)*, 53(3), 135–144. <https://doi.org/10.1159/000052668>
- Lahiri, D., Ardila, A., Dubey, S., Mukherjee, A., Chatterjee, K., & Ray, B. K. (2021). Effect of bilingualism on aphasia recovery. *Aphasiology*, 35(8), 1103–1124. <https://doi.org/10.1080/02687038.2020.1812032>
- Lambon Ralph, M. A., & Patterson, K. (2005). The neural and computational bases of semantic cognition. *Nature Reviews Neuroscience*, 6(6), 341–350. <https://doi.org/10.1038/nrn1668>.
- Lehtonen, M., Soveri, A., Laine, A., Järvenpää, J., de Bruin, A., & Antfolk, J. (2018). Is bilingualism associated with enhanced executive functioning in adults? A meta-analytic review. *Psychological Bulletin*, 144(4), 394–425. <https://doi.org/10.1037/bul0000142>
- Laerd Statistics (2015). Principal components analysis (PCA) and multiple regression using SPSS Statistics. Statistical tutorials and software guides. Retrieved from <https://statistics.laerd.com/>
- Landerl, K., Castles, A., & Parrila, R. (2022). Cognitive Precursors of Reading: A Cross-Linguistic Perspective. *Scientific Studies of Reading*, 26(2), 111–124. <https://doi.org/10.1080/10888438.2021.1983820>
- Landerl, K., Freudenthaler, H. H., Heene, M., De Jong, P. F., Desrochers, A., Manolitsis, G., Parrila, R., & Georgiou, G. K. (2019). Phonological Awareness and Rapid Automated Naming as Longitudinal Predictors of Reading in Five Alphabetic Orthographies with Varying Degrees of Consistency. *Scientific Studies of Reading*, 23(3), 220–234. <https://doi.org/10.1080/10888438.2018.1510936>
- Landi, Nicole. 2010. An examination of the relationship between reading comprehension, higher-level and lower-level reading sub-skills in adults. *Reading and Writing* 23: 701–17.
- Liu, H., & Cao, F. (2016). L1 and L2 processing in the bilingual brain: A meta-analysis of neuroimaging studies. *Brain and Language*, 159, 60–73. <https://doi.org/10.1016/j.bandl.2016.05.013>

- Lyman, R. S., Kwan, T. S., & CHAO, W. H. (1938). Left occipito-parietal brain tumor. With observations on alexia and agraphia in chinese and in english. *Chinese Medical Journal*, 54(06), 491–516. <https://doi.org/10.5555/cmj.0366-6999.54.06.p491.01>
- Madden, E. B. (2016, July 14). *The relationship between non-orthographic language abilities and reading performance: An exploration of the primary systems hypothesis in chronic aphasia*. <https://www.semanticscholar.org/paper/The-relationship-between-non-orthographic-language-Madden/6c993a06327c5b0cfe28844dabcf838c0ab82509>
- Madden, E. B., Conway, T., Henry, M. L., Spencer, K. A., Yorkston, K. M., & Kendall, D. L. (2018). The Relationship Between Non-Orthographic Language Abilities and Reading Performance in Chronic Aphasia: An Exploration of the Primary Systems Hypothesis. *Journal of Speech, Language, and Hearing Research*, 61(12), 3038–3054. [https://doi.org/10.1044/2018\\_JSLHR-L-18-0058](https://doi.org/10.1044/2018_JSLHR-L-18-0058)
- Marshall, J. C., Newcombe, F., & Patterson, K. E. (1987). Developmental analogues to acquired phonological dyslexia. In J. C. Marshall, K. E. Patterson, & M. Coltheart (Eds.), *Surface dyslexia* (pp. 143–158). Routledge & Kegan Paul.
- Marshall, J. C., & Newcombe, F. (1966). Syntactic and semantic errors in paralexia. *Neuropsychologia*, 4(2), 169–176. [https://doi.org/10.1016/0028-3932\(66\)90045-5](https://doi.org/10.1016/0028-3932(66)90045-5)
- Marshall, J. C., & Newcombe, F. (1973a). Patterns of paralexia: A psycholinguistic approach. *Journal of Psycholinguistic Research*, 2(3), 175–199. <https://doi.org/10.1007/BF01067101>
- Marshall, J., Patterson, K., & Coltheart, M. (1987). *Surface Dyslexia: Neuropsychological and Cognitive Studies of Phonological Reading*.
- Masterson, J., Coltheart, M., & Meara, P. (1985). Surface dyslexia in a language without irregularly spelled words. In K. E. Patterson, J. C. Marshall, & M. Coltheart (Eds.), *Surface dyslexia* (pp. 215–223). Taylor and Francis. <http://www.scopus.com/inward/record.url?scp=85066274292&partnerID=8YFLogxK>
- McCarthy, R. A., & Warrington, E. K. (1986). Phonological reading: Phenomena and paradoxes. *Cortex: A Journal Devoted to the Study of the Nervous System and Behavior*, 22(3), 359–380. [https://doi.org/10.1016/S0010-9452\(86\)80002-8](https://doi.org/10.1016/S0010-9452(86)80002-8)
- McClung, N. A., & Pearson, P. D. (2019). Reading comprehension across languages: Seven European orthographies and two international literacy assessments. *Written Language & Literacy*, 22(1), 33–66. <https://doi.org/10.1075/wll.00019.mcc>
- McNeil, J. E., & Warrington, E. K. (1993). Prosopagnosia: A Face-Specific Disorder. *The Quarterly Journal of Experimental Psychology Section A*, 46(1), 1–10. <https://doi.org/10.1080/14640749308401064>
- Meguro, K., Constans, J.-M., Shimada, M., Yamaguchi, S., Ishizaki, J., Ishii, H., Yamadori, A., & Sekita, Y. (2003). Corpus Callosum Atrophy, White Matter Lesions, and Frontal Executive Dysfunction in Normal Aging and Alzheimer’s Disease. A Community-Based Study: The Tajiri Project. *International Psychogeriatrics*, 15(1), 9–25. <https://doi.org/10.1017/S104161020300872X>

- Meier, E. L., Lo, M., & Kiran, S. (2016). Understanding semantic and phonological processing deficits in adults with aphasia: Effects of category and typicality. *Aphasiology*, 30(6), 719–749. <https://doi.org/10.1080/02687038.2015.1081137>
- Melby-Lervåg, Monica, and Arne Lervåg. 2014. Reading comprehension and its underlying components in second language learners: A meta-analysis of studies comparing first- and second-language learners. *Psychological Bulletin* 140: 409–33.
- Mendez, M. F. (2019). Bilingualism and Dementia: Cognitive Reserve to Linguistic Competency. *Journal of Alzheimer's Disease: JAD*, 71(2), 377–388. <https://doi.org/10.3233/JAD-190397>
- Meteyard, L., Bruce, C., Edmundson, A., & Oakhill, J. (2015). Profiling text comprehension impairments in aphasia. *Aphasiology*, 29(1), 1–28. <https://doi.org/10.1080/02687038.2014.955388>
- Miozzo M., Costa A., Hernández M., Rapp B. (2010). Lexical processing in the bilingual brain: evidence from grammatical/morphological deficits. *Aphasiology* 24, 262–287.
- Mitchum, C. C., & Berndt, R. S. (1991). Diagnosis and treatment of the non-lexical route in acquired dyslexia: An illustration of the cognitive neuropsychological approach. *Journal of Neurolinguistics*, 6(2), 103–137. [https://doi.org/10.1016/0911-6044\(91\)90003-2](https://doi.org/10.1016/0911-6044(91)90003-2)
- Nadeau S. E. (2019). Bilingual aphasia: explanations in population encoding. *J. Neurolingu.* 49, 117–143. [10.1016/j.jneuroling.2018.10.002](https://doi.org/10.1016/j.jneuroling.2018.10.002)
- Nag, S., & Snowling, M. J. (2011). Cognitive Profiles of Poor Readers of Kannada. *Reading and Writing: An Interdisciplinary Journal*, 24(6), 657–676. <https://doi.org/10.1007/s11145-010-9258-7>
- Nasreddine, Z. S., Phillips, N. A., Bédirian, V., Charbonneau, S., Whitehead, V., Collin, I., Cummings, J. L., & Chertkow, H. (2005). *The Montreal Cognitive Assessment, MoCA: A brief screening tool for mild cognitive impairment*. *Journal of the American Geriatrics Society*, 53(4), 695–699. <https://doi.org/10.1111/j.1532-5415.2005.53221.x>
- Norouzian, R., & Plonsky, L. (2018). Eta- and partial eta-squared in L2 research: A cautionary review and guide to more appropriate usage. *Studies in Second Language Acquisition*, 40(4), 721–741. <https://doi.org/10.1177/0267658316684904>
- Newcombe, F., & Marshall, J. C. (1985). Reading and writing by letter sounds. In K. E. Patterson, J. C. Marshall, & M. Coltheart (Eds.), *Surface dyslexia* (pp. 35–51). Lawrence Erlbaum.
- Ohno, T., Takeda, K., Kato, S., & Hirai, S. (2002). Pure alexia in a Japanese-English bilingual: Dissociation between the two languages. *Journal of Neurology*, 249(1), 105–107. <https://doi.org/10.1007/PL00007837>
- Paradis, M. (2009). Declarative and Procedural Determinants of Second Languages. *ResearchGate*. <https://doi.org/10.1075/sibil.40>
- Patterson, K. E. (1981). Neuropsychological approaches to the study of reading. *British Journal of Psychology*, 72(2), 151–174. <https://doi.org/10.1111/j.2044-8295.1981.tb02174.x>

- Patterson, K. E., & Marcel, A. J. (1992). Reading isolated words: No evidence for automatic incorporation of the phonetic code. *Psychological Research*, 54, 91–102. <https://doi.org/10.1007/bf00937137>.
- Patterson, K., & Behrmann, M. (1997). Frequency and consistency effects in a pure surface dyslexic patient. *Journal of Experimental Psychology: Human Perception and Performance*, 23(4), 1217–1231. <https://doi.org/10.1037/0096-1523.23.4.1217>
- Patterson, K., & Ralph, M. A. (1999). Selective disorders of reading? *Current Opinion in Neurobiology*, 9(2), 235–239. [https://doi.org/10.1016/s0959-4388\(99\)80033-6](https://doi.org/10.1016/s0959-4388(99)80033-6)
- Patterson, K., & Marcel, A. (1992). Phonological ALEXIA or PHONOLOGICAL alexia?.
- Patterson, S. L., Abel, T., Deuel, T. A., Martin, K. C., Rose, J. C., & Kandel, E. R. (1996). Recombinant BDNF rescues deficits in basal synaptic transmission and hippocampal LTP in BDNF knockout mice. *Neuron*, 16(6), 1137–1145.
- Paulesu, E., Démonet, J. F., Fazio, F., McCrory, E., Chanoine, V., Brunswick, N., Cappa, S. F., Cossu, G., Habib, M., Frith, C. D., & Frith, U. (2001). Dyslexia: Cultural diversity and biological unity. *Science (New York, N.Y.)*, 291(5511), 2165–2167. <https://doi.org/10.1126/science.1057179>
- Peach, R. (1988). Comprehension of sentence structure in anomic and conduction aphasia\*1. *Brain and Language*, 35(1), 119–137. [https://doi.org/10.1016/0093-934X\(88\)90104-6](https://doi.org/10.1016/0093-934X(88)90104-6)
- Pearson, K. (1896). Mathematical contributions to the theory of evolution.—III. Regression, heredity, and panmixia. *University College, London*, 254–317. <https://doi.org/10.1098/rsta.1896.0007>
- Perfetti, C., & Stafura, J. (2014). Word knowledge in a theory of reading comprehension. *Scientific Studies of Reading*, 18(1), 22–37. <https://doi.org/10.1080/10888438.2013.827687>
- Pettit, J. M., & Noll, J. D. (1979). Cerebral dominance in aphasia recovery. *Brain and Language*, 7(2), 191–200. [https://doi.org/10.1016/0093-934X\(79\)90016-6](https://doi.org/10.1016/0093-934X(79)90016-6).
- Perfetti, C. A., Liu, Y., Fiez, J., Nelson, J., Bolger, D. J., & Tan, L.-H. (2007). Reading in two writing systems: Accommodation and assimilation of the brain's reading network. *Bilingualism: Language and Cognition*, 10(2), 131–146. <https://doi.org/10.1017/S1366728907002891>
- Plaut, D. C. (1996). Relearning after damage in connectionist networks: Toward a theory of rehabilitation. *Brain and Language*, 52(1), 25–82. <https://doi.org/10.1006/brln.1996.0004>
- Plaut, D. C. (2003). Interpreting Double Dissociations in Connectionist Networks. *Cortex*, 39(1), 138–141. [https://doi.org/10.1016/S0010-9452\(08\)70085-6](https://doi.org/10.1016/S0010-9452(08)70085-6)
- Porch. (1967). *Porch Index of Communicative Ability; an assessment test for the measurement of aphasic behaviour in adults* | Science Museum Group Collection. <https://collection.sciencemuseumgroup.org.uk/objects/co537251/porch-index-of-communicative-ability-an-assessment-test-for-the-measurement-of-aphasic-behaviour-in-adults>

- Prabhu, S., Venkatasubban, V., Bhat, J. S., & Somashekara, H. S. (2024). Phonological Awareness and Word Decoding Skills in the Early Readers of Kannada. *Indian Journal of Psychological Medicine*, 02537176241252704. <https://doi.org/10.1177/02537176241252704>
- Ptak, R., Pietro, M. D., & Pignat, J.-M. (2016). The role of parieto-temporal connectivity in pure neglect dyslexia. *Brain Research*, 1648, 144–151. <https://doi.org/10.1016/j.brainres.2016.07.033>
- Purdy, M., Coppens, P., Madden, E. B., Mozeiko, J., Patterson, J., Wallace, S. E., & Freed, D. (2019). Reading comprehension treatment in aphasia: A systematic review. *Aphasiology*, 33(6), 629–651. <https://doi.org/10.1080/02687038.2018.1482405>
- Puttana, D., & Goswami, S. P. (2024). (PDF) Effect of semantic cueing for verbs and its thematic role approach on priming of verbs and its thematic roles in persons with aphasia. *ResearchGate*. [https://doi.org/10.4103/jisha.JISHA\\_6\\_20](https://doi.org/10.4103/jisha.JISHA_6_20)
- Rack, J. P. (1994). Dyslexia: The Phonological Deficit Hypothesis. In *Dyslexia In Children*. Routledge.
- Raman, I., & Weekes, B. S. (2005). Acquired dyslexia in a turkish-english speaker. *Annals of Dyslexia*, 55(1), 79–104. <https://doi.org/10.1007/s11881-005-0005-8>
- Ralph, M. A. L., Jefferies, E., Patterson, K., & Rogers, T. T. (2017). The neural and computational bases of semantic cognition. *Nature Reviews. Neuroscience*, 18(1), 42–55. <https://doi.org/10.1038/nrn.2016.150>
- Ralph, M. A. L., Moriarty, L., & Sage, K. (2002). Anomia is simply a reflection of semantic and phonological impairments: Evidence from a case-series study. *Aphasiology*, 16(1–2), 56–82. <https://doi.org/10.1080/02687040143000448>
- Rapcsak, S. Z. (2010). *Phonological Dyslexia and Dysgraphia: Cognitive Mechanisms and Neural Substrates*.
- Ratnavalli, E., Geetha Murthy, G., Nagaraja, D., Veerendrakumar, M., Jayaram, M., & Jayakumar, P. N. (2000). Alexia in Indian bilinguals. *Journal of Neurolinguistics*, 13(1), 37–46. [https://doi.org/10.1016/S0911-6044\(99\)00010-X](https://doi.org/10.1016/S0911-6044(99)00010-X)
- Ravi, S., & Chengappa, S. (2014). Reading Comprehension of Sentences in Kannada-English Bilingual Individuals with Aphasia. *International Journal of Medical and Health Sciences*. <https://www.semanticscholar.org/paper/Reading-Comprehension-of-Sentences-in-Bilingual-Ravi-Chengappa/c865c64b805ac9288a1c56c9cb7b78fe527b1a73>
- Rau, A. K., Moll, K., Moeller, K., Huber, S., Snowling, M. J., & Landerl, K. (2016). Same same, but different: Word and sentence reading in German and English. *Scientific Studies of Reading*, 20(3), 203–219. <https://doi.org/10.1080/10888438.2015.1136913>.
- Reis, A., Araújo, S., Morais, I. S., & Faísca, L. (2020). Reading and reading-related skills in adults with dyslexia from different orthographic systems: A review and meta-analysis. *Annals of Dyslexia*, 70(3), 339–368. <https://doi.org/10.1007/s11881-020-00205-x>
- Riley, E. A., & Kendall, D. L. (2013). The Acquired Disorders of Reading. In *Aphasia and Related Neurogenic Communication Disorders* (1st ed., pp. 157–172). Jones & Barlett Learning.

[https://www.researchgate.net/publication/263033989\\_The\\_Acquired\\_Disorders\\_of\\_Reading](https://www.researchgate.net/publication/263033989_The_Acquired_Disorders_of_Reading)

- Ripamonti, E., Aggujaro, S., Molteni, F., Zonca, G., Frustaci, M., & Luzzatti, C. (2014). The anatomical foundations of acquired reading disorders: A neuropsychological verification of the dual-route model of reading. *Brain and Language*, *134*, 44–67. <https://doi.org/10.1016/j.bandl.2014.04.001>
- Robson, H., Griffiths, T. D., Grube, M., & Woollams, A. M. (2019). Auditory, phonological, and semantic factors in the recovery from Wernicke’s aphasia poststroke: Predictive value and implications for rehabilitation. *Neurorehabilitation and Neural Repair*, *33*(10), 800–812. <https://doi.org/10.1177/1545968319868709>
- Rogers, T. T., Chen, L., & Lambon Ralph, M. A. (2017). A unified model of human semantic knowledge and its disorders. *Nature Human Behaviour*, *1*, 0039. <https://doi.org/10.1038/s41562-016-0039-8>
- Roth, C. (2011a). Boston Diagnostic Aphasia Examination. In J. S. Kreutzer, J. DeLuca, & B. Caplan (Eds.), *Encyclopedia of Clinical Neuropsychology* (pp. 428–430). Springer. [https://doi.org/10.1007/978-0-387-79948-3\\_868](https://doi.org/10.1007/978-0-387-79948-3_868)
- Rosselli, M., Ardila, A., Lalwani, L. N., & Vélez-Urbe, I. (2016). The effect of language proficiency on executive functions in balanced and unbalanced Spanish–English bilinguals. *Bilingualism: Language and Cognition*, *19*(3), 489–503. <https://doi.org/10.1017/S1366728915000309>
- Roux, F.-E., Lubrano, V., Lauwers-Cances, V., Trémoulet, M., Mascott, C. R., & Démonet, J.-F. (2004). Intra-operative mapping of cortical areas involved in reading in mono- and bilingual patients. *Brain: A Journal of Neurology*, *127*(Pt 8), 1796–1810. <https://doi.org/10.1093/brain/awh204>
- Rylková, M., & Kytarová, L. (2022). *The effect of bilingualism on the severity of aphasia in people after stroke in the acute stage*. *11*(21).
- Saffran, E., Bogyo, L. C., Schwartz, M. F., & Marin, O. S. M. (1980). Does deep dyslexia reflect right-hemisphere reading. *Deep Dyslexia*, 381–406.
- Saffran, E., & Coslett, B. (1998). Implicit vs. Letter-by-letter reading in pure alexia: a tale of two systems: *Cognitive Neuropsychology*: Vol 15, No 1-2. *Taylor & Francis*, *15*(1–2), 141–165.
- Saur, D., Hartwigsen, G., Preis, S., Baumgaertner, A., & Weiller, C. (2008). Ventrolateral and dorsolateral pathways for language. *Proceedings of the National Academy of Sciences*, *105*(46), 18035–18040. <https://doi.org/10.1073/pnas.0805238105>
- Sasanuma, S. (1993). Aphasia treatment in Japan. In *Aphasia treatment: World perspectives* (pp. 175-198). Boston, MA: Springer US.
- Sasanuma, S. (1995). Patterns of language deficits in two Korean-Japanese bilingual aphasic patients—a clinical report. *Aspects of Bilingual Aphasia*, 111-122.

- Schattka, K. (2010). Eye movement correlates of acquired central dyslexia. *Neuropsychologia*. [https://www.academia.edu/2671242/Eye\\_movement\\_correlates\\_of\\_acquired\\_central\\_dyslexia](https://www.academia.edu/2671242/Eye_movement_correlates_of_acquired_central_dyslexia)
- Schmalz, X., Beyersmann, E., Cavalli, E., & Marinus, E. (2016). Unpredictability and complexity of print-to-speech correspondences increase reliance on lexical processes: More evidence for the Orthographic Depth Hypothesis. *Journal of Cognitive Psychology*, 28(6), 658–672. <https://doi.org/10.1080/20445911.2016.1182172>.
- Schwartz, M. F., Saffran, E. M., & Marin, O. S. (1987). Agrammatic comprehension of relative clauses. *Brain and Language*, 32(1), 87–106. [https://doi.org/10.1016/0093-934X\(87\)90108-6](https://doi.org/10.1016/0093-934X(87)90108-6)
- Seidenberg, M. S., & McClelland, J. L. (1989). A distributed, developmental model of word recognition and naming. *Psychological Review*, 96(4), 523–568. <https://doi.org/10.1037/0033-295x.96.4.523>
- Senaha, M. L. H., & de Mattos Pimenta Parente, M. A. (2012). Acquired dyslexia in three writing systems: Study of a Portuguese-Japanese bilingual aphasic patient. *Behavioural Neurology*, 25(3), 255–272. <https://doi.org/10.1155/2012/854519>
- Seymour, P. H. K., Aro, M., & Erskine, J. M. (2003). Foundation literacy acquisition in European orthographies. *British Journal of Psychology (London, England: 1953)*, 94(Pt 2), 143–174. <https://doi.org/10.1348/000712603321661859>
- Siddi, D., & Hema, N. (2021). *Manual for syntax processing activities for Persons with Aphasia* (Unpublished Master's Dissertation). All India Institute of Speech and Hearing, Mysuru.
- Shankweiler, D., & Crain, S. (1986). Language mechanisms and reading disorder: A modular approach. *Cognition*, 24(1–2), 139–168. [https://doi.org/10.1016/0010-0277\(86\)90008-9](https://doi.org/10.1016/0010-0277(86)90008-9).
- Shallice, T. (1995). Single and multiple component central dyslexic syndromes. *Neurocase*, 1(3), 251–257. <https://doi.org/10.1093/neucas/1.3.251-1>
- Shallice, T., Warrington, E. K., & McCarthy, R. (1983). *Reading without Semantics*. <https://journals.sagepub.com/doi/10.1080/14640748308402120>
- Shanbal, J. (2009). Subtyping of Children with Developmental Dyslexia: Implications from Dual Route Cascaded Model in the Indian Context. *AIISH*, 133.
- Sheppard, S. M., & Sebastian, R. (2021). Diagnosing and managing post-stroke aphasia. *Expert Review of Neurotherapeutics*, 21(2), 221–234. <https://doi.org/10.1080/14737175.2020.1855976>
- Shyamala, K.C., Vijayashree, S., & RaviKumar. (2008). *Standardization of Western Aphasic Battery- Kannada (WAB-K)*. All India Institute Research Fund (ARF) project, AIISH, Mysuru, India.
- Silkes, J. P., Zimmerman, R. M., Greenspan, W., Reinert, L., Kendall, D., & Martin, N. (2021). Identifying verbal short-term memory and working memory impairments in individuals with latent aphasia. *American Journal of Speech-Language Pathology*, 30(1S), 391–406.

- Smith, K. G., & Lins, J. S. (2024). Oral Reading Fluency and Comprehension in Persons with Alexia and Aphasia. *Aphasiology*.  
<https://www.tandfonline.com/doi/abs/10.1080/02687038.2024.2314323>
- Smith, K. G., & Ryan, A. E. (2020). Relationship Between Single Word Reading, Connected Text Reading, and Reading Comprehension in Persons With Aphasia. *American Journal of Speech-Language Pathology*, 29(4), 2039–2048. [https://doi.org/10.1044/2020\\_AJSLP-19-00135](https://doi.org/10.1044/2020_AJSLP-19-00135)
- Spreen, O. (1977). Neurosensory Center Comprehensive Examination for Aphasia. *Neuropsychological Laboratory*.  
[https://cir.nii.ac.jp/crid/1573387449448531328#citations\\_container](https://cir.nii.ac.jp/crid/1573387449448531328#citations_container)
- Starrfelt, R., & Woodhead, Z. (2021). Reading and alexia. In *Handbook of Clinical Neurology* (Vol. 178, pp. 213–232). Elsevier. <https://doi.org/10.1016/B978-0-12-821377-3.00010-6>
- Suárez-Coalla, P., & Cuetos, F. (2015). Reading difficulties in Spanish adults with dyslexia. *Annals of Dyslexia*, 65(1), 33–51. <https://doi.org/10.1007/s11881-015-0101-3>
- Sunil, R., & Shymala, C. (2009). *Dementia Assessment Battery*. Unpublished Master's Dissertation. All India Institute of Speech and Hearing, Mysuru.
- Swamy, A., & Goswami, S. P. (2024). Appraising Linguistic and Reading Impairments in Kannada-Speaking Persons With Central Alexia. *Cureus*, 16(6), e63437. <https://doi.org/10.7759/cureus.63437>
- Tan, L. H., Spinks, J. A., Feng, C.-M., Siok, W. T., Perfetti, C. A., Xiong, J., Fox, P. T., & Gao, J.-H. (2003). Neural systems of second language reading are shaped by native language. *Human Brain Mapping*, 18(3), 158–166. <https://doi.org/10.1002/hbm.10089>
- Thiel, A., Black, S. E., Rochon, E. A., Lanthier, S., Hartmann, A., Chen, J. L., Mochizuki, G., Zumbansen, A., Heiss, W.-D., & NORTHSTAR study group. (2015). Non-invasive repeated therapeutic stimulation for aphasia recovery: A multilingual, multicenter aphasia trial. *Journal of Stroke and Cerebrovascular Diseases: The Official Journal of National Stroke Association*, 24(4), 751–758. <https://doi.org/10.1016/j.jstrokecerebrovasdis.2014.10.021>
- Thompson, C. K., Choy, J., Holland, A., & Cole, R. (2010). Sentactics®: Computer-automated treatment of underlying forms. *Aphasiology*, 24(10), 1242–1266. <https://doi.org/10.1080/02687030903474255>
- Tiwari, S., Karanth, P., & Rajashekar, B. (2017). Specific language impairment in a morphologically complex agglutinative Indian language-Kannada. *Journal of Communication Disorders*, 66, 22–39. <https://doi.org/10.1016/j.jcomdis.2017.03.002>
- Travis, C. E., Torres Cacoullos, R., & Kidd, E. (2015). Cross-language priming: A view from bilingual speech. *Bilingualism: Language and Cognition*, 20(2), 283–298. <https://doi.org/10.1017/S1366728915000127>
- Tochadse, M., Halai, A. D., Lambon Ralph, M. A., & Abel, S. (2018). Unification of behavioural, computational and neural accounts of word production errors in post-stroke aphasia. *NeuroImage. Clinical*, 18, 952–962. <https://doi.org/10.1016/j.nicl.2018.03.031>

- Tschirren, M., Laganaro, M., Michel, P., Martory, M.-D., Di Pietro, M., Abutalebi, J., & Annoni, J.-M. (2011). Language and syntactic impairment following stroke in late bilingual aphasics. *Brain and Language*, *119*(3), 238–242. <https://doi.org/10.1016/j.bandl.2011.05.008>
- Turkeltaub, P. E., Coslett, H. B., Thomas, A. L., Faseyitan, O., Benson, J., Norise, C., & Hamilton, R. H. (2012). The right hemisphere is not unitary in its role in aphasia recovery. *Cortex*, *48*(9), 1179–1186. <https://doi.org/10.1016/j.cortex.2011.06.010>
- Ueno, T., Saito, S., & Lambon Ralph, M. A. (2014). *The neural mechanisms underlying the phonological processing involved in reading aloud*. *NeuroImage*, *98*, 252–261. <https://doi.org/10.1016/j.neuroimage.2014.04.019>.
- Vaessen, A., Bertrand, D., Tóth, D., Csépe, V., Fáisca, L., Reis, A., & Blomert, L. (2010). Cognitive development of fluent word reading does not qualitatively differ between transparent and opaque orthographies. *Journal of Educational Psychology*, *102*(4), 827–842. <https://doi.org/10.1037/a0019465>
- Van Den Boer, M., Bazen, L., & De Bree, E. (2022). The Same yet Different: Oral and Silent Reading in Children and Adolescents with Dyslexia. *Journal of Psycholinguistic Research*, *51*(4), 803–817. <https://doi.org/10.1007/s10936-022-09856-w>
- Venugopal, M.B., & Goswami, S.P. (2009). *Manual for Adult fluent aphasia* (Unpublished Masters Dissertation ). University of Mysuru, Mysuru, India.
- Wagner, R. K., Torgesen, J. K., & Rashotte, C. A. (1994). Development of reading-related phonological processing abilities: New evidence of bidirectional causality from a latent variable longitudinal study. *Developmental Psychology*, *30*(1), 73–87. <https://doi.org/10.1037/0012-1649.30.1.73>
- Waller, M. R., & Darley, F. L. (1978). The influence of context on the auditory comprehension of paragraphs by aphasic subjects. *Journal of Speech, Language, and Hearing Research*, *21*(4), 732-745.
- Watila, M. M., & Balarabe, S. A. (2015). Factors predicting post-stroke aphasia recovery. *Journal of the Neurological Sciences*, *352*(1–2), 12–18. <https://doi.org/10.1016/j.jns.2015.03.020>
- Webb, W., & Love, R. J. (1983). Reading problems in chronic aphasia. *Journal of Speech & Hearing Disorders*, *48*(2), 164–171. <https://doi.org/10.1044/jshd.4802.164>
- Webster, J., Morris, J., Connor, C., Horner, R., McCormac, C., & Potts, A. (2013). Text level reading comprehension in aphasia: What do we know about therapy and what do we need to know? *Aphasiology*, *27*(11), 1362–1380. <https://doi.org/10.1080/02687038.2013.825760>
- Webster, J., Morris, J., & Howard, D. (2022). *Reading comprehension in aphasia: The relationship between linguistic performance, personal perspective, and preferences*. <https://www.tandfonline.com/doi/full/10.1080/02687038.2022.2039999>
- Webster, J., Morris, J., & Howard, D. (2023). Reading comprehension in aphasia: The relationship between linguistic performance, personal perspective, and preferences. *Aphasiology*, *37*(5), 785–801. <https://doi.org/10.1080/02687038.2022.2039999>

- Webster, J., Morris, J., Howard, D., & Garraffa, M. (2018). Reading for Meaning: What Influences Paragraph Understanding in Aphasia? *American Journal of Speech-Language Pathology*, 27(1S), 423–437. [https://doi.org/10.1044/2017\\_AJSLP-16-0213](https://doi.org/10.1044/2017_AJSLP-16-0213)
- Weekes, B. S. (2005). Acquired disorders of reading and writing: Cross-script comparisons. *Behavioural Neurology*, 16(2–3), 51–57. <https://doi.org/10.1155/2005/492935>
- Weekes, B. S. (2012). Acquired dyslexia and dysgraphia across scripts. *Behavioural Neurology*, 25(3), 159–163. <https://doi.org/10.1155/2012/950972>
- Wegner, M. L., Brookshire, R. H., & Nicholas, L. E. (1984). Comprehension of main ideas and details in coherent and noncoherent discourse by aphasic and nonaphasic listeners. *Brain and Language*, 21(1), 37–51. [https://doi.org/10.1016/0093-934x\(84\)90034-8](https://doi.org/10.1016/0093-934x(84)90034-8)
- Woollams, A. M., Silani, G., Okada, K., Patterson, K., & Price, C. J. (2011). Word or word-like? Dissociating orthographic typicality from lexicality in the left occipito-temporal cortex. *Journal of Cognitive Neuroscience*, 23(4), 992–1002. <https://doi.org/10.1162/jocn.2010.21502>
- Woollams, A. M. (2014). Connectionist neuropsychology: Uncovering ultimate causes of acquired dyslexia. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 369(1634), 20120398. <https://doi.org/10.1098/rstb.2012.0398>
- Woollams, A., Lambon-Ralph, M. A., & Patterson, K. (2022). Acquired disorders of reading and writing. *The Science of Reading: A Handbook*, 395-415.
- Yathiraj, A. & Amruthavarshini, B. (2018). *Modified language proficiency questionnaire*. Unpublished Master's Dissertation. All India Institute of Speech and Hearing, Mysuru.
- Ziegler, J. C., Castel, C., Pech-Georgel, C., George, F., Alario, F.-X., & Perry, C. (2008). Developmental dyslexia and the dual route model of reading: Simulating individual differences and subtypes. *Cognition*, 107(1), 151–178. <https://doi.org/10.1016/j.cognition.2007.09.004>

## APPENDIX A



**All India Institute of Speech and Hearing**  
(An autonomous Institute under the  
Ministry of Health and Family Welfare, Govt. of India)  
Center of Excellence - Assessed & accredited by NAAC with 'A' Grade  
ISO 9001: 2015 Implemented Institute  
Manasagangothri, Mysuru - 570 006

ಅಖಿಲ ಭಾರತ ವಾಕ್ ಶ್ರವಣ ಸಂಸ್ಥೆ  
ಮನಸಗಂಗೋತ್ರಿ, ಮೈಸೂರು - 570 006  
अखिल भारतीय वाक श्रवण संस्थान  
मानसगंगोत्री, मैसूर - 570 006

### ETHICS COMMITTEE APPROVAL FOR BIO-BEHAVIOURAL RESEARCH PROJECTS INVOLVING HUMAN SUBJECTS AT AIISH

#### AIISH ETHICS Committee (AEC)

**Title of the Thesis** : Exploring the Relationship between  
Linguistic and Reading Abilities in Bilingual  
Persons with Aphasia

**Name of the Candidate** : Ms. Akshaya S

**Name of the Guide** : Dr. S.P Goswami

**Proposed Duration of the Research Study** : 3 to 6 years

**Source of funding** : Nil

**Estimated budget** : Nil

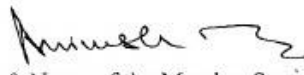
**Reference Number of the Proposal** : No. DOR.9.1/Ph.D/AS/926/2021-22  
dated 08.12.2022

**Date on which the AEC meeting was held** : 08.02.2023

**A clear statement of the decision reached AEC meeting  
(in the vent of the proposal is not approved, a statement  
of reasons for the same must be indicated** : Approved

**Advice & suggestions (if any)** : The participant's information and  
participants/ caregivers consent form should be in the participant's /caregiver's mother tongue.

Date: 10.02.2023

  
Signature & Name of the Member Secretary  
Dr. Animesh Barman  
Professor of Audiology  
Department of Audiology  
All India Institute of Speech and Hearing, Mysore-570006  
Member Secretary  
AIISH ETHICS  
COMMITTEE

## APPENDIX B

### CONSENT FORM

#### **Thesis on ‘Exploring the Relationship between Linguistic and Reading Abilities in Bilingual Persons with Aphasia’**

Information to the participants:

I, Ms. Akshaya S, working as Assistant Professor and pursuing Ph.D for thesis titled ‘*Exploring the Relationship between Linguistic and Reading Abilities in Bilingual Persons with Aphasia*’ under the guidance of Dr. S. P Goswami, Professor in Speech Pathology, Dept. of Speech Language Pathology, AIISH, Mysore — 6. The aim of the research is to examine the relationship between the linguistic abilities and reading abilities in Bilingual Persons with Aphasia across Kannada and English.

I need to collect data from individuals with aphasia in the age range of 18 years of age and above. I assure you that this data will be kept confidential. There is no influence or pressure of any kind by us or the investigating institute on your participation. There is no risk involved to the participants, but your cooperation in the study will go a long way in helping us in understanding the linguistic and reading abilities in Persons with Aphasia who are exposed to two languages.

Signature of Caregiver.

*(Name and Address)*

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

#### **Informed Consent**

I have been informed about the aims, objectives, and the procedure of the study. I understand that I have a right to refuse participation as a participant or withdraw my consent at any time.

I, the undersigned, give my consent to be a participant in this investigation/study/program.

**Signature of participant**

*Name*

**Signature of investigator**

Date

## APPENDIX C

### MODIFIED LANGUAGE PROFICIENCY QUESTIONNAIRE

**Developed by Yathiraj A., Jain S.N., and Amruthavarshini B. (2018)**

Name:

Age:

Gender: Male / Female

**Instructions:** Please read the below given information carefully and choose the most appropriate choice. Respond to all eight points by either filling in blanks or ticking (✓) the most appropriate response. (*Note:* L1 refers to the first language that you learnt; L2 refers to the second language that you learnt; L3 refers to the third language that you learnt)

\*\*\*\*

1. Name all the languages you have learnt since your childhood in the order of acquisition of the language.

Order of Languages acquired	Language Name
L1	
L2	
L3	

2. Since when have you been using your L1, L2 and L3 for understanding, speaking, reading and writing? (*Note.* Please tick (✓) one duration per language for understanding, speaking, reading, & writing)

Duration in years	Understanding			Speaking			Reading			Writing		
	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Less than 5 years												
5 to 10 years												
10.1 to 15 years												
Greater than 15 years												

3. How would you mark your level of proficiency for understanding, speaking, reading, and writing? (*Note.* Please tick (✓) one level proficiency per language for understanding, speaking, reading, & writing)

Level of Proficiency	Understanding			Speaking			Reading			Writing		
	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Low proficiency												
Fair proficiency												
Good proficiency												
Native like/perfect proficiency												

4. How would you rate your ability to switch between the languages? (*Note. Please tick (✓) one of the ratings*)

Rating Scale	Response (✓)
Low Ability	
Fair Ability	
Good Ability	
Perfect Ability	

5. Please tick (✓) which language you use maximum for the below mentioned situations: (*Note. Please tick (✓) one language per situation*)

Sl. No.	Situations	L1	L2	L3
a	Interaction with family			
b	Education/ work			
c	Listening to instruction tapes at school			
d	Text books			
e	Dictionary			
f	Story books			
g	Newspapers			
h	Internet source			
i	Writing			
j	Interacting with friends			
k	Interacting with neighbours			
l	Watching TV/ YouTube			
m	Listening to the radio (music)			
n	Market places			

6. On a scale of one to four, how often do you use the languages known to you in the following situations? (*Rating key: 1 = never; 2 = Sometimes; 3 = Most of the time; 4 = Always; Note. Please write the numbers 1, 2, 3, or 4, for each situation per language*).

Sl. No.	Situations	L1	L2	L3
A	Interaction with family			
B	Schooling/ work			
C	Listening to instruction tapes at school			
D	Text books			
E	Dictionary			
F	Story books			
G	Newspapers			
H	Internet source			
I	Writing			
J	Interacting with friends			
K	Interacting with neighbours			
L	Watching television/ YouTube			
M	Listening to the radio (music)			
N	Market places			

7. How frequently do others identify you as a native speaker based on your accent or pronunciation in the language? (*Note. Please tick (✓) one rating per language*)

Rating Scale	L1	L2	L3
Never			
Sometimes			
Most of the time			
Always			

8. For how many hours do you use the following languages? (*Note. Please tick (✓) one duration per language*)

Duration	L1	L2	L3
Greater than 2 hours			
Greater than 3 hours			
Greater than 4 hours			
Greater than 5 hours			

*Note: Refer Scoring key for analysis*

## APPENDIX 1b

### SCORING KEY

#### MODIFIED LANGUAGE PROFICIENCY QUESTIONNAIRE

Developed by Yathiraj A., Jain S.N., and Amruthavarshini B. (2018)

**Instructions to professional scoring the scale:** Please score the responses on a scale of 1 to 4 for each skill / question as directed.

\*\*\*\*

1. Name all the languages you have learnt since your childhood in the order of acquisition of the languages.  
**No score** (*Information to be used for descriptive analysis*)
  
2. Since when have you been using your L1, L2 and L3 for understanding, speaking, reading and writing?

Duration (in years)	Scores	Understanding			Speaking			Reading			Writing		
		L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Less than 5 yrs	1												
5 to 10 yrs	2												
10.1 to 15 yrs	3												
Greater 15 yrs	4												
<b>Total Scores</b>		<b>L1 = /16</b>			<b>L2 = /16</b>			<b>L3 = /16</b>					

3. How would you mark your level of proficiency for understanding, speaking, reading, and writing?

Level of Proficiency	Scores	Understanding			Speaking			Reading			Writing		
		L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Low proficiency	1												
Fair proficiency	2												
Good proficiency	3												
Native like/perfect proficiency	4												
<b>Total Scores</b>		<b>L1 = /16</b>			<b>L2 = /16</b>			<b>L3 = /16</b>					

4. How would you rate your ability to switch between the languages?

Rating Scale	Scores	Response		
Low Ability	1			
Fair Ability	2			
Good Ability	3			
Perfect Ability	4			
<b>Total Scores</b>		<b>L1 = /4</b>	<b>L2 = /4</b>	<b>L3 = /4</b>

5. Tick (✓) which language you use maximum for the following situations:

**No score** (*Information to be used for descriptive analysis*)

6. On a scale of one to four, how often do you use the languages known to you in the following situations? (*Instruction to professional scoring the scale: Total the ratings given per language*).

Sl. No.	Situations	L1	L2	L3
a	Interaction with family			
b	Schooling/ work			
c	Listening to instruction tapes at school			
d	Text books			
e	Dictionary			
f	Story books			
g	Newspapers			
h	Internet source			
i	Writing			
j	Interacting with friends			
k	Interacting with neighbors			
l	Watching television/ YouTube			
m	Listening to the radio (music)			
n	Market places			
<b>Total Score</b>		<b>/56</b>	<b>/56</b>	<b>/56</b>

7. How frequently others identify you as a native speaker based on your accent or pronunciation in the language?

Rating Scale	Scores	L1	L2	L3
Never	1			
Sometimes	2			
Most of the time	3			
Always	4			
<b>Total Score</b>		/4	/4	/4

8. For how many hours do you use the following languages?

Duration	Scores	L1	L2	L3
Greater than 2 hours	1			
Greater than 3 hours	2			
Greater than 4 hours	3			
Greater than 5 hours	4			
<b>Total Score</b>		/4	/4	/4

<b>L1</b>	/100
<b>L2</b>	/100
<b>L3</b>	/100

## APPENDIX D

### 1. Semantic Tasks

#### a. Picture Association Task:

In this task, participants will be presented with four foils and a target picture, all in the form of printed picture flashcards. The participant will be expected to match the target picture with foils of four picture flashcards on three types of associations namely, distinctive feature association (camel as target word- dessert, water, pet & forest); categorical association (apple- orange) and noun verb (bat- hit or scissor- cut) association.

Association	Set 1	Set 2
<b>Distinctive feature</b>	Camel- Dessert Sugarcane- Sugar Book- Paper Rain- Water Soap- Foam	Antenna- Radio Cow- Milk Fish- Water Apple- Orange Mobile- Computer
<b>Categorical association</b>	Dog- Cat Bus- Car Apple- Orange River- Sea	Watch- Clock Tiger- Lion Nose- Leg Rose- Sunflower
<b>Noun verb</b>	Bed – Sleep Pen- Write Water- Drink Soap- Bath Book- Read	Aeroplane- Fly Chair- Sit Cigarette- Smoke Axe- Cutting Eyes- Crying

#### b. Picture Matching/ Identification task:

Participants will be presented with four printed picture flashcards and they are instructed to match or identify the spoken word (target stimulus) to picture out of four foils. The items assessed in this task will comprise of common nouns and common verbs. For example; the target verbal stimuli will be ‘knife’ and the participant has to identify out of four picture flashcards- ‘table’, ‘knife’, ‘pen’, and ‘grapes’

Sl. No.	Nouns		Sl.No.	Verbs	
	Kannada	English		Kannada	English
1	Flower	Forest	1	Barking	Dancing
2	House	Water	2	Blowing	Brushing
3	Door	Window	3	Coughing	Painting
4	Scissors	Wheel chair	4	Eating	Saluting
5	Eyes	Train	5	Praying	Swimming
6	Radio	Clock	6	Swimming	
7	Cat	Mouse	7	Crying	
8	Watch	Match stick	8	Combing	
9	Axe	Comb	9	Sweeping	
10	Window	Wall	10	Saluting	

## APPENDIX D

### c) Auditory synonym judgment task:

Participants will be presented with pairs of words related in terms synonyms through auditory mode by the researcher. They are instructed to indicate 'yes' or 'no' for the relatedness of pairs. For example; 'look- see', 'happy- excited', 'speak- tell'. (MANAT-K)

Sl. No.	Kannada	English
1	/de:ha- shareera/	Good- Beautiful
2	/raste- daari/	Bad – Ugly
3	/neeru- tharkari/ (Wrong)	Vehicle- Fish (Wrong)
4	/betta-gudda/	Dog- Ball (Wrong)
5	/ca:ru- meenu/ (Wrong)	Man- Person
6	/kaNNu- nayana/	Lady- Women
7	/kappu- ha:lu/ (Wrong)	Jeep- River (Wrong)
8	/raja- arasa/	Watch- Clock
9	/manushya- surya/ (Wrong)	Man- Tree (Wrong)
10	/gagana- aka:sha/	Big- Huge

### d) Auditory comprehension task:

Participants will be presented with polar questions through auditory mode and they will be expected to answer 'yes' or 'no' to the questions. For example; 'Sky is blue in color' (polar question) - 'yes' (expected answer) (LPT- K).

Sl. No.	Kannada	English
1	/nimma hesaru ramakrishna na?/	Do stars shine in the sky at night?
2	/neevu manealli va:sava:giddira ?/	Is the ocean is filled with feathers?
3	/ee u:rina hesaru maisuru aa?/	Is Apple red in color?
4	/idu sinema mandira ve?/	Do we use mobile to talk?
5	/ee koNeya bagilu muchide?/	Do we drive the car in the sky ?
6	/kallu neeralli muLuguthade	Are apples red in colour?
7	/surja rathri kaNuthade/	Does a postman deliver cars?
8	/neevu baLehaNNu thinnuva modalu sippe thegithira?	Does fish swim in water?
9	/simha naikintha DoDDada?	Do we get tea powder from the tea plantations?
10	/suththige inda mara katharisutha:ra?	Do we go to the hospital when we have fever?

## APPENDIX D

### 2. Phonological Tasks

#### a) Real word rhyme judgement:

Participants will be presented with real rhyming words verbally, and they will be instructed to judge if they sound the same or not. For example; ‘mission- passion’, ‘transform- inform’ and so on.

Sl. No.	Kannada	English
1	/Hu:vu- haavu/	Good-food
2	/matthe-kothi/ (wrong)	Type-hype
3	/ele-ole/	Gone-Cone
4	/bale- mooLe/ (wrong)	Harsh- Heat
5	/a:Ta- u:Ta/	Magnet- Mango
6	/pennu- bennu/	Mouse- House
7	/magga- manga/	Bank- Rank
8	/ajja- ayya/ (wrong)	Read- Reel
9	/jaaDi- gaaDi/	Fare- Fear
10	/bassu- batru/ (wrong)	Gold- Mold

#### b) Non word rhyme judgement:

Participants will be presented with rhyming non words verbally, and they will be instructed to judge if they sound the same or not. For example; ‘Toption- Bension’ and so on. (RAP-K)

Sl. No.	Kannada	English
1	/kabasa- tabasa/	Hoopsikle- Topsikle
2	/darla- parla/	Carpik- barpik
3	/komita- topati/ (wrong)	Jangle- Keppel (wrong)
4	/chamali- kumali/	Doption- Loption
5	/patkat- katpat/ (wrong)	Vollide- boddle (wrong)
6	/gaLaja- nakaja	Doop- roop
7	/kanata- yatana/ (wrong)	Tentle- Gunkle (wrong)
8	/bhaarata- guraka/ (wrong)	Trod- Drod
9	/magalu- kagalu/	Gock- Fock
10	/kadapa- thadapa/	Pandol- Kantle (wrong)

#### c) Parsing/ blending sounds:

Participants will be instructed to join the parts or sounds and identify the target words on choice of four items. For example; Isolation parsing: /p/ - /pat/; Blending: /m/ + /mat/. Syllables Parsing: /pla/ - /plate/; Blending: /pla/ + /ate/. (MAAT- K)

Sl. No.	Kannada	English
<b>Parsing</b>		
1	/mara/- /ra/= ma, pa,ba	mat- /m/ = at, bat, ta, or ot
2	/ili/ - /li/= i, u, a,	kable - /k/ = ble, able, table
3	/uta/- /u:/= ta, tha, pa	tree - /t/= free, creep, ree
4	/ele/- /e/= le, pe, te	hang- /g/ = tang, han, hen, tan
5	/arasa/- /ra/= asa, ara, ama	Classmate- mate= class, glass, mate

## APPENDIX D

Blending		
1	/aga/ + /sa/= /agasa, arasa, amasa/	/b/+ /ottle/= bottle, battle, cattle
2	/ki/+ /taki/= /kitiki, kitaki, putaki/	/m/+ /at/= bat, mat, cat
3	/chama/ + /cha/= /chamita, chapacha, chamacha/	/l/+ /aite/= fight, light, height
4	/kan/+ /nadi/= thannadi, kannadi, kannada	/d/+ /ans/= dance, fence, chance
5	/tar/+ /kari/= /tarkari, togarikai, tokai/	/k/+ /ard/= hard, fraud, card

### 3. Syntax Tasks

#### a) Comprehension of Plural & tense forms:

Participants will be presented with pairs of words varying in their respective plural forms and tense forms. The participants are instructed to respond if the pair is in the correct form to the target word or not. For example: 'table- tables', 'child- children' (plural forms); 'come- came', 'fall- fell' and 'wanted- wanted' and so on. (LPT-K)

#### Plural forms

Sl. No.	Kannada	English
1	/huDugi- huDigiyaru/	Balloon- balloons
2	/ajji- ajjigaLu/ (wrong)	Child- childs (wrong)
3	/anna- anna/	School- schools
4	/manushya- janaru/	Pencil- pencil (wrong)
5	/mara- maragaLu/	Water- waters (wrong)
6	/neeru- neerugaLu/ (wrong)	Man- men
7	/ganDasu- ganDasaru/	Lady- ladies
8	/pustaka- pustakagaLu/	Fruit- fruit (wrong)
9	/hengasU- hengasandiru/ (wrong)	Paper- papers
10	/akki- akkigaLu/ (wrong)	Person- people

#### Tense forms

Sl. No.	Kannada	English
1	/maaDu- maaDida/	Come- came
2	/ba- bandanu/	Read- Readed
3	/Idzu- Idzugu/	Fall- Fell
4	/nagu- nakkida/	Paint- painted
5	/noDu- noDida/	Drink- Drunk
6	/malagu- malagu/	Drive- Drove
7	/thinnu- thinnugaLu/	Steal- Stole
8	/oDu- oDida/	Jump- Jumped
9	/thoLi - thoLida/	Stop- stopped
10	/beeLu- biddanu/	Cut- Cutted

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### b) Spoken sentence to picture matching:

Participants will be presented with four picture flashcards and a sentence will be presented verbally. The participant is expected to match with verbal sentence to respective picture form.

Sl. No.	Kannada	English
1	/a:ka:ʃadalli/ /ha:ra:Duva/ /vaahana/-	The vehicle that sails on the sea..... (ship)
2	/huttadalli/ /va:sa ma:Duva/ /pra:Ni/-	The animal that lives in the den..... (lion)
3	/ati/ /sundarava:gi/ /nartane/ /maaDuva/ /pakʃi/	The sky is filled with white ..... (clouds)
4	/bareyalu/ /upayo:gisuva/ /vastu/-	When we are thirsty, we drink .....(water)
5	/hallu/ /udzdʒalu/ /upayo:gisuva/ /vastu/-	We use ..... to bath (soap)
6	/pe:par/ /kattarisalu/ /upayo:gisuva/ /vastu/-	The object used for lighting the lamp is....(match box)
7	/kasaguDisalu/ /upayo:gisuva/ /vastu/-	Mangoes are grown from..... (tree)
8	/khuʃiya:da:ga/ /nagutte:ve;/ /no:va:da:ga/-	Children go to ..... to study (school)
9	/braʃ/ /mattu/ /pe:stninda/ /na:vu/ /hallannu/-	Children use pencil and pen to .....in their books (write)
10	/pra:NigaLu/ /naDeyuttave;/ /pakʃigaLu/-	Peacock is the most beautiful bird, known for ..... (dancing)

### c) Sentence completion with locatives:

Participants will be presented with a target picture, subsequently an incomplete sentence will be presented verbally. The participant is expected to fill in with appropriate locative form (in, on, over, under and so on) respective to the picture stimulus and the oral sentence. For example: 'The apple is ..... (on) the table'.

Sl. No.	Kannada (options)	English (options)
1	/baalu medzu ..... Ide/ (mele)	The cat is .....the table (on)
2	/marada ..... koti Ide/ (keLage)	The dog is .....the chair (under)
3	/meenu neerina ..... Ide/ (oLage)	The horse ran .....the bush (over)
4	/bhavi ..... neeru Ide/ (olage)	The fishes are swimming .....the water. (in)
5	/bekku ..... na:I Ide/ (munde)	The bus driver rides .....the road. (on)
6	/bas ..... ka:ru Ide/ (hinde)	The train runs .....the track. (on)
7	/marada ..... koti Ide/ (keLage)	The boy is running ..... the girl. (behind)

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### 4. Oral Reading Tasks:

Participants will be presented with set of printed flashcards of single words (orthographic) and they are instructed to read aloud each word on presentation. All the words will be matched for length and complexity. For each item, they will be given 15 secs (max) time to read. The following words will be assessed in this task:

#### a) Real word reading (Kannada and English). Example: /se:bu/ & ‘table’

Sl. No.	Kannada	English
1	/kempu/- ಕೆಂಪು	Boy
2	/chamacha/- ಚಮಚ	House
3	/manga/- ಮಂಗ	Piano
4	/arasa/- ಅರಸ	Mobile
5	/gula:bi/- ಗುಲಾಬಿ	Papaya
6	/kudure/- ಕುದುರೆ	Computer
7	/aramane/- ಅರಮನೆ	Butterfly
8	/parichaya/ - ಪರಿಚಯ	Flowerpot
9	/a:bharaNa/- ಆಭರಣ	Aeroplane
10	/devasta:na/- ದೇವಸ್ಥಾನ	Tape-recorder
11	/yajamanaru/- ಯಜಮಾನರು	Scissors
12	/puLiyogare/- ಪುಳಿಯೋಗರೆ	Chocolate
13	/thenginaka:/- ತೆಂಗಿನಕಾಯಿ	Businessman
14	/mangaluru/- ಮಂಗಳೂರು	Helicopter
15	/ sōmavāra /- ಸೋಮವಾರ	Spectacles

#### b) Non word reading (Kannada and English). Example: /hampara/ & ‘ganter’

Sl. No.	Kannada	English
1	/kiko/	pipa
2	/pako/	tako
3	/mupa/	muti
4	/chagu/	fako
5	/liksha/	lipatu
6	/gaLaja/	pabalo
7	/nakaja/	janter
8	/kanata/	malabi

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9	/yatana/	hayato
10	/chakapi/	danking
11	/palaba/	mubbler
12	/sabava/	parble
13	/mappiso/	ganking
14	/tagguhi/	datoriko
15	/tharvya/	patramber

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c) **Irregular word reading** (only in English). Example: ‘yatch’

Sl. No.	English
1	Field
2	Have
3	Kitchen
4	Yatch
5	Friend
6	Listen
7	Hunger
8	Psychology
9	Children
10	Watch

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### 5. Reading Comprehension (Silent) Tasks:

a) **Single word level:** All participants will be assessed on this task through various sub tasks like

**i. Written word to picture matching:**

Participant will be instructed to read the written word in the flash card and match with the respective picture out of choice of four pictures; (DAB-K)

Sl. No.	Kannada	English
1	/kOLi/	Lotus
2	/meenU/	House
3	/huDuga/	Gate
4	/lo:Ta/	Frog
5	/ba:gilu/	Chair
6	/chamacha/	Pencil
7	/pUstaka/	Orange
8	/pIsthul/	Laptop
9	/gaDija:ra/	Sunflower
10	/beegada kai/	Umbrella

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### ii. Written synonym judgement

Participants will be presented with target word in written form on flashcard and instructed to match with the respective synonym to the word out of four printed word flashcards. Example: 'Happy- joy'; (LPT-K)

Sl. No.	Kannada	English
1	/raja/- /arasa/ (kelasa, saInka, nai)	Good- Nice (price, gift, light)
2	/daje/- /karuNe/ (kopa, mara, vandane)	Danger- Risky (unhappy, whisky, water)
3	/kopa/- /sIttU/ (besara, meTTu, ratri )	Old- Elderly (hospital, kindly, office)
4	/ane/- /gaja/ (ka:Du, radza, kitaki)	Empty- Vacant (Full, patent, cooker)
5	/chikka/- /saNna/ (dhappa, aNna, bagilu)	Job – Occupation (Money, collection, Chair)
6	/thande/- /appa/ (amma, thuppa, vimana)	Stone- Rock (House, Clock, Fridge)
7	/kelsa/- /kayaka/ (haNa, balaka, hangi)	Bad- Ugly (Road, Googly, Ball)
8	/surja/- /ravi/ (beLige, kavi, samudra)	Present- Gift (Happy, theft, Trolley)
9	/neeru/- /dzala/ (meenu, bala, raste)	Infant – Baby (Cry, lobby, cloth)
10	/kaNNU/- /najana/ (de:ha, payaNa, ba:gu)	Intelligent- Smart (Detectives, Cart, Computer )

### iii. Written word and semantic association:

Participants will be presented with target word in written (printed) form on the flashcard and instructed to match with the respective semantically related word out of four written (printed) words. Example: 'Orange' target word – 'apple, ball, water, tangle'. (LPT-K)

Sl. No.	Kannada	English
1	/mola/- /praNi/ (maNi, jinke, ka:ru)	Eyes- Nose (Pose, Red, Cat)
2	/mosaru/- /ha:lu/ (ka:lu, neraLe, ba:tu)	Lion- Tiger (Figure, Table, Gear )
3	/kaalu/- /naDi/ (maDi, fa:nu, bagilu)	Snack- Chips (Tips, Fax, Match)
4	/mara/-/neraLu/ (mancha, kere, karaLu)	Iron- metal (kettle, garage, Flower)
5	/maLe/-/ni:rU/ (u:ru, vimana, sha:le)	Chappathi- Food (Good, River, Charger )
6	/huli/-/jinke/ (sanke, maLige, saikalu)	Garlic- Onion (Option, Minion, Bridge)
7	/sebU/- /kIththaLe/ (maLe, aka:sha, deepa)	Finger- Hand (Sand, Bucket, Basket)
8	/huVu/- /gUlabi/ (charabi, pulavu, payasa)	River - Water (Matter, parachute, Printer)
9	/erekai/- /bendekai/ (kalangaDi, tenginakai, kudure )	Banana- Apple (Mapple, telegram, Moutain)
10	/gaDija:ra /- /samaja / (pariva:ra, samadza, vinaja )	Aeroplane- Rocket (Pocket, television, internet )

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b) **Sentence level:** All participants will be assessed on this task through various sub tasks like

### i. Written sentence to picture matching:

Participant will be instructed to read (silently) the written sentence in the printed card and match to the respective picture out of choice of four pictures

Sl. No.	Kannada	English
1	/ba:l Te:bal me:le ide/	A boy is brushing his teeth.
2	/magU toTTillalli malagide/	Teacher is teaching in the school.
3	/na:I gat mUnde ide/	People are buying vegetables in the market.
4	/a:ne hullu thinnuthide/	The newspapers are being printed in the press.
5	/meenu neeralli idzuthide/	A boy and a girl are riding their bicycle.
6	/manga marada me:le ide/	The river is flowing between the beautiful mountains.
7	/makkaLu maidanadalli a:Ta aDutiddaare/	The goldsmith is making the jewelry in the shop.
8	/ makkaLu shaalealli paTa keluthiddare /	Children are playing see-saw, slide and swing in the park.
9	/hudugi matte muduki raste da;TuthidaaLe/	The engineers are constructing a multi-storied apartment in the city.
10	/arasa aramanealli manthrigaLa jyothe kuthiddaare/	The municipality is collecting garbage from the residential streets.

### ii. Written sentence judgment:

Participants will be presented with correct and incorrect form of sentences in printed form and asked to judge for the correctness of the sentence on reading; (reading treatment manual)

Sl. No.	Kannada	English
1	/bassugaLu hoguttide/	Children are playing in the ground.
2	/Huli neerinalli vasa maduthave/ (wrong)	The bird is driving in the sky (Wrong)
3	/hakkI guDina mele kuLitide/	A clock shows time
4	/avanu kasa thinnuthiddaale/ (wrong)	The boy ran to school; she fell down on the way (Wrong)
5	/magu TattayoLage malagide/ (wrong)	Laptop is used to play football (Wrong)
6	/a:kashana candra mo:Da ide/ (wrong)	The plate is on the water in the cup. (Wrong)
7	/taTTe jyothe ni:rina lo:Ta ide/	Children play cricket in the playground.
8	/avaru phoninalli ma:taDutiddaare/	We use mobile phones to talk.
9	/guru shishyaru sha:lealli iddave/ (wrong)	A girl jumped the wall and he got hurt. (Wrong)
10	/uta ma:Duvaga ellaru shantaragi ku:tiruttave/	The Earth revolves around the Sun and Moon rotates around the Earth.

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### iii. Written sentence completion:

Participants will be presented with incomplete sentence in printed form and they are instructed to fill in with appropriate form with choice of 4 words. ‘The sky is ..... in color’.

Sl. No.	Kannada	English
1	/po:lis .....annU hiDidanU/ /pustaka/ /kaLLa/ /bavUta/ /ha:vU/	We travel from one place to another using ..... Books Vehicles Vegetables Water
2	/giDada baNNa ..... iruthade/ /neeli/ /hasiru/ /kappu/ /kesaru/	Fishermen sail in .....  Bike Aeroplane Boat Bus
3	/ramesh avaru ca:rugaLu mattu la:rijannu riperI ma:Duttare. Avaru obba..... /dardzi/ /janthra/ /mekanik/ /chalaka/	Raj takes orders from every table in the restaurants. He works as.....  Waiter Driver Manager Teacher
4	/shikshakarU mattu vidjartigaLu bEsigeja nanthara ..... ge barutha:re/ /sha:lege/ /hospital/ /bjank/ /devasta:na/	Pooja cannot read from board in the classroom. So doctor prescribed her to wear.....  Mask Spectacles Blindfold Hearing aid
5	/march thingaLu javaga barute/ /maLe nantara/ /dzulai nantara/ /april munche/ /mai munche/	In the weekdays, Monday falls after ..... Saturday Tuesday Sunday Wednesday
6	/raitarU akki, dzoLa, ka:IU mattU .....beLijuttare/ /iDali/ /baTTe/ /bhumI/ /tarakaigaLu/	Ravi packed his bag. He packs books, pencil box, pens, water bottle and lunch bag before leaving to .....  Hospital Police station Playground School.
7	/karU, bassU, vIma:na jella ..... gUmpige sErUttave/ /tarakai/ /pra:Ni/ /va:hana/ /vastu/	The grandmother was not able to eat with her hands, so she asked for .....to eat  Napkin Bottle Spoon Cup

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8	/naavu barijokke ..... upajogasuteevi/ /pencil/ /baik/ /chakU/ /chamacha/	The mountains were filled with snow and people were waiting for .....to find some warmth in the freezing cold.  Sunlight Moonlight Rain Clouds
9	/tande tai makkaLige oLLe..... kalisabEkU/ /u:Ta/ /nidde/ /budhdhI/ /roopa/	We are aware of the everyday affairs from ..... Hospital Books Watchman Newspaper
10	/dzanarU prati va;ra sama:nu mattu tarakai taralU ..... ge hoguttare/  /akashakke/ /a;spatre/ /cinema mandira/ /angaDi/	The lions, tigers, elephants, deers all belong to .....  Domestic animals Pet animals Wild Animals Aquatic animals

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### iv. Written sentence conceptual matching:

Participants will be presented with target sentence in printed form on one flashcard and will be instructed to match with other set of printed sentences which are conceptually related to the target sentence. For example: Target sentence- ‘When the sun rises’ - ‘it lights up the whole world’.

Sl. No.	Kannada	English
1	/indane balikeinda – vaju malinya aguthe/	When it rains,- it fills up the rivers and lakes
2	/surja muLigida – dzagathu kaththalu aguthade/	Good exercises results in good health
3	/haNi haNi saridare- sagara aguthade/	Excessive sunlight – destroys nature.
4	/eddilu upayogadinda- vidyuth uthpadane maDuthare/	Study of plants and soil helps in good yield.
5	/roga nirodaka samshodane rogavannu thadiyalu upayoga vaguthade/	Technology helps in mass communication (television, mobiles)

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### c) Paragraph level:

All participants will be assessed on this task through various sub tasks like

**i. Paragraph to picture matching:** Participant will be instructed to read the written paragraph (print form) in the flash card and match to the respective picture out of choice of four pictures.

1) It is a bright sunny day. The sky is clear and the birds are chirping around. All kids are taken out to the garden and a teacher is narrating a story to them. All kids are happily listening to the story.

1) ಇದು ಪ್ರಕಾಶಮಾನವಾದ ಬಿಸಿಲಿನ ದಿನವಾಗಿದೆ. ಆಕಾಶವು ತಿಳಿಯಾಗಿದೆ ಮತ್ತು ಪಕ್ಷಿಗಳು ಸುತ್ತಲೂ ಚಿಲಿಪಿಲಿಗುಟ್ಟುತ್ತಿದೆ. ಎಲ್ಲಾ ಮಕ್ಕಳನ್ನು ತೋಟಕ್ಕೆ ಕರೆದೊಯ್ಯಲಾಗುತ್ತದೆ ಮತ್ತು ಶಿಕ್ಷಕರೊಬ್ಬರು ಅವರಿಗೆ ಒಂದು ಕಥೆಯನ್ನು ಹೇಳುತ್ತಿದ್ದಾರೆ. ಎಲ್ಲಾ ಮಕ್ಕಳು ಸಂತೋಷದಿಂದ ಕಥೆಯನ್ನು ಕೇಳುತ್ತಿದ್ದಾರೆ.



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2. One day, a woodcutter came out to the forest. It was a sunny day. He wants to build a small house for his family. So, he starts cutting a big tree thinking of building a beautiful house.

2. ಒಂದು ದಿನ, ಒಬ್ಬ ಮರಕಡಿಯುವವನು ಕಾಡಿಗೆ ಬಂದನು. ಅದು ಬಿಸಿಲಿನ ದಿನವಾಗಿತ್ತು. ಅವನ ಕುಟುಂಬಕ್ಕೆ ಒಂದು ಮನೆಯನ್ನು ನಿರ್ಮಿಸಲು ಬಯಸುತ್ತಿದ್ದಾನೆ. ಆದ್ದರಿಂದ, ಅವನು ಸುಂದರವಾದ ಮನೆಯನ್ನು ನಿರ್ಮಿಸಲು ಒಂದು ದೊಡ್ಡ ಮರವನ್ನು ಕತ್ತರಿಸಲು ಯೋಚಿಸುತ್ತಾನೆ.



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3. Today is Priya's birthday. She has invited all her friends from neighborhood for her birthday party. Her mother has ordered a beautiful cake. She has also baked small cup cakes and got some juice and chocolates for all. All kids are happy and ready for the celebrations wearing birthday hats.

3. ಇಂದು ಪ್ರಿಯಾಳ ಹುಟ್ಟುಹಬ್ಬ. ಅವಳು ತನ್ನ ಎಲ್ಲಾ ನೆರೆಹೊರೆಯ ಸ್ನೇಹಿತರನ್ನು ಹುಟ್ಟುಹಬ್ಬದ ಸಂತೋಷಕೂಟಕ್ಕಾಗಿ ಆಹ್ವಾನಿಸಿದಳು. ಅವಳ ತಾಯಿ ಸುಂದರವಾದ ಕೇಕ್ ಅನ್ನು ಆರ್ಡರ್ ಮಾಡಿದ್ದಾಳೆ. ಅವಳು ಕೂಡಾ ಎಲ್ಲರಿಗೆ ಸಣ್ಣ ಕಪ್ ಕೇಕ್ ಮಾಡಿದ್ದಾಳೆ, ಹಾಗೂ ಚಾಕೋಲೇಟ್ ಮತ್ತು ಜ್ಯೂಸ್ ಅನ್ನು ತಂದಿದ್ದಾಳೆ. ಎಲ್ಲಾ ಮಕ್ಕಳು ಹುಟ್ಟು ಹಬ್ಬದ ಟೋಪಿಗಳನ್ನು ಧರಿಸಿ ಸಂತೋಷದಿಂದ ಆಚರಣೆಗೆ ಸಿದ್ಧರಾಗಿದ್ದಾರೆ.



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### ii. Paragraph thematic matching:

Participant will be instructed to read the written paragraph (print form) in the flash card and match to the respective picture out of choice of four pictures which are related to the theme of the printed paragraph.

This is a festival observed in in the month of August. It is celebrated with warm feelings of love and affection between brothers and sisters. On this day, sisters of all ages tie a Rakhi around the wrists of their brothers. After the Rakhi, the brother offers sweets to his sister. They symbolically protect them, receive a gift in return, and traditionally invest the brothers with a share of the responsibility of their potential care.

ಇದು ಆಗಸ್ಟ್ ತಿಂಗಳಲ್ಲಿ ಆಚರಿಸಿದ ಹಬ್ಬ. ಇದನ್ನು ಸಹೋದರ ಸಹೋದರಿಯರ ನಡುವೆ ಪ್ರೀತಿ ಮತ್ತು ವಾತ್ಸಲ್ಯದ ಭಾವನೆಗಳೊಂದಿಗೆ ಆಚರಿಸಲಾಗುತ್ತದೆ. ಈ ದಿನ ಎಲ್ಲಾ ಸಹೋದರಿಯರು ತಮ್ಮ ಸಹೋದರನ ಕೈಗೆ ರಾವಿಯನ್ನು ಕಟ್ಟುತ್ತಾರೆ. ನಂತರ ಸಹೋದರನು ತನ್ನ ಸಹೋದರಿಗೆ ಸಿಹಿ ತಿಂಡಿಯನ್ನು ನೀಡುತ್ತಾನೆ. ನಂತರ ಸಹೋದರ ಪ್ರತಿಯಾಗಿ ಉಡುಗೊರೆಯನ್ನು ನೀಡುತ್ತಾನೆ.



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2. This ceremony is very colourful, and celebrations may extend for several days. The bride's and groom's home entrance, doors, wall, floor, roof are decorated with colors, flowers, and other decorations. It is considered as an auspicious union between a man and woman with commitments to each other for their bright future. Both the bride's and groom's families unite and perform multiple rituals with great joy and happiness. Hundreds of people who wish and witness the ceremony. It will be followed by a grand traditional feast

ಈ ಸಮಾರಂಭವು ತುಂಬಾ ವರ್ಣರಂಜಿತವಾಗಿದೆ ಮತ್ತು ಆಚರಣೆಗಳು ಹಲವಾರು ದಿನಗಳವರೆಗೆ ವಿಸ್ತರಿಸಬಹುದು. ವಧು-ವರರ ಮನೆ ಪ್ರವೇಶ ಬಾಗಿಲು, ಗೋಡೆ ನೆಲ ಛಾವಣಿಯನ್ನು ಬಣ್ಣಗಳು, ಹೂವುಗಳು ಮತ್ತು ಇತರ ವಸ್ತುಗಳಿಂದ ಅಲಂಕರಿಸಲಾಗಿದೆ. ಇದು ಪುರುಷ ಮತ್ತು ಸ್ತ್ರೀ ನಡುವಿನ ಮಂಗಳಕರ ಒಕ್ಕೂಟವೆಂದು ಪರಿಗಣಿಸಲಾಗಿದೆ. ತಮ್ಮ ಪ್ರಕಾಶಮಾನ ಭವಿಷ್ಯಕ್ಕೆ ಪರಸ್ಪರ ಬದ್ಧತೆಗಳನ್ನು ಮಹಿಳೆ ಹೊಂದಿರುತ್ತಾಳೆ. ವಧು ಮತ್ತು ವರನ ಎರಡೂ ಕುಟುಂಬಗಳು ಒಂದಾಗುತ್ತವೆ ಮತ್ತು ಬಹಳ ಸಂತೋಷದಿಂದ ಅನೇಕ ಆಚರಣೆಗಳನ್ನು ಮಾಡುತ್ತಾರೆ. ನೂರಾರು ಜನರು ಈ ಸಮಾರಂಭಕ್ಕೆ ಸಾಕ್ಷಿಯಾಗುತ್ತಾರೆ, ಹಾಗೂ ನಂತರ ಭವ್ಯವಾದ ಸಾಂಪ್ರದಾಯಿಕ ಕಾರ್ಯಕ್ರಮ ನಡೆಯಲಿದೆ.



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3. This results in the contamination of air due to the presence of substances in the atmosphere that are harmful to the health of humans and other living beings, or cause damage to the climate or to materials. It is also the contamination of indoor or outdoor surrounding either by chemical activities, physical or biological agents that alters the natural features of the atmosphere. This can also cause diseases, allergies, and even death to humans; it can also harm other living organisms such as animals and food crops, and may damage the natural environment. This can be caused by both human activities and natural phenomena.

ಮಾನವರು ಮತ್ತು ಇತರ ಜೀವಿಗಳ ಆರೋಗ್ಯಕ್ಕೆ ಹಾನಿಕಾರಕ ಅಥವಾ ಹವಾಮಾನ ಅಥವಾ ವಸ್ತುಗಳಿಗೆ ಹಾನಿಯನ್ನುಂಟು ಮಾಡುವ ವಾತಾವರಣದಲ್ಲಿರುವ ವಸ್ತುಗಳ ಉಪಸ್ಥಿತಿಯಿಂದಾಗಿ ಇದು ಗಾಳಿಯ ಮಾಲಿನ್ಯಕ್ಕೆ ಕಾರಣವಾಗುತ್ತದೆ. ಇದು ವಾತಾವರಣದ ನೈಸರ್ಗಿಕ ಲಕ್ಷಣಗಳನ್ನು ಬದಲಾಯಿಸುವ ರಾಸಾಯನಿಕ ಚಟುವಟಿಕೆಗಳು, ಭೌತಿಕ ಅಥವಾ ಜೈವಿಕ ಏಜೆಂಟ್‌ಗಳಿಂದ ಒಳಾಂಗಣ ಅಥವಾ ಹೊರಾಂಗಣ ಸುತ್ತಮುತ್ತಲಿನ ಮಾಲಿನ್ಯವಾಗಿದೆ. ಇದು ಮಾನವರಿಗೆ ರೋಗಗಳು, ಅಲರ್ಜಿಗಳು ಮತ್ತು ಸಾವಿಗೆ ಕಾರಣವಾಗಬಹುದು. ಇದು ಪ್ರಾಣಿಗಳು ಮತ್ತು ಆಹಾರ ಬೆಳೆಗಳಂತಹ ಇತರ ಜೀವಿಗಳಿಗೆ ಹಾನಿ ಮಾಡುತ್ತದೆ ಮತ್ತು ನೈಸರ್ಗಿಕ ಪರಿಸರವನ್ನು ಹಾನಿಗೊಳಿಸಬಹುದು. ಇದು ಮಾನವ ಚಟುವಟಿಕೆಗಳು ಮತ್ತು ನೈಸರ್ಗಿಕ ವಿದ್ಯಮಾನಗಳಿಂದ ಉಂಟಾಗಬಹುದು.



## APPENDIX D

### iii. Paragraph inferential matching:

Participant will be instructed to read the written paragraph (print form) in the flash card and match to the respective printed sentence out of choice of four in regard to the inference of the printed paragraph.

1. Once upon a time, there lived a crow. One summer day, the crow felt thirsty and began to look for some water. It flew over the fields but couldn't find. It felt exhausted and she was about to give up.

Then the crow saw a jug near a farm. It quickly landed down there to check whether there was any water. It looked inside the jug. There was some water. The crow wanted to drink but couldn't reach the water because of jug's narrow neck. It tried to push it down, but it was too heavy and thought a while. Then the crow looked around and saw small stones. The crow picked the stones up one by one and threw them inside the jug. Thus, the water level rose up enough and it quenched its thirst thanks to the crow clever plan.

A. "Where there is a will, there is a way".

B. "Honesty is the best policy."

C. "Time and tide wait for none".

D. "Look before you leap."

ಒಂದಾನೊಂದು ಕಾಲದಲ್ಲಿ ಒಂದು ಕಾಗೆ ವಾಸಿಸುತ್ತಿತ್ತು. ಒಂದು ಬೇಸಿಗೆಯ ದಿನ, ಕಾಗೆಗೆ ತುಂಬ ಬಾಯರಿಕೆ ಆಯಿತು ಮತ್ತು ಸ್ವಲ್ಪ ನೀರನ್ನು ಹುಡುಕಲು ಪ್ರಾರಂಭಿಸಿತು ನೀರನ್ನು ಹುಡುಕುತ್ತಾ ಸ್ಥಳದಿಂದ ಸ್ಥಳಕ್ಕೆ ಹಾರಿತು, ಆದರೆ ಕಾಗೆಗೆ ಎಲ್ಲಿಯೂ ನೀರು ಸಿಗಲಿಲ್ಲ. ಅದರಲ್ಲಿ ಒಂದು ಹನಿಯೂ ಸಿಗದಿದ್ದಕ್ಕೆ ಅದು ತುಂಬಾ ದುಃಖಿತವಾಯಿತು ಮತ್ತು ನೀರಾಶೆಗೊಂಡಿತು.

ಆಗ ಹೊಲವೊಂದರ ಬಳಿ ಒಂದು ಹೂಜಿ ಕಂಡಿತು. ನೀರು ಇದೆಯೇ ಎಂದು ಪರೀಕ್ಷಿಸಲು ಬೇಗನೆ ಹಾರಿ ಬಂತು. ಹೂಜಿಯೊಳಗೆ ನೋಡಿದಾಗ ಸ್ವಲ್ಪ ನೀರು ಇತ್ತು. ಕುಡಿಯಲು ಹೋದಾಗ ನೀರನ್ನು ತಲುಪಲು ಸಾಧ್ಯವಾಗಲಿಲ್ಲ. ಹೂಜಿಯ ಕಿರಿದಾದ ಕುತ್ತಿಗೆಯಿಂದಾಗಿ ಅದನ್ನು ಕೆಳಗೆ ತಳ್ಳಲು ಪ್ರಯತ್ನಿಸಿತು ಆದರೆ ಅದು ತುಂಬ ಭಾರವಾಗಿತ್ತು. ಸ್ವಲ್ಪ ಹೊತ್ತು ಯೋಚಿಸಿತು ನಂತರ ಸುತ್ತಲೂ ನೋಡಿತು ಮತ್ತು ಸಣ್ಣ ಕಲ್ಲುಗಳನ್ನು ಒಂದೊಂದಾಗಿ ಎತ್ತಿ ಹೂಜಿ ಒಳಗೆ ಎಸೆಯಿತು. ಹಾಗಾಗಿ, ನೀರಿನ ಮಟ್ಟವು ಸಾಕಷ್ಟು ಏರಿತು ಮತ್ತು ಕಾಗೆ ತನ್ನ ಬುದ್ಧಿವಂತಿಕೆಯಿಂದ ತನ್ನ ಬಾಯರಿಕೆಯನ್ನು ತಣಿಸಿಕೊಂಡಿತು.

1. ಮನಸಿದ್ದರೆ ಮಾರ್ಗವಿದೆ

2. ಪ್ರಾಮಾಣಿಕತೆಗಿಂತಲೂ ಮಿಗಿಲಾದದ್ದು ಇಲ್ಲ

## APPENDIX D

3. ಸಮಯ ಮತ್ತು ಅಲೆ ಯಾರಿಗೂ ಕಾಯೋದಿಲ್ಲ
4. ಯಾವೂದೇ ನಿರ್ಧಾರವನ್ನು ಯೋಚಿಸಿ ತೆಗೆದುಕೊಳ್ಳಬೇಕು

2. Once upon a time, a farmer had a goose that laid a golden egg every day. The egg provided enough money for the farmer and his wife for their day-to-day needs. The farmer and his wife were happy for a long time. But one day, the farmer got an idea and thought, “Why should I take just one egg a day? Why can't I take all of them at once and make a lot of money?”

The foolish farmer's wife also agreed and decided to cut the goose's stomach for the eggs. As soon as they killed the bird and opened the goose's stomach, to find nothing but guts and blood. The farmer, realizing his foolish mistake, cries over the lost resource!

- A. “A friend in need is a friend indeed”.
- B. “Think and act. Don't be greedy”
- C. “Time and tide wait for none”.
- D. “Slow and steady wins the race.”

ಒಂದಾನೊಂದು ಕಾಲದಲ್ಲಿ ಒಬ್ಬ ರೈತನಿಗೆ ಪ್ರತಿ ದಿನ ಚಿನ್ನದ ಮೊಟ್ಟೆ ಇಡುವ ಕೋಳಿ ಇತ್ತು. ಈ ಮೊಟ್ಟೆಯಿಂದ ರೈತ ಮತ್ತು ಅವನ ಹೆಂಡತಿಯ ದೈನಂದಿನ ಅಗತ್ಯಗಳಿಗಾಗಿ ಸಾಕಷ್ಟು ಹಣವನ್ನು ಒದಗಿಸಿದೆ. ಧೀರ್ಘಕಾಲ ರೈತ ಮತ್ತು ಹೆಂಡತಿ ಸಂತೋಷದಿಂದಿದ್ದರು. ಆದರೆ ಒಂದು ದಿನ ರೈತನಿಗೆ ಒಂದು ಉಪಾಯ ಹೊಳೆಯಿತು ಮತ್ತು ಯೋಚಿಸಿದನು “ನಾನು ದಿನಕ್ಕೆ ಒಂದು ಮೊಟ್ಟೆಯನ್ನು ಏಕೆ ತೆಗೆದುಕೊಳ್ಳಬೇಕು? ನಾನು ಎಲ್ಲವನ್ನೂ ಒಂದೇ ಬಾರಿಗೆ ತೆಗೆದುಕೊಂಡು ಸಾಕಷ್ಟು ಹಣವನ್ನು ಏಕೆ ಮಾಡಬಾರದು? ಈ ವಿಚಾರವನ್ನು ಮೂರ್ಖ ರೈತನ ಹೆಂಡತಿಯೂ ಒಪ್ಪಿದಳು ಮತ್ತು ಮೊಟ್ಟೆಗಳಿಗಾಗಿ ಕೋಳಿಯ ಮೊಟ್ಟೆಯನ್ನು ಕತ್ತರಿಸಲು ನಿರ್ಧರಿಸಿದಳು. ಬೇಗ ಬೇಗನೆ ಹಕ್ಕಿಯನ್ನು ಕೊಂದು, ಮೊಟ್ಟೆಯನ್ನು ಕೊಯಿದರು ಏನೂ ಕಾಣುವುದಿಲ್ಲ. ರೈತ ತನ್ನ ಮೂರ್ಖ ತಪ್ಪನ್ನು ಅರಿತು ಕಳೆದು ಹೋದ ಸಂಪನ್ಮೂಲದ ಬಗ್ಗೆ ಅಳುತ್ತಾನೆ.

1. ಅತಿ ಆಸೆ ಗತಿ ಗೇಡು
2. ಸಮಯ ಮತ್ತು ಅಲೆ ಯಾರಿಗೂ ಕಾಯೋದಿಲ್ಲ
3. ನಿಧಾನವೇ ಪ್ರಧಾನ
4. ಮಾತು ಬಲ್ಲವನಿಗೆ ಜಗಳವಿಲ್ಲ ಊಟ ಬಲ್ಲವನಿಗೆ ರೋಗವಿಲ್ಲ.

## APPENDIX D

3. One sunny day, the ant was looking for water. After a while, he came near a lake. He wanted to drink water, but he couldn't reach it. Then he saw a long grass reaching into the water. He quickly climbed on it and walked to the water. Suddenly, he slipped and fell into the water.

A pigeon flying over the lake saw him in trouble. She quickly found a leaf and left it near the ant. The ant climbed on it and the pigeon carried him by the lake. At that moment, a huntsman saw the pigeon and took out his net to catch her. When he was coming towards her, the ant noticed the huntsman and bit her foot to warn. The pigeon suddenly jumped and saw the huntsman and flew away.

A. "A friend in need is a friend indeed".

B. "Never believe flatterers"

C. "If you do good, good will come to you."

D. "Slow and steady wins the race."

ಒಂದು ಬಿಸಿಲಿನ ದಿನ, ಇರುವೆ ನೀರಿಗಾಗಿ ಹುಡುಕುತ್ತಿತ್ತು. ಸ್ವಲ್ಪ ಹೊತ್ತಿನ ನಂತರ ಕೆರೆಯೊಂದರ ಬಳಿ ಬಂತು . ನೀರು ಕುಡಿಯಲು ಬಯಸಿತು. ಆದರೆ ನೀರನ್ನು ಕುಡಿಯಲು ಸಾಧ್ಯವಾಗಲಿಲ್ಲ. ನಂತರ ನೀರಿಗೆ ಹತ್ತಿರವಿರುವ ಉದ್ದನೆಯ ಹುಲ್ಲುಕಂಡಿತು. ಅದು ಬೇಗನೆ ಅದರ ಮೇಲೆ ಹತ್ತಿ ನೀರು ಕುಡಿಯಲು ಹೋಯಿತು. ಇದ್ದಕ್ಕಿದ್ದಂತೆ, ಅದು ಜಾರಿ ನೀರಲ್ಲಿ ಬಿತ್ತು. ಕೆರೆಯ ಮೇಲೆ ಹಾರುತ್ತಿದ್ದ ಪಾರಿವಾಳವು ಇರುವೆಯನ್ನು ತೊಂದರೆಯಲ್ಲಿರುವುದನ್ನು ಕಂಡಿತು. ಪಾರಿವಾಳವು ಬೇಗನೆ ಎಲೆಯನ್ನು ಕಂಡು ಅದನ್ನು ಇರುವೆಯ ಬಳಿ ಬಿಟ್ಟಿತು. ಇರುವೆ ಅದರ ಮೇಲೆ ಹತ್ತಿತು ಮತ್ತು ಪಾರಿವಾಳವು ಇರುವೆಯನ್ನು ಕೆರೆಯ ಮೂಲಕ ಸಾಗಿಸಿತು. ಆ ಸಮಯದಲ್ಲಿ ಬೇಟೆಗಾರನೊಬ್ಬ ಪಾರಿವಾಳವನ್ನು ನೋಡಿದನು ಮತ್ತು ಹಿಡಿಯಲು ತನ್ನ ಬಲೆಯನ್ನು ಹೊರತೆಗೆದನು. ಅವನು ಪಾರಿವಾಳದ ಕಡೆಗೆ ಬರುತ್ತಿದ್ದಾಗ, ಇರುವೆ ಬೇಟೆಗಾರನನ್ನು ಗಮನಿಸಿತು ಮತ್ತು ಪಾರಿವಾಳವನ್ನು ಎಚ್ಚರಿಸಲು ಇರುವೆ ಪಾರಿವಾಳದ ಕಾಲು ಕಚ್ಚಿತು. ಪಾರಿವಾಳ ಇದ್ದಕ್ಕಿದ್ದಂತೆ ಜಿಗಿದು ಬೇಟೆಗಾರನನ್ನು ನೋಡಿ ಹಾರಿಹೋಯಿತು.

1. ಒಳ್ಳೆಯ ಕೆಲಸ ಮಾಡುವುದರಿಂದ ಒಳ್ಳೆದಾಗುತ್ತದೆ.
2. ಅತಿ ಆಸೆ ಗತಿ ಕೇಡು
3. ಮುಂದಾಲೋಚನೆಯಿಲ್ಲದೆ ಯಾವುದೇ ಕೆಲಸ ಮಾಡಬಾರದು
4. ಗರ್ವದಿಂದ ಸುಖವಿಲ್ಲ

(APPENDIX E) SCORE SHEET

Patient Name:

Age:

TASK	SUB SECTION	ITEM NO.	RESPONSE		REMARKS
<b>Semantic</b>					
<b>Picture Association Task</b>					
			<b>Kannada</b>	<b>English</b>	
	<b>Distinctive feature</b>	1			
		2			
		3			
		4			
		5			
	<b>Categorical association</b>	1			
		2			
		3			
		4			
		5			
	<b>Noun verb</b>	1			
		2			
		3			
		4			
		5			
<b>Picture Matching/ Identification task</b>					
	<b>Nouns</b>	1			
		2			
		3			
		4			
		5			
	<b>Verbs</b>	1			
		2			
		3			
		4			
		5			
<b>Auditory synonym judgment task</b>					
		1			
		2			
		3			
		4			
		5			
		6			
		7			

(APPENDIX E) SCORE SHEET

Patient Name:

Age:

		8			
		9			
		10			
<b>Auditory comprehension task</b>					
		1			
		2			
		3			
		4			
		5			
		6			
		7			
		8			
		9			
		10			
<b>Phonological Tasks</b>					
<b>Real word rhyme judgement</b>					
		1			
		2			
		3			
		4			
		5			
		6			
		7			
		8			
		9			
		10			
<b>Non word rhyme judgement</b>					
		1			
		2			
		3			
		4			
		5			
		6			
		7			
		8			
		9			
		10			
<b>Parsing/ blending sounds</b>					
	<b>Parsing</b>	1			
		2			

(APPENDIX E) SCORE SHEET

Patient Name:

Age:

		3			
		4			
		5			
	<b>Blending</b>	1			
		2			
		3			
		4			
		5			

**Syntax Tasks**

**Comprehension of Plural & tense forms**

	<b>Plural Forms</b>	1			
		2			
		3			
		4			
		5			
		6			
		7			
		8			
		9			
		10			
	<b>Tense Form</b>	1			
		2			
		3			
		4			
		5			
		6			
		7			
		8			
		9			
		10			

**Spoken sentence to picture matching**

		1			
		2			
		3			
		4			
		5			
		6			
		7			
		8			

(APPENDIX E) SCORE SHEET

Patient Name:

Age:

		9			
		10			
<b>Sentence completion with locatives</b>					
		1			
		2			
		3			
		4			
		5			
<b>Oral Reading Tasks</b>					
<b>Real word reading</b>					
		1			
		2			
		3			
		4			
		5			
		6			
		7			
		8			
		9			
		10			
		11			
		12			
		13			
		14			
		15			
<b>Non word reading</b>					
		1			
		2			
		3			
		4			
		5			
		6			
		7			
		8			
		9			
		10			
		11			
		12			
		13			
		14			

(APPENDIX E) SCORE SHEET

Patient Name:

Age:

		15				
<b>Irregular word reading</b>						
		1				
		2				
		3				
		4				
		5				
		6				
		7				
		8				
		9				
		10				
<b>Reading Comprehension</b>						
<b>Single word level</b>						
<b>Written word to picture matching</b>		1				
		2				
		3				
		4				
		5				
		6				
		7				
		8				
		9				
		10				
<b>Written synonym judgement</b>		1				
		2				
		3				
		4				
		5				
		6				
		7				
		8				
		9				
		10				
	<b>Written word and semantic association</b>		1			
			2			
			3			
			4			

(APPENDIX E) SCORE SHEET

Patient Name:

Age:

	5			
	6			
	7			
	8			
	9			
	10			

<b>Sentence level</b>				
-----------------------	--	--	--	--

	<b>Written sentence to picture matching</b>	1				
		2				
		3				
		4				
		5				
		6				
		7				
		8				
		9				
		10				
		<b>Written sentence judgment</b>	1			
			2			
			3			
			4			
			5			
			6			
			7			
			8			
			9			
			10			
		<b>Written sentence completion</b>	1			
			2			
			3			
			4			
			5			
			6			
			7			
			8			
			9			
			10			

(APPENDIX E) SCORE SHEET

Patient Name:

Age:

Paragraph level					
	<b>Paragraph to picture matching</b>	1			
		2			
		3			
	<b>Paragraph thematic matching</b>	1			
		2			
		3			
	<b>Paragraph inferential matching</b>	1			
		2			
		3			

DOMAIN	MAX Score	Patient Score
Semantics		
Syntax		
Phonology		
Oral Reading		
Reading Comprehension		
WAB -K AQ		
WAB -E AQ		
Language proficiency		