UNIVERSITY OF READING

Consequences of bi-literacy in bilingual individuals: in the healthy and neurologically impaired

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DECLARATION OF ORIGINAL AUTHORSHIP

I confirm that this is my own work and the use of all material from other sources has been properly and fully acknowledged.

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कर्मण्येवाधिकारस्ते मा फलेषु कदाचन |
मा कर्मफलहेतुर्भूर्मा ते सङ्गोऽस्त्वकर्मणि || 2.47 ||

"Perform your duty and do not be attached to your expectations"

ॐ पूर्णमदः पूर्णमिदम् पूर्णात् पूर्णमुदच्यते
पूर्णस्य पूर्णमादाय पूर्णमेवावशिष्यते ||

"From the completeness comes the completeness and what is complete remains complete forever"

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Abstract

Background. In the current global, cross-cultural scenario, being bilingual or multilingual is a norm rather than an exception. In such an environment an individual may be actively involved in reading and writing in all their languages in addition to speaking them. Regular use of two or more languages is termed as bilingualism and being able to read and write in both of them is referred to as bi-literacy. Research indicates that bilingualism has an impact on language production and cognition, specifically executive functions. Given the impact of literacy and bilingualism, the reasonable question that arises, is whether bi-literacy would offer an additional impact on language production and cognition. This becomes even more relevant in a multilingual, multi-cultural society such as India. We examined the impact of bi-literacy on oral language production (at word and connected speech level), comprehension and on non-verbal executive function measures in bi-literate bilingual healthy adults in an immigrant diaspora living in the UK. In addition to English, they were speakers of one of the South Indian languages (Kannada, Malayalam, Tamil and Telugu). The significance of bi-literacy among bilinguals assumes further importance in aphasia (language impairment due to brain damage). For those who have aphasia in one or more languages due to brain damage, the severity of impairment maybe different in both languages, also the modalities of language may be differentially affected. In particular, reading and writing maybe impaired differently in the languages used by a bi/multilingual. Manifestation of reading impairments are also dependent on the nature of the script of the language being read [e.g., Raman & Weekes (2005) report differential dyslexia in a Turkish-English speaker who exhibited surface dyslexia in English and deep dysgraphia in Turkish]. Our study contributes to the field of bilingual aphasia by focusing specifically on reading differing from the existing literature of aphasia in bilinguals, where the focus has predominantly been on language production and comprehension. Studying reading impairments provides a better understanding of how the reading impairments are manifested in the two languages, which will aid appropriate assessment and intervention. This research investigated the impact of bi-literacy in both populations (healthy adults and neurologically impaired) in two phases: Phase I (in UK) and Phase II (in India).

Aim. Phase I investigated the impact of bi-literacy on oral language production (at word level and connected speech), comprehension and non-verbal executive function in bi-literate bilingual healthy adults. Phase II examined the reading impairments in two languages of bilingual persons with aphasia (BPWA).

Methods. For Phase I, participants were thirty-four bi-literate bilingual healthy adults with English as their L2 and one of the Dravidian languages (Kannada, Malayalam, Tamil and Telugu) as their L1. We have used the term 'print exposure' as a proxy for literacy. They were divided into a high print exposure (HPE, n=22) and a low print exposure (LPE, n=12) group based on their performance on two tasks measuring L2 print exposure- grammaticality judgement task and sentence verification task. We also quantified their bilingual characteristics- proficiency, reading and writing characteristics and dominance. The groups were matched on years of education, age and gender. Participants completed a set of oral language production tasks in L2 (at word level) namely -verbal fluency, word and non-word repetition; comprehension tasks in L2 namely synonymy triplets task and sentence comprehension task (Chapter 2); oral narrative task in L2 (at connected speech level) (Chapter 3) followed by non-verbal executive function tasks tapping into inhibitory control (Spatial Stroop and Flanker tasks), working memory (visual n-back and auditory n-back) and task switching (colour-shape task) (Chapter 4).
For Phase II, we characterized the reading abilities of four BPWA who spoke one of the Dravidian languages (Kannada, Tamil, Telugu) (alpha-syllabic) as their L1 and English (alphabetic) as their L2. We quantified their bilingual characteristics- proficiency, reading and writing characteristics and dominance. Subtests from the Psycholinguistic Assessment of Language Processing in Aphasia (PALPA; Kay, Lesser & Coltheart, 1992) were used to document the reading profile of BPWA in English and reading subtests from Reading Acquisition Profile (RAP-K; Rao, 1997) and words from Bilingual Aphasia test -Hindi (BAT; Paradis & Libben, 1987) were used to document the reading profile of BPWA in Kannada and Hindi respectively.

Findings. Based on the findings of Phase I (i.e., results from Chapter 2-4), we found prominent differences between HPE and LPE on comprehension measures (synonymy triplets and sentence comprehension tasks). This is in contrast to the results observed in monolingual adults, were semantics is less impacted by print exposure. Moreover, our predictions that HPE will result in better oral language production skills were borne out in specific conditions- semantic fluency and non-word repetition task (at word level) and higher number of words in the narrative, higher verbs per utterance and fewer repetitions (at connected speech level). In addition, the non-verbal executive functions, we found no direct link between print exposure (in L2) and non-verbal executive functions in bi-literate bilinguals excepting working memory (auditory N-back task). Additionally, another consistency in our findings is that there seems to be a strong link between print exposure and semantic processing in our research. The findings on the semantic tasks have been consistent across comprehension (synonymy triplets task and sentence comprehension task) and production (semantic fluency) favouring HPE.

The findings from Phase II (Chapter 5) reveal differences of reading characteristics in the two languages (with different scripts) of the four BPWA. This research provides preliminary evidence that a script related difference exists in the manifestation of dyslexia in bi-scriptal BPWA speaking a combination of alphabetic and alpha-syllabic languages.

Conclusions. Our research contributes to the existing literature by highlighting the relationship between bi-literacy and language production, comprehension and non-verbal cognition where bi-literacy seems to have a higher impact on language than cognition. The contrary findings from the monolinguals and children literature, highlight the importance for considering nuances of bilingual research and specifically challenges the notion that semantic comprehension is not significantly affected by literacy. In the neurologically impaired population, our research provides a comprehensive profiling of reading abilities in BPWA in the Indian population with languages having different scripts. Using this profiling and classification, we are able to affirm the findings previously found in literature emphasizing the importance of script in the assessment of reading abilities in BPWA. Such profiling and classification assist in the development of bilingual models of reading aloud and classifying different types of reading impairments.

Chapter 1 Introduction.

Introduction

World societies are becoming global, multilingual and cross-cultural. Consequently, exposure to different language and writing systems is becoming a norm rather than an exception. Multicultural societies such as India, have a tendency to create an environment where becoming multilingual is actively encouraged and almost imperative. Individuals in such a system naturally tend to acquire reading and writing along with spoken language. Literacy implies the ability to read and write using a writing system that requires a reader to map onto a particular language. There is evidence to show that impact of literacy on cognitive-linguistic, social, and psychological aspects begins from an early age and continues onto adulthood (Rao, 2014). Therefore, literacy is an important psycho-linguistic attribute. An individual who is bilingual, also tends to acquire reading and writing in two languages, also termed as bi-literate.

Bilingualism has shown to impact oral language and cognition. Research of oral language production in bilingual population have shown mixed findings when compared to monolinguals (Bialystok et al., 2008; Luo et al., 2010; Paap et al., 2017; Sandoval et al., 2010). On the other hand, research suggests that bilingualism offers a cognitive advantage mostly with regard to a boost in the executive functions in comparison to the monolinguals (Martin-Rhee & Bialystok, 2008; Bialystok, 2006; Bialystok, 2009).

Research on the impact of literacy on various psycholinguistic attributes is confined to monolinguals and research thus far has indicated that literacy has an impact on oral language skills [e.g. verbal fluency (Ardila et al., 2010) and non-word repetition (Kosmidis, Tsapkini, Folia, Vlhou, & Kiosseoglou, 2004)] and cognitive processing [e.g. measures of executive function like Stroop task and trail making (Barnes, Tager, Satariano & Yaffe, 2004)]. Therefore, there is evidence to show that literacy impacts both spoken and written language e.g., Ventura etal.,2004; Ziegler et al., 2004; Alario et al.,2007; Burgos et al.,2014) as well as cognition (Ardila et al. 2010). With respect to the neurologically impaired population, individuals who have language impairment in one or more languages due to brain damage (bilingual aphasia), the severity of impairment maybe different in both languages, also the modalities of language may be differentially affected. Reading and writing maybe impaired differently in the languages spoken by a bi/multilingual. Manifestation of reading impairments are also dependent on the nature of the script of the language being read (Raman & Weekes, 2003,2005; Weekes et al., 2007; Senaha & Parente, 2012; Karanth, 1981; Ratnavalli et al, 2000).

Consequently, in this research, we explored how bi-literacy among bilinguals is impacting oral language production, comprehension and executive functions. Specifically, we explored the relationship of literacy in bilinguals in two phases. In the first phase (Phase I), we explored the impact of literacy on cognitive-linguistic attributes such as oral language production (single word and connected speech level), comprehension and cognitive aspects in bilingual healthy adults. In the second phase (Phase II), we explored the relationship of literacy in bilinguals in a neurologically impaired population. In this chapter, we will briefly introduce the concept of bilingualism and bi-literacy (Section1.1.1), followed by importance of measuring variables of bilingualism and bi-literacy (Section 1.2), we will discuss the background for Phase I and its rationale (Section 1.3) and finally discuss the background for Phase II and its rationale (Section 1.4).

1.1. Bilingualism and Bi-literacy

Bilingualism can be defined as “the regular use of two or more languages (or dialects), and bilinguals are those people who use two or more languages (or dialects) in their everyday lives” (Grosjean, 2008, p. 10). Bilinguals have both languages at their disposal at a given point in time (Hernandez, Bates and Avila,1996; Rodriguez-Fornells et al.,2005; Chee,2006; Crinion et al.,2006; Kroll, Bobb and Wodniecka,2006). The definition of bilingualism in Grosjean (2008) does not specify whether it encompasses the modalities of reading and writing. Bilinguals may possess the ability to read and write in the two languages that they use regularly. Such abilities to read and write in more than one language is an additional skill. Such individuals are uniquely qualified as bi-literate bilinguals.

Bi-literacy can be defined as 'any and all instances in which communication occurs in two (or more) languages in or around writing' (Hornberger 1990, 213), where these instances may be events, actors, interactions, practices, activities, classrooms, programs, situations, societies, sites, or worlds (Hornberger 2000, 362; Hornberger and Skilton-Sylvester 2000, 98). On the other hand, Rauch et al (2011) defines bi-literacy as being a proficient reader in both one's native language and second language. From the above definitions, it is clear that bi-literates form a subset of bilinguals.

Interest in bilingualism has consistently increased because of various socio-political factors such as migration and globalisation (Surrain & Luk, 2017) and therefore inquiry into bilingualism has been increasingly common. Research on bi-literacy is still in the nascent state and comparison can be drawn from bi-literacy acquisition in children (Bialystok, Luk & Kwan, 2005). Dworin (2003) suggests that knowledge of two writing systems influences language learning in both languages. However, the impact of bi-literacy on language learning in children is moderated by the proximity of the writing systems (Bialystok, Luk & Kwan, 2005). Despite these findings, biliteracy remains an unexplored area, especially in adulthood.

A bi-literate bilingual can read and write in both languages, making bi-literacy an important aspect of bilingualism research. In this research, question of the impact of bi-literacy in bilinguals is framed differently for the healthy adults and the neurologically impaired population. For the healthy adults, the research question is whether a bi-literate has an additional impact on oral language production (at the word level and connected speech) and non-verbal cognition. For the neurologically impaired population (with dyslexia) the research question is how reading impairments are manifested in two languages of bi-literate bilingual persons with aphasia (BPWA).

We address both these questions in a two-phase study. Phase I deals with the healthy population investigating the impact of bi-literacy on oral language production (at word level and connected speech), comprehension and non-verbal cognition in bi-literate bilingual adults. Phase II deals with neurologically impaired population specifically examining reading impairments in two languages of BPWA. This chapter is divided into two parts- Section 1.2 discusses Phase I and section 1.3 discusses Phase II. For phase I, we will briefly discuss the difficulties of measuring the variables of bi-literacy and bilingualism in any population (Section 1.2), followed by a discussion of impact of these variables (Section 1.3) on oral language production (Section 1.3.1), comprehension (section 1.3.2) and executive functions (section 1.3.3). For Phase II, we discuss the problems in measuring impairments in bi-literate bilinguals (section 1.4.1) and then discuss how our study aims to address this problem (section 1.4.2).

1.1.1 Importance of measuring the variables of bilingualism and bi-literacy

Bilinguals are described based on various attributes such as language proficiency, language dominance, language usage. These attributes are used to profile and characterise bilinguals. Consequently, measuring variables like language proficiency, dominance and usage is crucial.

Quantifying the level of bilingualism using these attributes is a critical step towards comparing findings across studies of bilingualism in areas such as cognitive functioning and linguistic outcomes. In addition, measuring proficiency and dominance facilitates cross-linguistic comparisons and to accurately estimate the effects of bilingualism on language processing and cognition, it is important that language dominance be assessed uniformly (Gollan et al., 2012). Another reason it is important to measure language dominance is when bilinguals are restructuring their languages (Grosjean, 1998). Restructuring refers to losing fluency in L1 and gaining fluency in L2 (Grosjean, 2002). This is highly relevant to the immigrant population where they tend to lose the lexical or syntactic knowledge in either of the languages (Grosjean, 1998). The participants in Phase I of our study are Indian immigrants residing in the UK, hence language dominance is a key variable which we have addressed. Similarly, we have included language usage as a variable as the amount that individuals use their languages on a daily basis is likely an important attribute at all ages (Surrain & Luk, 2017). Understanding and profiling all of these attributes will give a universal picture of language status. Given this evidence in literature, it is important to measure "the extent of bilingualism" by measuring language proficiency, dominance and current language usage patterns.

Research on bilinguals was mainly focused on monolingual versus bilingual comparisons (Bialystok et al., 2012; Peal & Lambert, 1962; Costa, Hernandez & Sebastia-Galle, 2008). However, the trend is now changing to focus more on bilingual comparisons in order to provide a deeper insight into bi/multilingual population (Costa & Santesteban,2004; Bialystok, Craik & Luk, 2007) E.g. Comparison across sub-groups- early vs. late proficiency; high vs. low proficiency. Additionally, in bi-literate bilinguals it is also possible that L1 and L2 proficiency may influence each other in the context of language combinations. (E.g. For a person with Kannada as his first language and English as second language, the spoken form of L1 may be acquired first informally and reading/writing much later at school in the formal context. On the other hand for English (L2), literacy skills may be acquired first and spoken/ understanding later with literacy skills).

Therefore, for better characterisation of bilinguals, especially with respect to reading and writing, it is important to document and profile the reading and writing skills accurately. We address this in Phase I. Phase I focuses by assessing the reading and writing skills in both the languages that the bi-literate bilinguals speak. Within the bi-literate bilingual neurologically impaired population, information on level of bilingualism and language status provides a stronger basis for assessment and rehabilitation of various communication disorders (Dash & Kar, 2012). Therefore, in Phase II, we assess the pre- and post-morbid reading and writing skills of BPWA. In children studies, the term literacy refers to acquisition of reading and writing (Bialystok, Luk & Kwan, 2005; Reyes, 2012). In adult literature, the same term is less direct and could refer to level of education, schooling (Kosmidis et al, 2006; Silva et al, 2012). Therefore, for the current study we use the term 'print exposure' as a proxy for measuring 'literacy'.

Language proficiency and dominance can be measured in both subjective and objective measures. Some researchers have used subjective measures like self-assessments, questionnaires and rating scales. Examples: Measures of bilinguals' language history; Current language use (Grosjean,1982) Self-report Classification Tool (SRCT; Lim, Liow, Lincoln, Chan, & Onslow, 2008); Bilingual Dominance Scale (BDS; Dunn & Fox Tree, 2009). On the other hand, few other researchers have used objective measures to quantify language proficiency and dominance. For example: Speed of naming pictures in the two languages (Mägiste, 1992); Reading comprehension Task (Dash and Kar,2013); Lexical Translation Task (Dunn & Fox Tree,2009); Sentence Translation Task (Dunn & Fox Tree, 2009) to name a few. Based on all of these, the current understanding is that a combination of both objective and subjective measures would be more effective than using any measure alone (Luk & Bialystok, 2013) in assessing these measures. Therefore, both subjective and objective measures would be used in the current research.

We translate this viewpoint to a more focused paradigm of assessing reading and writing in bi-literate bilinguals. In our research, language proficiency and dominance were assessed subjectively by adapting the questionnaires available in the literature to suit the current study. For assessing language proficiency, the adapted questionnaire (from Li, Sepanski, & Zhao, 2006; Birdsong et al, 2012; Luk & Bialystok, 2013; Munoz, 2000) included the following sections-Language history/background, Language Usage and Language Proficiency (including reading & writing to assess print exposure in both languages). Language dominance was assessed using Bilingual Dominance Scale (BDS; Dunn & FoxTree, 2009) (See Appendix 2.2) which includes the following sections: age of acquisition, L1 & L2 usage and restructuring. Objectively, language proficiency was assessed using a lexical decision task based on LexTale (Lemhöfer & Broersma, 2012) and a picture naming task based on Boston Naming test (Kaplan, Goodglass, & Weintraub, 1983). The participants were objectively assessed on their print exposure in their second language (L2) by administering a grammaticality judgement task taken from the Philadelphia Comprehension battery (Saffran, Schwartz, Linebarger, Martin, & Bochetto, 1988) (See Appendix 2.3) and a sentence verification task (adapted from Royer, Greene & Sinatra, 1987) (See Appendix 2.4).

1.2 Impact of print exposure on oral language production (word level and connected speech), comprehension and executive functions in bi-literate bilinguals in UK (Phase I)

An important part of studying language production requires us to understand how individuals integrate current input with prior knowledge to evolve a mental representation (Birren and Schaie, 2006). In order to understand this, along with oral language production, language comprehension also needs to be addressed. Executive functions are a family of mental processes needed when you have to concentrate and pay attention in performing a particular task (Burgess & Simons 2005, Espy 2004, Miller & Cohen 2001). These are essential for mental and physical health; success in school and in life; and cognitive, social, and psychological development (Diamond, 2013). All three aspects (oral language production, comprehension and executive functions) are impacted by extent of bilingualism and literacy in any individual. In the following section, we will briefly review this impact.

1.2.1 Impact of print exposure on oral language production (word level and connected speech) in bi-literate bilinguals.

Research has shown that print exposure has an impact on language production both at the word level and connected speech in monolinguals (Ardila et al., 2010). In general, literature suggest print exposure positively impacts connected speech in monolingual children (Katz et al., 2012; Cunningham and Stanovich, 1991; Montag & McDonald, 2015). Studies on monolingual population have compared groups within monolinguals for example illiterates and literates (Kosmidis, Tsapkini, Folia, Vlahou, & Kiosseoglou, 2004); groups of individuals with varying levels of education (Kosmidis et al, 2006; Silva et al, 2012; Cunningham and Stanovich, 1991). These studies indicate that print exposure has an impact on oral language production at the word level in monolinguals in tasks such as word and non-word repetition, verbal fluency and vocabulary task. This literature is covered in detail in section 2.2.1 and 3.2.1.

Similar studies of oral language production in bilingual population have shown mixed findings when compared to monolinguals (Bialystok et al., 2008; Luo et al., 2010; Paap et al., 2017; Sandoval et al., 2010). For instance, studies by Gollan et al., (2002), Rosselli et al., (2000) and Sandoval et al., (2010) show that monolinguals produced higher number of correct responses in semantic fluency tasks. Whereas, Bialystok, Craik, and Luk (2008) compared younger and older monolinguals and bilinguals on an English vocabulary test (PPVT-III), Boston naming test, and two tests of verbal fluency (semantic and letter). They found bilinguals to obtain lower scores compared to monolinguals across all the age groups.

At the connected speech level, most of the literature focuses on comparing bilingual narratives with monolingual narratives showing no observable trend. For instance, Pearson (2001) compared false belief in English monolingual and Spanish-English bilingual children using Frog story in both English and Spanish. Findings suggest that bilinguals report false belief about half as often as monolinguals. However, findings regarding the length of narrative, proportion of evaluative clauses is mixed. While Chen & Yan (2010) found bilingual narratives were shorter, Dewaele & Pavlenko (2003) reported no such difference. Similarly, with regard to evaluative clauses, Chen and Yan (2011) found bilinguals used a higher proportion of evaluative clauses than monolinguals, Shrubshall (1997) found the converse. Specific narrative measures have been positively associated with learning to read in bilingual children. For example, Miller et al (2006) show that narrative measures such as mean length of utterance', as a measure of morpho-syntactic complexity, 'number of different words' as a measure of lexical diversity, 'words per minute' as a measure of fluency and 'narrative scoring scheme' as measure of coherence predict reading measures in both languages.

Given the impact of print exposure and bilingualism on oral language production at word and connected speech level, for our research we have chosen oral language production tasks both at word level and connected speech. For the word level tasks, we use verbal fluency which taps into both linguistic components (Fernaeus et al, 2008) and executive functioning (Ostberg et al, 2005). Word and non-word repetition and letter fluency tasks tap into phonological processing (daSilva et al, 2004; Castro-Caldas, Petersson, Reis, Stone-Elander, & Ingvar, 1998; Kosmidis, Tsapkini, & Folia, 2006; Reis & Castro-Caldas, 1997). We have used both semantic and letter fluency as well as word-nonword repetition to investigate the impact of print exposure on oral language production in bi-literate bilingual speakers with varying levels of print exposure in L2.

For a deeper insight into verbal fluency, in addition to number of correct (CR), we also use several methods such as time course analysis, cluster and switching analysis to characterize verbal fluency (Luo et al., 2010; Troyer, Moscovitch, & Winocur, 1997). These measures have been adapted from (Patra, Bose & Marinis, 2018). Table 2.1 (Patra, Bose & Marinis, 2018) describes these measures and variables. Similarly, for word and non-word repetition, we quantify performance in terms of CR, difference score and error analyses.

For connected speech, it has been suggested that connected speech exhibits language properties that can be analysed only through narrative analysis (Pavlenko, 2008) and hence narrative analysis is a valid method of probing language skills (Bishop & Edmundson, 1987; Botting, 2002). Therefore, we use a narrative task which was elicited using, 'Frog Where are you Story?' (Mayer, 1969). This tool provides a standardised protocol for administration and it gives an opportunity to discuss findings across studies. We use the story in conjunction with Computerized Language Analysis (CLAN) (McWhinney, 2016) which allows multiple analyses of utterance level measures, morpho-syntactic measures, lexical measures, and measure of repair.

1.2.2 Impact of print exposure on comprehension in bi-literate bilinguals

An important part of studying language production requires us to understand how individuals integrate current input with prior knowledge to evolve a mental representation (Birren and Schaie, 2006). In order to understand this, along with oral language production, language comprehension also needs to be addressed.

Literature finds that in adults, print exposure has a limited role on semantic processing and comprehension (Reis and Castro-Caldas,1997; Kosmidis et al., 2004) and in children (monolingual and bilingual) since they are still in literacy acquisition phase, print exposure seems to have a significant impact (Manly et al, 1999; Nation & Snowling, 1998; Hedrick and Cunningham,1995). A strong relationship has been established between bilingualism and comprehension in children (Nation & Snowling, 1998; Proctor et al, 2005) (Refer to section 2.2.3 for a review).

Typically, studies (Nation & Snowling, 1998; Proctor et al, 2005; Manly et al, 1999) have focused on assessing comprehension either using comprehension measures at the word level such as synonmy triplets, the Woodcock Language Proficiency Battery or sentence level such as The BDAE Complex Ideational Material subtest. However, comprehension occurs both at word and sentence level and hence it is important to consider both these aspects of comprehension. Therefore, in our study, we investigate the effect of print exposure on comprehension at both the word level and sentence level using the synonymy triplets' task from the Philadelphia comprehension battery (Saffran, Schwartz, Linebarger, Martin & Bochetto, 1988) and sentence comprehension task taken from the Test for Reception of Grammar-2 (TROG-2) (Bishop, 2003) respectively.

1.2.3 Impact of print exposure on executive functions in bi-literate bilinguals

Royall et al (2002) defines executive functions as a broad set of cognitive skills required for "planning, initiation, sequencing, and monitoring of complex goal directed behaviour". Each of these components of executive functions are typically treated independently. However, many authors (Miyake et al., 2000; Miyake & Friedman, 2012; Lehto et al, 2003; Diamond, 2013) have made a case of considering all of these components as functioning co-dependently and yet existing as separable constructs. In our research, we use this approach by examining executive control within the categories of inhibitory control, working memory (WM), and cognitive flexibility (also called set shifting, mental flexibility, or mental set shifting (Miyake et al., 2000; Miyake & Friedman, 2012). This framework facilitates comparison of our results to the existing literature.

Studying literacy skills provides a better understanding of the organisation of cognition. For instance, learning to read improves the performance of verbal and visual memory (Folia and

Kosmidis,2003), generalised executive functions (Barnes, Tager, Satariano & Yaffe,2004), improved working memory, [See Ardila et al. (2010) for critical review; Silva et al., (2012)].

Within the literature we have reviewed, we have noticed that print exposure/ literacy seems to have a higher impact on verbal executive function tasks. In general, higher literacy levels significantly predict performance on visuospatial tasks using a neuropsychological battery (Ardila & Rosselli, 1989; Manly et al,1999), verbal working memory (Silva et al, 2012, Folia and Kosmidis, 2003), general executive function tasks (Barnes et al, 2004). No such association was observed for non-verbal executive function tasks (For instance, Folia and Kosmidis, (2003) found null results on non-verbal memory tasks). An important limitation of each of the above studies is that they tap into either a specific cognitive domain that are independent of each other or tend to club these within a broad umbrella of neuropsychological batteries (general executive functioning) (Ardila & Rosselli, 1989; Manly et al,1999).

Furthermore, research on bilingualism has shown that bilinguals exhibit an advantage over monolinguals on tasks of non-verbal executive functions such as the Simon task (Bialystok, Craik, Klein, & Viswanathan, 2004), Stroop task (Bialystok, Craik, & Luk, 2008) and task-switching (Prior & Gollan, 2011). There are also reports suggesting that bilingual advantage in executive function may be very restricted to a particular task as most studies use only a single measure of executive function and others who have used multiple measures lack convergent validity (Paap & Greenberg,2013). For a detailed review see section 4.2.1 to 4.2.3.

In terms of inhibitory control, research has shown bilingual advantage on tasks such as Simon in children, young adults and older people (Martin & Bialystok, 2003; Bialystok, 2006; Bialystok, Craik, Klein, & Viswanathan, 2004; van der Lubbe & Verleger, 2002), Stroop and arrow Simon task (Bialystok et al, 2008), attentional network task (Costa, Hernandez & Sebastian Galles, 2008), antisaccade task (Bunge, Dudukovic, Thomason, Vaidya, & Gabrieli, 2002). On the other hand, some authors [e.g., Kousaie & Phillips (2012)] have not found any significant bilingual advantage in the Stroop, Simon and Flanker task (See section 4.2.2.1 for a further details).

From the methodological perspective, majority of the studies in literature employ non-verbal inhibitory control tasks. In our study, we have sought to investigate the impact of print exposure on inhibitory control using non-verbal inhibitory control tasks (spatial Stroop and Flanker) in a bi-literate bilingual population incorporating print exposure as an additional variable. We quantified the performance in spatial Stroop and Flanker task using Stroop effect and conflict effect respectively.

With respect working memory, the relationship between bilingualism and working memory is not very clear (Dong et al., 2015). There is not enough evidence to suggest that bilinguals are at an advantage in tasks such as free recall task (Fernandez et al, 2007), spatial N-back (Soveri et al, 2011) either. N-back requires online monitoring and updating working memory (Monk et al, 2011). The N-back task has been extensively used as a measure of working memory (Monk et al., 2011; Kane et al, 2007; Jaeggi et al, 2010). In our study, we try to explore the relationship between an extraneous factor (print exposure) and working memory updating using the N-back task in bi-literate bilinguals. We use D prime (d') to validate the results of the N-back task as D prime is less prone to confounding factors such as demographic factors as compared to digit span and letter-number sequencing (Haatveit et al, 2010).

In relation to task switching, Prior & McWhinney (2010) and Prior & Gollan (2011) have found that language switching correlates with task switching, contrastively Paap et al (2015) and Calabria et al (2012) have found no positive correlation between the two switches. We have sought to investigate whether print exposure might impact switching ability in bi-literate bilinguals. We have used the non-verbal task switching paradigm by computing the switch costs described in Prior & McWhinney (2010) to examine whether print exposure could contribute to task switching ability.

In general, it was noted that the relationship between print exposure and executive function is not particularly well established. Within bilingual research, majority of the tasks which have shown the impact of bilingualism are non-verbal executive function tasks. Since, we want to elicit the relationship of print exposure within bilinguals, it was prudent to choose only non-verbal executive function tasks. We have chosen two tasks in each of the executive function measures in order to obtain convergent validity [as described in (Paap & Greenberg,2013)], with the exception of task switching as the task switching paradigm itself tends to incur large costs, are more difficult and may be more sensitive to group differences (see Monsell, 2003).

1.3 Reading impairments in bi-literate bilingual persons with aphasia (BPWA) (Phase II)

Bilingual aphasia can be defined as an impairment in one or more languages in bilingual individuals following a brain damage (Kiran & Gray, 2018). In individuals with bilingual aphasia, one or both languages may be affected and the severity of impairment maybe different in both languages (Fabbro & Paradis, 1995; Fabbro, 2001). Similarly, different modalities such as reading and writing maybe impaired differently in the different languages spoken by a bi/multilingual (Wilson, Kahlaoui & Weekes, 2012). Reading and writing disorders in individuals with aphasia are relatively under reported (Lorenzen & Murray,2008).

In bi-literate bilingual persons with aphasia (BPWA) measuring the impact of bi-literacy on oral language production, comprehension and executive functions is complicated by the presence of language impairments. This makes it impossible to administer BPWA with the same set of tasks as used in Phase I with bi-literate bilingual healthy adults. Additionally, we have studied the Indian population in UK in Phase I, and BPWA in Phase II in India speaking the Indian languages to maintain uniformity. In Phase II we aimed to profile and characterise the reading impairments within this Indian population. As the population we targeted was bi-literate bilingual, characterising reading impairments was the only way we could evaluate the reading skills in a BPWA.

1.3.1. Challenges in measuring impairments in bi-literate bilinguals

As in healthy bi-literate bilinguals (as described in section 1.2), we need to measure and document bilingual attributes such as language proficiency, dominance and usage. Measuing these attributes objectively(as described in section 1.2) is difficult to achieve. However, in BPWA this measurement is complicated by their existing language impairments and even more difficult to objectively quantify. In order to overcome this particular challenge in our study we adapt the questionnaire used in Phase I (healthy adults) to measure the same attributes in BPWA in Phase II by introducing a pre-morbid and current language proficiency and usage specifically focusing on reading and writing.

India is one of the most multilingual nations in the world (Tsimpli et al, 2018) The Indian constitution in its 8th schedule recognizes 22 languages as scheduled languages and English is one of the official languages spoken. Therefore, it offers ample scope of studying bilinguals with different combinations of L1 and L2. This also has the side effect of not being able to find the same language combinations in the entire BPWA cohort. We have overcome this difficulty in our research, by choosing participants speaking one of the four Dravidian languages (Kannada, Malayalam, Tamil and Telugu) spoken in South of India as their L1 and English as their L2. Figure 1.1 illustrates the diversity of languages within the Indian sub-continent.

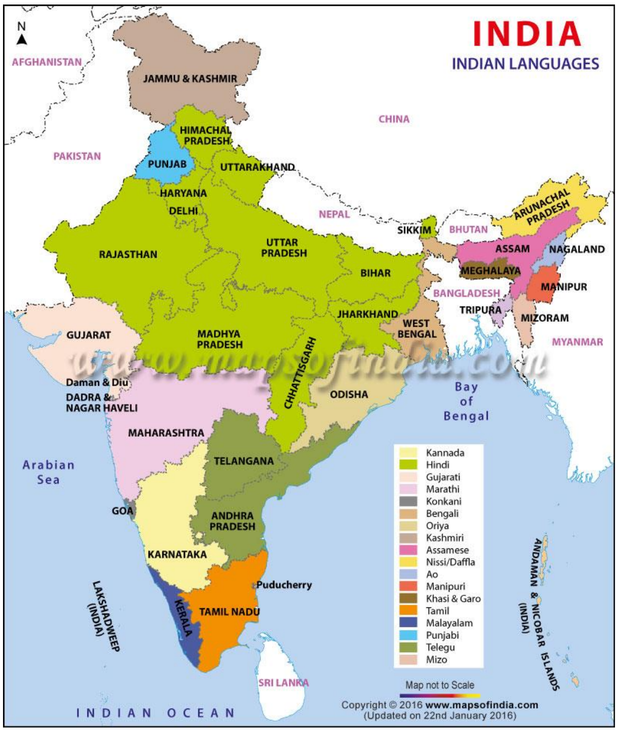


Figure 1.1 Map of India depicting the languages spoken across the country. The states in green speak Hindi (Indo-Aryan language); The state in ivory speaks Kannada; The states in darker green speak Telugu and the state in brown speaks Tamil; The state in blue speaks Malayalam. These four together constitute the Dravidian languages spoken in the Southern part of India

Another parameter we have used to ensure homogeneity of L1 is the script differences between L1 and L2. Script differences are particularly important because manifestation of reading impairments has shown dependency on the nature of the script (See Weekes, 2012 for a review). In bilinguals, this is further complicated by the language combination (e.g. orthography-to-phonology transparency vs opaqueness or morphological complexity) and the existence of multiple scripts (alphabetic, syllabic/alpha-syllabic and idiographic) (Eng & Obler, 2002; Weekes,2012; Weekes & Raman 2008; Law, Wong, Yeung & Weekes, 2008; Kambanaros & Weekes, 2013). In Phase II we have chosen BPWA with a combination of languages with an alphabetic and syllabic script such as alphabetic English and alpha-syllabic Indian languages namely Kannada and Hindi.

1.3.2. Reading impairments and tasks chosen in BPWA.

Reading and writing impairments in individuals, as a result of brain injury or neurologic condition, is referred to as acquired dyslexia and dysgraphia respectively (Coltheart, 1981). Acquired dyslexia is further classified into deep, surface, phonological; this classification is based on models of reading aloud developed based on studies on monolingual individuals with aphasia (Coltheart,1981; Siendenberg & McClelland, 1989). The dual-route cascaded model (DRC) developed by Coltheart et al. (2001) is the most widely used model to explain English reading but has since proven useful in other languages as well (Weekes, 2005) (See Figure 1.2). This model assumes three fundamental routes of reading, a sublexical route used for reading new words and non-words that could be used for reading regular words as well, a lexical pathway that reads known words without access to their meaning and a lexical semantic pathway that contacts the meaning of the words.

Each level of dyslexia is explained by a disruption in each pathway; phonological dyslexia by the disruption of the sublexical grapheme-to-phoneme conversion route; surface dyslexia by the disruption of the direct and/or semantic pathways that leads to overreliance on the sublexical pathway; deep dyslexia by damage to both lexical and sublexical pathways, which leads reading to occur only through the semantic pathway.

An alternative neurological model to explain reading and consequently levels of dyslexia is the ‘triangle model’ (Harm & Seidenberg, 2004; Plaut *et al.*, 1996; Seidenberg & McClelland, 1989). This postulates the existence of triangle of units (phonology, semantics and orthography) that have bi-directional pathways between them. The model postulates that reading and writing occur not by whole-word representation but rather on sub-lexical mappings with different weights between the units (see Woollams *et al.*, 2007, for instance). This model describes phonological dyslexia and dysgraphia as due to damage to the phonological pathway. Surface dyslexia is explained as an impairment of the semantic units or to the semantics-phonology pathway (Plaut, 1997). Finally, deep dyslexia results from the damage to the orthography-to-semantics and phonological pathways (Plaut & Shallice, 1993).

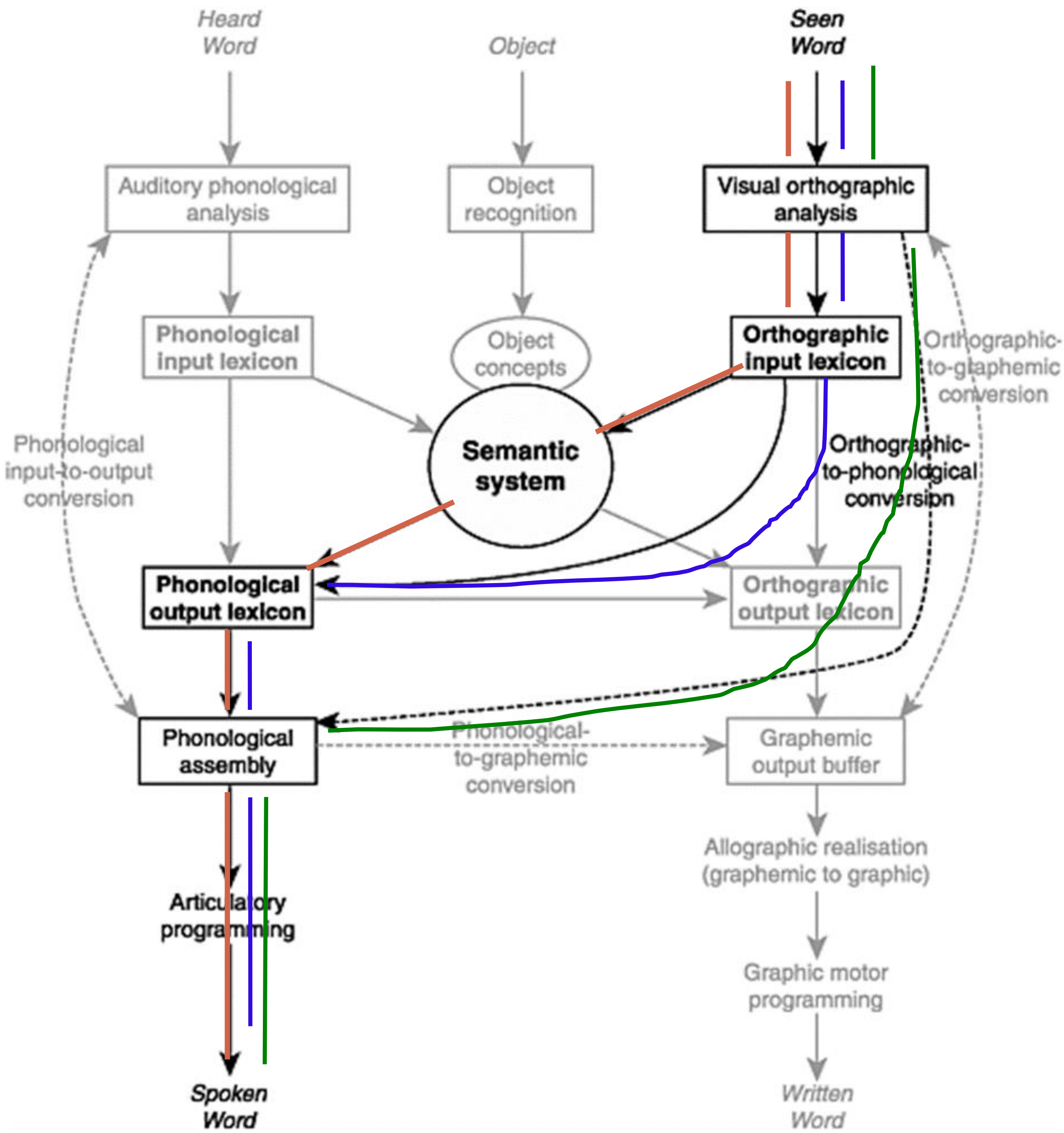


Figure 1.2 Architecture of the Dual-route cascaded model (Coltheart et al, 2001). The red markings indicate the indirect lexical route/ semantic route/indirect semantic route; the blue markings indicate the direct lexical route/direct non-semantic route and the green markings indicate the sub-lexical route/ orthography-phonology conversion route/non-lexical route.

Processing of reading and writing is driven by both neural mechanisms in the brain and the script similarity between languages themselves (Abutalebi *et al.*, 2001; Kim *et al.*, 1997, Brysbaert & Dijkstra, 2006; Weekes, 2005; Weekes *et al.*, 2007). Evidence exists that languages that have similar orthographies (such as Dutch and English) have few effects of differences in script on word recognition (Brysbaert & Dijkstra, 2006; Weekes, 2005; Weekes, Yin & Zhang 2007). Disassociations between orthographies of bilingual or bi-literate acquired dyslexia have been documented since the late 1970's and early 1980s (Karanth, 2002).

There are only a few studies on reading impairment in bi-literate bilinguals PWA in languages with two different writing systems [for instance, Japanese (Kanji & Kana) (Sasanuma, 1980), Cantonese- English (Eng & Obler, 2002), Turkish- English (Raman and Weekes, 2005), Portuguese-Japanese (Senaha & Parente, 2012)]. All of these studies have documented differential dyslexia in the respective BPWAs (See section 5.2.2 for a detailed review). There is there is an astonishing dearth of studies on reading impairment among BPWA in India, speaking the Indian languages [e.g., Kannada- English (Karanth, 1981); Kannada – English bilinguals (Ratnavalli et al., 2000); Hindi- English (Karanth, 2002). A significant limitation of all of these studies is that they have been reported as case studies on diagnostic language tests using reading and writing subtests to examine the participants' reading abilities and not really delving into the different aspects of reading such as imageability, frequency and regularity in both languages to characterise the dyslexia.

In our research, we employ a two-pronged approach which studies neurologically impaired bilingual Indians (bi-literate pre-stroke) by a) documenting and profiling the reading abilities in both the languages, b) classifying the type of dyslexia based on the dual-route cascaded (DRC) model with languages employing two different scripts (alphabetic- English, alpha-syllabic- Hindi/Kannada). As the literature clearly lacks a focused study which encompasses different aspects of reading, we have attempted to tap into different aspects of reading profile in the two languages by borrowing from the literature such as Psycholinguistic Assessment of Language Processing in Aphasia (PALPA; Kay, Lesser &

Coltheart, 1992) in English, reading subtests from Reading Acquisition Profile (RAP-K; Rao, 1997) in Kannada (used in children and adapted to adults in our study) and words from Bilingual Aphasia test -Hindi (BAT; Paradis & Libben, 1987). The tasks chosen to characterise the type of dyslexia were mapped onto the different levels of the DRC model. Letter discrimination, visual (lexical decision and legality decision) tasks, word and syllable lengths map onto the visual orthographic analysis and orthographic input lexicon. An effect of spelling sound regularity can be mapped onto the lexical route. Imageability effects implicate the semantic system and frequency effects could be attributed to the use of lexical route. The orthography to phonology conversion is responsible for non-word reading.

Our research focuses on consequences of bi-literacy in bilingual individuals in healthy and neurologically impaired. Table 1.1 provides a summary of the specific research questions and methodology of the experimental chapters.

Table 1.1

Summary of research questions and methods of experimental chapters

Chapter 2. Impact of print exposure on oral language production and comprehension in bi-literate bilingual healthy adults.	
Specific research questions	**Methods**
•To determine the differences in oral language production tasks (verbal fluency and word and non-word repetition) and comprehension measures (synonymy triplets and sentence comprehension tasks) between high print exposure and low print exposure participants. •To investigate the relationship between print exposure in L2 and measures of oral language production and comprehension.	***Participants:*** A total of thirty-four neurologically healthy bi-literate bilingual adults in the age range of 25-55 years with varying levels of print exposure in their second language were recruited for the current study. ***Objective measures of print exposure:*** Grammaticality judgement and Sentence verification task ***Language production tasks:*** Verbal fluency tasks (semantic and letter); word & non-word repetition in English ***Variables:*** Quantitative: (number of correct responses, fluency difference score), Time-course (1st RT, sub-RT, initiation, slope), Qualitative (cluster size, number of switches); number of correct word and non-word repetition; Proportion of errors. ***Comprehension measures:*** Synonymy triplets and sentence comprehension in English ***Variables:*** % Accuracy. Percent errors by grammatical structures.
Chapter 3. Impact of print exposure on narrative production in bi-literate bilingual healthy adults	
Specific research questions	**Methods**
•To determine the difference in narrative characteristics in the L2 oral narratives of healthy bi-literate bilingual adults with high print exposure in L2 (HPE) and low print exposure in L2 (LPE. •To determine the relationship between print exposure in L2 with narrative measures (utterance level measures, morphosyntactic measures, lexical	***Participants:*** Same as in Chapter 2 ***Narrative measures:*** Utterance level measures, Morpho-syntactic measures, Lexical measures, Repair measures ***Variables:*** Total Utterances, Words, % grammatical errors, Verbs per utterance, % past participle, % auxiliaries, % third person singular, % past tense, % present participle,

measures and repair measures) of L2 oral narratives.	%plurals, %nouns, TTR nouns, % verbs, TTR verbs, % adverbs, % adjectives, % prepositions, %conjunctions, %determiners, %pronouns, %Wh words and number of retraces and repetitions.

Chapter 4. Impact of print exposure on executive functions in bi-literate bilingual healthy adults

Specific research questions	**Methods**
•To determine the differences in measures of inhibition (spatial Stroop and Flankers task), working memory (visual and auditory N-back) and task switching (colour-shape task), between high print exposure and low print exposure participants.	***Participants:*** Same as in Chapter 2 ***Executive function measures:*** Spatial Stroop, Flanker, N-back (visual and auditory), color-shape task
•To determine the relationship between print exposure in L2, age and years of education with measures of inhibition, working memory and task switching.	***Variables:*** Stroop effect (RT and accuracy), Conflict effect (RT and accuracy), D' score, and switch cost (RT and accuracy)

Chapter 5. Reading difficulties in bi-literate bilingual persons with aphasia (BPWA)

Specific research questions	**Methods**
•To determine type of dyslexia in both languages of BPWA and perform cross-linguistic comparison.	***Participants:*** A total of seven bilingual persons with aphasia (BPWA) were recruited for the study, with the post- onset duration ranging from 4 months to 6 years 11 months. Four participants included for the study. Case series approach followed. ***Variables:*** *English reading:* Letter discrimination, Legality decision and visual lexical decision, spoken word picture matching, written word picture matching, non-word repetition, effect of imageability, frequency, regularity, word length, grammatical class, non-word reading. *Kannada reading:* Simple words, geminates, polysyllabic words and special words (measuring regularity).

In chapters 2-4, we focus on the bi-literate bilingual healthy population and design experiments to tease apart the consequences in terms of oral language production, comprehension and executive functions. In chapter 5, we focus on the reading impairments in bi-literate bilingual persons with aphasia and design experiments to identify how script differences affect the manifestation of reading impairment in the two languages.

Chapter 2 . Impact of print exposure on oral language production and comprehension in bi-literate bilingual healthy adults

2.1 Abstract

Background. Research has demonstrated that print exposure has an impact on oral language production and lesser impact on comprehension in monolinguals. On the other hand, studies of oral language production (such as performance on verbal fluency tasks) in bilingual population have shown mixed findings when compared to monolinguals without considering print exposure. Among bilinguals, print exposure in both languages is a further variable adding to the heterogeneity of the bilingual population. Consequently, the impact of print exposure on oral language production and comprehension in bi-literate bilingual population remains unknown.

Aim. The aim of this study was to investigate the impact of print exposure on oral language production and comprehension in bi-literate bilingual speakers with varying levels of print exposure in L2.

Methods and Procedure Thirty-four bi-literate bilingual participants were divided into a high print exposure and a low print exposure group based on their performance on print exposure. The groups were matched on years of education, age and gender. We compared the performance of these participants on a set of oral language production tasks namely semantic fluency and letter fluency task, word and non-word repetition; comprehension tasks namely synonymy triplets task and sentence comprehension task. We quantified the performance on verbal fluency in terms of quantitative (number of correct, fluency difference score); time course (First-RT, Subsequent-RT, Initiation parameter and slope and qualitatively (cluster size and number of switches). For the word and non-word repetition we quantified the performance in terms of number of correct and difference score. For the comprehension measures, we used number of correct and error analysis.

Findings. The key findings are that there were no group differences on measures of verbal fluency and overall accuracy for word and non-word repetition tasks. However, the error analyses on word and non-word repetition task showed similar pattern of errors for both groups on word repetition but a higher percentage of errors on low imageability items for LPE.

In addition, few variables (e.g., semantic fluency (CR), number of switches, non-word repetition) showed a significant positive correlation with print exposure and years of education. In contrast, the semantic comprehension measures showed significant group differences and significant positive correlations with measures of print exposure.

Conclusions and Implications. This is a first-of -its-kind study that takes into account print exposure in oral language production task and comprehension in bi-literate bilingual adults. Contrary to expectation, there was a significant impact of print exposure on semantic comprehension measures and none on oral language production measures.

2.2 Introduction

Research till date indicates that literacy has a significant impact on oral language skills (Ardila et al., 2010), cognitive processing (Barnes et al 2004) and a lesser impact on semantic comprehension (Kosmidis, Tsapkini, Folia, Vlahou, & Kiosseoglou, 2004) in monolingual adults. Studies to date in this field have compared i) illiterates vs. literates; and ii) groups of individuals with varying levels of education; but have focused on monolingual populations. Studies of oral language production in bilingual population have shown mixed findings when compared to monolinguals (Bialystok et al., 2008; Luo et al., 2010; Paap et al., 2017; Sandoval et al., 2010). Studies by Gollan et al., (2002), Rosselli et al., (2000) and Sandoval et al., (2010) show that monolinguals produced higher number of correct responses in semantic fluency tasks. On the contrary, it is established that bilinguals are at a disadvantage in tasks involving language processing such as vocabulary measures, picture naming etc (Bialystok & Luk, 2012; Ivanova & Costa, 2005). (Further details in 2.2.4)

Among bilinguals, literacy is a further variable adding to the heterogeneity of the bilingual population. A bi- literate bilingual is an individual who can read, write, understand and speak more than one language (Ng, 2015). As with bilingualism, the degree of bi-literacy will vary amongst individuals. Interest in bi-literacy has emerged only recently; it's effect on linguistic and cognitive performance remains largely unknown (Reyes, 2012). Literacy is sometimes referred to as the acquisition of reading and writing (eg., Bialystok, Luk & Kwan, 2005; Reyes, 2012) and sometimes measured based on level of education, schooling or text exposure (Kosmidis et al, 2006; Silva et al, 2012; Cunningham and Stanovich, 1991). For this research, we use the term 'print exposure' as a proxy for 'literacy'. We define print exposure as the quantitative measure of literacy derived from the use of print material in one language. This incorporates the advantages of different literacy measures. We measure print exposure subjectively by using self-reported ratings of frequency of reading in each language, proficiency of reading and writing in different contexts of a bilingual healthy adult. Print exposure is measured objectively by using a grammaticality judgement task and sentence verification task.

In this chapter we will discuss our methods and results of exploring the impact of print exposure on oral language production and comprehension within a bi-literate bilingual population. Within this introduction we review the literature of impact of print exposure on oral language production (2.2.1), impact of print exposure on comprehension (2.2.3), oral language production and comprehension in the bilingual population (2.2.4), measuring print exposure and bilingual status (2.2.5) and gaps in the literature (2.2.6). We then present the overarching goal derived from our investigations of literature (2.3). We present the methods used in our study starting with discussing the participant profile (2.4.1), our methods for measuring language proficiency, dominance and print exposure (2.4.2), the experimental measures used (2.4.3) for oral language production (2.4.4 & 2.4.5) and comprehension (2.4.6). We discuss the statistical analyses used (2.5) and the results in the same order as the methods (2.6). Finally, we discuss the results in 2.7.

2.2.1 Impact of print exposure on oral language production tasks

Research has shown that print exposure and reading ability contribute to differences in lexical and syntactic language production measures such as verbal fluency (Ardila et al 2010; Kosmidis, Tsapkini, Folia, Vlahou, & Kiosseoglou, 2004), non-word repetition (Kosmidis, Tsapkini, Folia, 2006) in monolingual healthy adults. Kosmidis et al (2004) used semantic fluency and letter fluency task in the Greek language where illiterates performed comparably to low literates on semantic fluency task; whereas illiterates performed poorer than low literates on letter fluency. Kosmidis, Tsapkini & Folia (2006) found that there was no difference on the word repetition across illiterates, low education and high education groups, however on the non-word repetition task the illiterates performed poorer than the other two groups of literates suggesting a literacy effect However, most of the research on these relationships has occurred in the monolingual population. Little is known about the relationship between print exposure and oral language production in bilingual adults. Understanding this relationship becomes relevant in the context of growing bi-literate bilingual population in the world. However, there are a few studies examining the relationship between print exposure and oral language production in bilingual children. Therefore, we focus on reviewing the studies with monolingual populations and bilingual children exploring the relationship between print exposure and several oral language production tasks.

Katz et al (2012) examined the performance of a lexical decision task and a naming task to predict reading skills (using decoding, sight word recognition, fluency, vocabulary and comprehension) and speech factors closely related to reading i.e., phonological awareness and rapid naming. This study recruited a cohort of 99 college students with varying reading abilities. In this study, the lexical decision tasks highlight the cognitive processes used in identifying printed text. It was hypothesised that the performance on the lexical decision task would reflect the levels of print exposure. Reading ability was measured using the following tests- the Woodcock-Johnson III Diagnostic Reading Battery (WJ, Woodcock, Mather, & Schrank, 2004), the Test of Word Reading Efficiency, Form A (TOWRE; Torgesen, Wagner, & Rashotte, 1999) and the Gray Oral Reading Test-4, Form A (GORT, 2001). Vocabulary size was measured using the Peabody Picture Vocabulary Test, Form A (PPVT; Dunn & Dunn, 2007) and subtests from the Woodcock-Johnson Diagnostic Reading Battery (WJ) (Woodcock, Mather & Schrank, 2004) and the Weschler Abbreviated Scale of Intelligence (WASI) (Weschler, 1999). Findings suggested that participants with larger vocabularies had lower reaction times on lexical decision task; however, this correlation was not very strong ($r<0.5$). The interpretation of this finding is that, higher print exposure would naturally increase vocabulary size. The major limitation of this study is lack of use of a standardised tool such as LexTale (Lemhöfer, & Broersma, 2012) which prevents easy comparison with other similar studies.

Cunningham and Stanovich (1991) investigated the impact of print exposure on verbal fluency and vocabulary. This study recruited children from fourth, fifth and sixth grades with cohort sizes of 34, 33 and 67 children in each grade respectively. A modified version of the Title recognition Test (Stanovich & West, 1989) was used as a proxy to measure print exposure. The Title recognition test consisted of 39 items in total of which 25 were genuine book titles and 14 foils for titles. The titles were chosen to be books outside the curriculum to probe reading outside the classroom. Children were asked to read the list of titles and mark the titles they identified as books. Within their cohort, children were divided into high print exposure group (high Title recognition score) and low print exposure group (low Title recognition score) based on a median spilt of the scores. As a next step, the low print exposure from each cohort were combined to form a larger set of low print exposure cohort (low Title recognition score) and similarly for the high print exposure group (high Title recognition score). The results revealed that Title recognition test was significantly correlated to measures of verbal fluency and vocabulary (as measured by the Peabody Picture Vocabulary Test – Revised (Dunn & Dunn, 1981)). This suggests that Title recognition test predicts both verbal fluency and vocabulary. The limitations of the study are firstly the Title recognition test requires a tailor-made set of items for each school making it difficult to generalise and use it as a standard tool in research. Secondly, while the Title recognition test may have been a good measure of print exposure then (early 90s), it does not account for the gamut of print resources available in the present day (e.g. online resources, e-books etc). Finally, to adapt this to adults is still more challenging considering the range of print resources used by adults such as books, online resources, newspapers and academic reading material.

Montag and MacDonald (2015) examined the effects of print exposure on spoken language production using the frequency of relative clauses in child-directed speech and children's literature in a corpus analyses and a picture description task. The written corpus yielded higher number of passives compared to objective-relative clauses. Consequently, in the written corpus analyses the study infers that children with higher print exposure experience passive constructions more frequently. In the picture description part of the study- 30 undergraduate students, 30 eight-year olds and 30 twelve years olds were tested. Print exposure was measured differently for adults and children. For adults they used the Author Recognition Task (Acheson, Wells and MacDonald, 2008); and for children, a modified version of the Title Recognition Test (Cunningham and Stanovich, 1991) was used. For the three groups a picture description task was used to elicit object and passive relative clauses. Results showed text exposure and age predicted production choices; older individuals and those with higher rates of text exposure produced more passive constructions. The authors conclude that print exposure can impact spoken production.

In monolingual adults, the focus of research has been to understand the relationship between print exposure and oral language production tasks mainly comparing illiterates and literates, and literates with different levels of education or informal screening of literacy levels.

da Silva et al., (2004) examined a population of monolingual adults to investigate whether education affects the qualitative aspects of verbal fluency. Their participants were 37 females split into two groups – 19 literates and 18 illiterates. They were administered a category fluency task for concrete (supermarket items) and less concrete (animals) categories. Print exposure (literacy) was measured using a combination of letter identification task, a reading comprehension task and a writing of words. They found that illiterates performed on par with the literates on the category fluency task for categories which were more concrete (such as supermarket items-edible things which have more sensori-motor realisations, hence considered more concrete), but for less concrete (such as animals) there was a difference in performance between the illiterates and literates. Two additional results of this study were, that firstly there was a significant difference in the number of switches between the two groups, literates having more switches, secondly the illiterates tended to produce larger clusters even though the mean cluster size was not significantly different. The poor performance of illiterates on these tasks was attributed to the over reliance on semantic processing due to an inadequacy in phonological processing. This difference in grapheme-phoneme correspondence between the two groups results in a disadvantage in illiterates specifically on the tasks of phonological processing such as word repetition, non-word repetition and letter fluency that are found in other studies (Castro-Caldas, Petersson, Reis, Stone-Elander, & Ingvar, 1998; Kosmidis, Tsapkini, & Folia, 2006; Reis & Castro-Caldas, 1997). This is a significant limitation of this study, where the authors have not examined letter fluency that taps into the phonological processing. In our study, we aim to quantify this effect (print exposure/literacy on oral language production) using both measures of verbal fluency- letter and semantic fluency. We have incorporated different analysis techniques such as quantitative (number of correct), qualitative (clustering and switching) and time course analyses.

Petersson et al, (2000) compared Positron Emission Tomography (PET) images of 3 literate and 3 illiterate adults undertaking a simple, auditory verbal repetition task. The task included word and pseudo-word items. Results showed the illiterate group used neural interactions differently across words / pseudo-words whereas there were no significant differences for the literate group. Differences between the two groups were not significant for words, however there were differences for pseudo-words. The authors concluded that acquisition of orthographic language skills modulates auditory verbal language networks in the human brain.

Manly et al (1999) examined the effects of print exposure using a neuropsychological test battery in adults over 65 years with 0- 3 years of education. A total of 251 participants were recruited for this study. The tasks administered (that are relevant to the current chapter) were naming [using Boston naming test (Kaplan et al., 1983)], letter fluency and category fluency (animals, food and clothing). Print exposure was documented by self-report. The findings suggest that illiterates performed poorer than literates on naming and letter fluency task. Consequently, no significant differences were noted on the category fluency task. The authors suggest that the difference in performance on naming could be because the drawings were ambiguous or less recognisable by the illiterate cohort. Correspondingly, in the letter fluency task the difference may be due to the fact that the illiterates being unaware of phoneme-grapheme correspondence. The findings of category fluency were in-line with previous research by Reis and Castro-Caldas (1997) and da Silva et al (2004). A severe drawback of this study was that print exposure was measured subjectively and not objectively measured using a tool. The current understanding is that a combination of both objective and subjective measures would be more effective than using any measure alone(Luk & Bialystok, 2013) in assessing these measures.

Some researchers have used different levels of education to differentiate among literates. Kosmidis et al., (2004) investigated the distinction between processing information in semantic fluency and letter fluency task in the Greek language. The demographics of this study consisted of 19 illiterate women (mean age: 71.95 years) and another age-matched group of 20 women who had attended school from 1-9 years. The third group of 21 women who had progressed beyond the basic level of education i.e., greater than 10 years. This naturally split the participant cohort into illiterate, low literate (low education) and high literate (high education), They administered the semantic fluency task (animals, fruits, objects) and letter fluency task (chi, sigma, alpha) in Greek and carried out a cluster analysis. It was observed that illiterates performed comparably to low literates (clusters of same size) on semantic fluency task whereas in letter fluency illiterates performed poorer than lower literates. Therefore, literacy seems to have the most impact on tasks of phonological processing even when controlled for years of education.

Kosmidis, Tsapkini & Folia (2006) studied the lexical decision and word and non-word repetition for measuring the effect of literacy/ education on lexical processing in Greek. The participant cohort was the same as Kosmidis et al (2004). The stimuli for repetition task consisted of real words and non-words which were read in a mixed order. Scoring was done based on the number of correctly repeated words and non-words. The same stimuli were used for lexical decision task where the participants had to judge whether the presented stimuli were a word or not. They found that there was no difference on the word repetition across illiterates, low education and high education groups, however on the non-word repetition task the illiterates performed poorer than the other two groups of literates suggesting a literacy effect for non-word repetition. This reduced performance of illiterates on non-word repetition was attributed to the illiterates lacking knowledge of grapheme-phoneme correspondence, therefore resorting to semantic information to process the auditory stimuli (Castro-Caldas et al., 1998). For the lexical decision task, there was a gradation in performance of the three groups with the high education group performing better than the low education group and the illiterate group's performance being the poorest among the three groups. This suggests that there was a distinct education effect observed on lexical processing.

A study by Ratcliff et al (1998) claimed that literacy is a crucial factor for phonemic processing. They used education level as a marker for literacy. They administered a semantic fluency (animals and fruits) and Letter fluency (P&S) task on three groups of adults aged 34-35 years (Hindi speaking monolinguals). The groups consisted of 30 participants with no formal education) 30 participants with 5 years of education and 30 participant 10 years of education. They found a main effect of task (category scores > letter fluency score) and main effect of level of education (higher education participants performed better). There was also a greater effect of education on the letter fluency task. The authors posit that due to sensitivity of letter fluency scores to the level of literacy, the letter fluency task is an important task to be included when measuring the impact of literacy. Not all tasks that measure a given cognitive function such as verbal fluency are equivalent. The factors limiting performance are presumably different for different population dynamics. Consequently, measures of letter fluency from studies such as Ratcliff et al (1998) form the baseline for a given population. Similarly, our current study could form the baseline for Indian diasporic bi-literate bilingual population.

In sum, there seems to be a discrepancy in how print exposure is measured and documented. Every measure has advantages as well as disadvantages. Some researchers have used education level as a marker for categorizing literates as high vs. low literates (Ratcliff et al., 1998; Kosmidis et al., 2004) while others have used literacy levels as a marker in literates showing that high literates perform better than low literates on oral language production tasks (non-word repetition, verbal fluency) (Kosmidis et al., 2004 & Kosmidis et al., 2006) or literacy tertiles based on performance on a literacy task (reading words) where literacy was associated with better cognitive function (Barnes, Tager, Satariano & Yaffe, 2004). These authors tested a continuum of participants from illiterates to high literates (prolific readers with advance vocabularies) on North American Adult Reading Test (NAART), word reading with irregular spellings. Weiss et al (1995) used reading level as measured by a bilingual measure of reading comprehension and found it to be more related to MMSE scores than years of education, age or ethnicity. Studies on bi-literacy acquisition, have used literacy instruction to measure print exposure (Proctor et al ,2005; Bialystok, Luk and Kwan, 2009).

From the methodological perspective, measurement of print exposure using measures such as Title recognition test has its limitations and a more robust measurement tool for print exposure is necessary. Moreover, none of the above-mentioned techniques can be directly applied to measure print exposure in bi-literate bilingual adults as these does not account for the gamut of print resources available in the present day (e.g. online resources, e-books etc). Finally, to adapt this to adults is still more challenging considering the range of print resources used by adults such as books, online resources, newspapers and academic reading material.

Drawing upon the literature, we have addressed the issue of measuring print exposure in bi-literate bilingual adults in this research by measuring print exposure in both languages of bi-literates using a subjective rating scale of reading and writing in both L1 and L2. Consequently, we have also used two objective measures for measuring print exposure in L2 namely, grammaticality judgment task and sentence verification task. With these measures we strive to improve the preciseness of measuring print exposure (literacy).

Furthermore, print exposure seems to predict well measures such as verbal fluency, word and non-word repetition, syntactic verbal output and comprehension abilities to some extent. However, it is not clear whether the same relationship exists in the bi-literate bilingual adult population. An important part of studying language production requires us to understand how individuals integrate current input with prior knowledge to evolve a mental representation

(Birren and Schaie, 2006). Therefore, for measuring oral language production, we will use verbal fluency measures (semantic and letter fluency) adapted from Patra, Bose & Marinis (2018) and word and non-word repetition task from Psycholinguistic assessment of language processing in aphasia (PALPA, Kay, Lesser & Coltheart, 1992).

2.2.3. Impact of print exposure on language comprehension

Reis and Castro-Caldas (1997) discuss a three-path language processing which include semantic, lexical and phonological strategies believed to be functioning in parallel. Processing of semantic information is considered to be innate whereas the phonological information is explicitly learned through acquiring phoneme-grapheme correspondence. The authors state that literates have access to both lexico-semantic and phonological pathways in contrast to illiterates who have no access or limited to the phonological pathway. Thus, illiterates have a deficit in phonological processing (Manly et al., 1999; Morais, Cary, Alegria, & Bertelson, 1979). Therefore, they tend to rely on semantic processing strategies alone. There have been reports in the past suggesting that literacy has a lesser impact on semantic tasks as semantic ability is an innate ability and it is not affected by education (Kosmidis et al., 2004).

One study by Manly et al (1999) examined the effects of print exposure on auditory comprehension in adults over 65 years with 0- 3 years of education. A total of 251 participants were recruited for this study. They administered an auditory comprehension task using first six items of the Complex Ideational Material subtest of the BDAE (Goodglass & Kaplan, 1983). They found significant print exposure related differences (literates better than illiterates) on the BDAE Comprehension subtest. They relate the findings to literacy acquisition in children, where preliterate children have difficulty understanding reversible sentences (Scribner & Cole, 1981). Such reversible sentences have been used in The BDAE Complex Ideational Material subtest (e.g., "Do two pounds of sugar weigh more than one?") which adult illiterates also have problems interpreting (Lecours et al., 1987; Rosselli et al., 1990). They attribute the poor performance of the illiterates to lack of exposure to written language. This exposure in literates provides them with practice in interpretation of complex sentences in which subject–object order is varied, and in decoding logical relationships from language, that is lacking in illiterates.

There are a few studies examining the relationship between print exposure and oral semantic processing in monolingual children and some in bi-literate bilingual children. One such study by Nation and Snowling (1998) examined semantic processing and development of word recognition skills between two groups of children. This consisted of 16 normal readers and 16 poor comprehenders between 6-11 years of age. They used two tasks- synonym judgement and rhyme judgement, of which synonym judgement is relevant to our current discussion. This task consisted of 40 items out of which 20 were synonyms and 20 were non-synonyms. The pairs were matched for frequency and imageability. The results show that the poor comprehenders were slower and made a greater number of errors on synonym judgements. Their findings offer support poor comprehenders have weaker semantic skills as compared to normal readers.

Research has demonstrated that listening comprehension can be used as a proxy for general oral language skill, additionally this is a crucial component in the reading process (Gough and Tunmer, 1986, Aarnoutse, van den Bos, & Brand-Gruwel, 1998; Hoover& Gough, 1990; Juel, Griffith, & Gough, 1986). Hedrick and Cunningham (1995), working with intermediate elementary students, used hierarchical regression techniques to explore the unique variation in reading outcomes explained by listening comprehension. Their results suggested a bi-directional relationship between reading and listening comprehension i.e., strong listening comprehension skills were associated with positive reading outcomes, whereas skilled readers also tended to display more strongly developed listening comprehension.

Listening comprehension has shown to be an important component of oral language skill even in bilinguals. A study by Proctor et al (2005) investigated if L2 reading skills can predict L1 literacy skills in a sample of 132 Spanish-English bilingual children (in elementary school). 91 of these children received literacy instruction in Spanish and 41 received literacy instruction in English. A Computer-Based Academic Assessment System (Sinatra & Royer,1993) was used to measure decoding skills (alphabetic knowledge and fluency), and the Woodcock Language Proficiency Battery was used to measure vocabulary knowledge, listening comprehension, and reading comprehension. They found that children who received English instruction outperformed children with Spanish instruction in all of the experimental tasks and the difference was most significant in listening comprehension task.

To summarise, we find that in adults, print exposure has a limited role on semantic processing and comprehension. However, in children (monolingual and bilingual) since they are still in literacy acquisition phase, print exposure seems to have a significant impact. In bilingual adults, there is not enough evidence to derive any relationship between the aforementioned variables. This study fills that gap.

An important part of studying language production requires us to understand how individuals integrate current input with prior knowledge to evolve a mental representation (Birren and Schaie, 2006). In order to understand this, along with oral language production, language comprehension also needs to be addressed. Consequently, in our study along with oral language production, we also investigate the effect of print exposure on comprehension. Hence, we decided to assess comprehension at the word level and sentence level using the synonymy triplets' task from the Philadelphia comprehension battery (Saffran, Schwartz, Linebarger, Martin & Bochetto, 1988) and sentence comprehension task taken from the Test for Reception of Grammar-2 (TROG-2) (Bishop, 2003) respectively.

2.2.4. Oral language production and comprehension in the bilingual population

The literature summarised so far focus on the impact of print exposure on oral language production and comprehension within the monolingual adult population and minority number on bilingual child population. However, studying language and literacy in monolinguals is not representative of bilingualism and bi-literacy (Grosjean, 2010). There is little knowledge on impact of oral language production and comprehension in bi-literate bilingual adults. This is important as a majority of bilinguals who are literates are also bi-literates. Many studies on bilinguals have demonstrated bilingual differences (even though there is no consensus on a bilingual advantage) in performance on various language production tasks such as verbal fluency (Bialystok et al., 2008; Luo et al., 2010; Paap et al., 2017; Sandoval et al., 2010).

Verbal fluency has been studied as a measure of lexical access in monolinguals and bilinguals showing mixed findings (Bialystok et al., 2008; Luo et al., 2010; Paap et al., 2017; Sandoval et al., 2010). Verbal fluency taps into both linguistic components (Fernaeus et al, 2008) and executive functioning (Ostberg et al, 2005). Studies by Gollan et al., (2002), Rosselli et al., (2000) and Sandoval et al., (2010) show that monolinguals produced higher number of correct responses in semantic fluency tasks. Conversely, Bialystok et al (2008) found that this advantage disappeared when the groups were matched on receptive vocabulary. The reverse result has been identified in letter fluency, i.e., in matched groups bilinguals outperform monolinguals (Luo et al., 2010).

On the contrary, it is established that bilinguals are at a disadvantage in tasks involving language processing such as vocabulary measures, picture naming (Bialystok & Luk, 2012; Ivanova & Costa, 2005). None of the above-mentioned studies clearly specify whether their bilingual population tested were bi-literates and hence fail to discuss the differences if any exhibited by bi-literate bilinguals on similar tasks.

Research on bi-literacy is still in the nascent state and comparison can be drawn from bi-literacy acquisition in children. For instance, Bialystok, Luk & Kwan (2005) measured decoding abilities in 5-7-year-old monolingual and bilingual children. A cohort size of 132 children were divided into four distinct groups- English monolingual (40), Cantonese–English bilingual (29), Hebrew–English bilingual (30), and Spanish–English bilingual (33). Choice of groups were motivated by the similarity relationships of the languages and writing systems. The degree of bilingualism in the three bilingual groups were matched using parental report, Peabody Picture Vocabulary Test scores and education. The bilingual groups received literacy instruction in both the languages. The tasks administered were- forward and backward digit span task, phoneme counting and non-word decoding task. The results revealed that for two of these groups, Hebrew and Spanish bilinguals, literacy advantage was more significant in English compared to the other groups. Similarly, the children in these two advanced groups revealed a strong correlation between their nonword decoding skills in the two languages. The Chinese bilingual group performed similar to monolinguals in all the tasks, implying no benefit of their unique language profile. The authors conclude that languages which have similar writing systems (alphabetic) tend to benefit the bilinguals enhancing their performance in all the tested tasks.

Consequent to reviewing these studies, what remains unclear is whether bilinguals with two different writing systems (for example Indian bilinguals speaking alphabetic English and alpha-syllabic Kannada) would show the same trend? Currently, the impact of print exposure on oral language production and comprehension have not been explored in bi-literate bilingual adults with different writing systems. Consequently, this leads to the question of whether the results observed in children will translate to adults and if so by how much?

From the above literature, it is clear that print exposure seems to predict well measures such as verbal fluency, word and non-word repetition, syntactic verbal output and comprehension abilities to a measurable extent. However, it is not clear whether the same relationship exists in the bi-literate bilingual adult population. Globally, research on biliteracy is still in the nascent state with studies emerging focusing mostly on biliteracy acquisition in children (Bialystok, Luk & Kwan, 2005; Reyes, 2012) and none thus far targeting the adult population. Bilingualism research in adults has focused on the cognitive-linguistic aspects not clearly specifying or defining bi-literacy. Despite the clear benefits of bilingualism and literacy, what remains unanswered is whether bi-literate-bilinguals exhibit differences in oral language production tasks mediated by print exposure in L2. For example, do people with higher print exposure in L2 produce more accurate responses on a verbal fluency task compared to low print exposure(L2)?

In addition, there seems to be a discrepancy in how print exposure is measured and documented. Therefore, the gaps existing in the literature which need to be addressed are with respect to the fact that most of the research on print exposure/literacy has primarily dealt with the monolingual population. The research on oral language production and comprehension in bilingual population has shown mixed results and does not take into account if the bilinguals in question were also bi-literates. This therefore poses a question on how bi-literacy would impact oral language production in bilinguals and whether it would actually result in creating an additional advantage for the bilinguals.

The aim of the present study was to examine the impact of print exposure on oral language production and comprehension in bi-literate bilingual healthy adults with varying levels of print exposure in L2. We have measured print exposure in L2 using objective measures (grammaticality judgement and sentence verification) and also subjectively documented the print exposure in L1 and L2.

Furthermore, as this is a bi-literate bilingual study, it is important to gather information on the extent of bilingualism in terms of language proficiency, dominance and language usage of the participants in modalities such as listening and speaking along with reading and writing (print exposure) in both L1 and L2 (Grosjean, 1998; Marian & Neisser, 2000; Birdsong, 2014). Therefore, in the current study we have profiled the participants for their language proficiency, dominance, current language usage using a subjective rating scale in both L1 and L2 and objectively using lexical decision task and picture naming task in L2.

We have used both semantic and letter fluency as well as word-nonword repetition to investigate the impact of print exposure on oral language production at the word level in bi-literate bilingual speakers with varying levels of print exposure in L2. Additionally, we examine the semantic comprehension abilities in bi-literate bilinguals using synonymy triplets task and sentence comprehension task.

In this study, in addition to number of correct (CR), we use a number of methods such as time course analysis, cluster and switching analysis to characterize verbal fluency (Luo et al., 2010; Troyer, Moscovitch, & Winocur, 1997). These measures have been adapted from (Patra, Bose & Marinis, 2018). Table 2.1 (Patra, Bose & Marinis, 2018) describes these measures and variables. We also use verbal fluency measures used in Patra, Bose & Marinis (2018) to delve deeper into our data.

Time-course analysis contributes to the understanding of linguistic knowledge and executive control in verbal fluency (Luo et al., 2010; Sandoval et al., 2010). Time course analysis revealed that high-vocabulary bilinguals generated higher number of correct responses and demonstrated a longer Sub-RT and a flatter slope than the monolinguals. We are using time-course analysis to examine if print exposure has a significant impact in bi-literate bilinguals' word production.

Clustering is the strategic process that helps to generate words within a subcategory and utilizes the speaker's ability to access words within subcategories. A breakdown in the lexical system or difficulty to access the lexical system could lead to the reduction in cluster size (Troyer, Moscovitch, Winocur, Alexander, & Stuss, 1998). There have been reports of cluster size being affected by levels of print exposure in monolinguals (Kosmidis et al., 2004).

Switching is the ability to shift efficiently to a new subcategory when a subcategory is exhausted; reduced switching is suggestive of reduced executive control ability (Troyer et al., 1997; Tröster et al., 1998). Research on print exposure/literacy (in monolinguals) and bilingual population (without considering print exposure levels) has shown that both clustering and switching abilities contribute to the total number of correct responses; however, in category fluency, clustering accounts for more of the variance for number of correct; whilst in letter fluency, switching accounts for more of the variance for number of correct. Thus, clustering and switching analysis provides another well-established means to inform the linguistic and executive debate for bi-literate bilinguals. We use clustering and switching analysis to inform the linguistic and executive aspect for bi-literate bilinguals with different levels of print exposure

Table 2.1

Contribution of Verbal Fluency Variables to the Linguistic and Executive Control Components

Parameters	Definition	Significance	**Linguistic process**	**Executive control processes**
Quantitative				
1. Number of correct responses	Number of responses produced in one minute excluding any errors (e.g. cross-linguistic, words from different category for semantic fluency and different letters for letter fluency, repetition, non-word etc).	Measures word retrieval abilities.	√	√
2. Fluency difference score	Differences in the number of correct responses between semantic and letter fluency conditions as a proportion of correct responses in the semantic fluency condition.	Measures the ability to maintain the performance in the difficult condition.		√
Time course				
1. 1st RT	Time duration from the beginning of the trial to the onset of first response.	Preparation time to initiate the response.	√	
2. Sub-RT	Average of time intervals from the onset of first response to the onset of each subsequent response.	Measures the word retrieval latency.		√
3. Initiation	Starting point of the logarithmic function that is the value of y when t =1 or *ln*(t) =0 (e.g. initiation parameter for the above-mentioned logarithmic function is y = 4.31 -1.312 *ln* (1) = 4.31 – 0 =4.31).	Measures the initial linguistic resources or vocabulary available to perform the task.	√	
4. Slope	Shape of the curve (e.g. slope value for the logarithmic function *y* = 4.31 - 1.312 *ln* (1) is -1.312)	Measures the word retrieval speed across the time duration of the task.		√
Qualitative				
1. Cluster size	Number of successive words produced within a semantic subcategory (e.g. African animals, Pets, etc.) or number of successive words which fulfil certain criteria (e.g. begin with first two letters, rhyme words, etc.) in the letter fluency condition.	Strategy to perform efficiently by searching the available linguistic resources in the present subcategory.	√	
2. Number of switches	Number of transitions between two clusters, one cluster to a single word, one single word to another cluster, or between two single words.	Strategy to perform efficiently by switching into a newer subcategory when the search process is exhausted for the present subcategory.		√

Adapted from Patra, Bose & Marinis (2019)

We recruited thirty-four participants and classified them into high print exposure and low print exposure based on their performance in two literacy tasks. The groups were matched on years of education, age and gender. We collected and collated information on the following variables: language history, education details, occupational status, current language usage, language proficiency (which includes reading and writing) and dominance. All the participants were bi-literate bilinguals from South India residing in the UK. The participants spoke one of the Dravidian languages (Malayalam, Kannada, Tamil, Telugu) as their native language and English as their second language. These Dravidian languages are alpha-syllabic in nature and more transparent as compared to English which is alphabetic. We compared the performance of these participants on a set of oral language production tasks namely -semantic fluency and letter fluency task, word and non-word repetition; comprehension tasks namely synonymy triplets task and sentence comprehension task.

We quantified the performance on verbal fluency in terms of quantitative (number of correct, fluency difference score); time course (First-RT, Subsequent-RT, Initiation parameter and slope and qualitatively (cluster size and number of switches). For the word and non-word repetition we quantified the performance in terms of number of correct and difference score. For the comprehension measures, we used number of correct and error analysis.

To address this aim, we used a set of oral language production tasks and comprehension measures and posed the following predictions:

1. To determine the differences in oral language production tasks (verbal fluency and word and non-word repetition) between high print exposure and low print exposure participants.

   We hypothesised that the high print exposure and low print exposure participants would perform similar on semantic fluency tasks as print exposure does not directly impact semantic knowledge. However, we predicted that the participants in the high print exposure group would perform better (higher number of words) than low print exposure group on letter fluency condition. We expected, participants in the high print exposure group to have a smaller fluency difference score; a smaller cluster size and greater number of switches and in the time-course analysis, longer Sub-RT and flatter slope in letter fluency.

We also predicted that the participants in the high print exposure group would produce a greater number of correct words and non-words than low print exposure group on word and non-word repetition task, as print exposure seems to have a positive impact on word and non-word repetition.

2. To determine if the performance on comprehension measures (synonymy triplets and sentence comprehension tasks) are mediated by the differences in L2 print exposure.
   We predicted that there would be no differences between the high and low print exposure groups on both the comprehension measures as we expected that print exposure would not have a direct influence on semantic comprehension.

3. To investigate the correlations between print exposure in L2 and measures of oral language production and comprehension.
   We hypothesised that there would be a strong and positive correlation between print exposure in L2 and measures of oral language production tasks in L2. Since we expected no direct link between print exposure and comprehension measures, we hypothesised that there would be no significant correlations between print exposure in L2 and measures of comprehension on L2 (% accuracy on synonymy triplets and sentence comprehension task).

2.4 Methods

2.4.1 Participant profile

A total of thirty-four neurologically healthy adults in the age range of 25-55 years with varying levels of print exposure in their second language were recruited for the current study. Participants were bi-literate bilinguals being able to read and write in the two languages that they spoke. The aim was to classify them into high and low print exposure groups based on print exposure in L2 as measured by grammaticality judgement and sentence verification task (See section 2.4.2.1.2.3 & 2.4.2.1.2.4). All the participants belonged to a cohort of bi/multilinguals speaking one of the south Indian languages (either Kannada/Tamil/ Telugu/ Malayalam) as their native language and English as their second language. All the participants were immigrants living in parts of Berkshire county, London or other regions of the UK. They acquired both the languages before the age of ten years. The participants were fluent in both the native language and English. Participation in this study was voluntary and a written consent was obtained from the participants prior to participation in the study (See Appendix. 2.5 for an example of information sheet and consent form). All the procedures in this study were approved by the University of Reading Research Ethics Committee (Ethical approval code: 2015-071-AB).

All the participants reported that they were right-handed and had normal or corrected to normal vision, no history of associated hearing problems and no previous history of speech, language, cognitive and neurological deficits. The participants were screened on the Montreal Cognitive Assessment (MOCA; Nassredine,2010) to rule out the presence of any underlying cognitive deficits. To be included in the study, the participants had to be bi-literate bilingual adults with their L1 being one of the Dravidian languages; should have had a minimum of ten years of education. Participants with a history of any neurological and/or speech and language problems were excluded from the study.

All the participants were administered a detailed questionnaire to collect information with respect to their demographic details (age, gender, educational qualification, years of education, occupation, handedness).

A background questionnaire was used to collect information about the demographic details (age, gender, years of education, current occupational status) of all participants. The mean and standard deviation values and the results of the statistical tests for the demographic details of the participants are presented in table 2.2. Appendix 2.1 provides raw scores of each participant for all the background measures (age, gender, years of education, occupation). The participants in both groups had wide range of occupations. The participants in the high print exposure group were university students (4), post-doctoral researchers (2), lecturer (1), homemakers (2), managers (4), nurse (2), software engineer (2), business analyst (1), web developer (2), tax assistant (1) and banking executive (1). Participants in the low print exposure group were university students (3), homemaker (2), nurse (1), software engineer (2), social worker (1), saleswoman (1), pharmacy dispenser (1) and research assistant (1). Independent sample t-tests were performed where data was normally distributed and Mann-Whitney U tests were performed where data was non-normally distributed. There was no significant difference between high print exposure and low print exposure groups on measures of age, years of education and gender. The participants in both the groups were highly educated as evident from their years of education (HPE: M= 17.68 years; LPE: M= 16.08 years).

Table 2.2

Mean (M), Minimum (Min) and Maximum (Max) values and statistical results of the demographic variables

Measures	High Print Exposure (N=22)			Low Print Exposure (N=12)			Statistical Results
	M	Min-Max	SD	M	Min-Max	SD	
Age (years)	34.50	25-52	7.28	33.41	24-46	8.01	t(32) = 0.4, p=0.69
Years of education	17.68	15-22	2.12	16.08	13-17	1.24	U^1 = 82, p=0.06
MOCA	28.41	26-30	1.09	27.08	26-30	1.44	U^1 = 202.50, p=0.009**
Gender	N			N			$X^2(1)$ = 0.064, p=0.80
Male	10			6			
Female	12			6			

[1]– Mann-Whitney U test; * p<.05, ** p<0.01.

2.4.2. Background measures.

The participants were assessed on various measures to document and profile their characteristics of bilingualism and print exposure. In this section, we discuss the language background measures used.

2.4.2.1 Measuring bilingualism and print exposure. The participants were assessed both subjectively and objectively to document and characterize their bilingualism and print exposure. The summary of background measures is outlined in table 2.3 and 2.4.

2.4.2.1.1 Subjective Measures of Language Proficiency and Dominance Language proficiency and dominance were assessed subjectively by adapting the questionnaires available in the literature to suit the current study. For assessing language proficiency, the adapted questionnaire (from Li, Sepanski, & Zhao, 2006; Birdsong et al, 2012; Luk & Bialystok, 2013; Munoz, 2000) included the following sections-Language history/background, Language Usage and Language Proficiency (including reading & writing to assess print exposure in both languages) (see Appendix 2.2). Language dominance was assessed using Bilingual Dominance Scale (BDS; Dunn & FoxTree, 2009) which includes the following sections: age of acquisition, L1 & L2 usage and restructuring (See Appendix 2.2).

Table 2.3

Background subjective measures of language proficiency and dominance

Subjective Measures of Language proficiency and dominance						
Measures	Materials Used	Details	Time taken	L1(Kannada, Tamil, Telugu, Malayalam)	L2 (English)	Scores Obtained
Language history/background, Language Usage and Language Proficiency (including print exposure in reading & writing)	Questionnaire adapted from (Li, Sepanski, & Zhao, 2006; Birdsong et al,2012; Luk & Bialystok, 2013; Munoz, 1999)	1. Demographic Details (8 Questions) 2. Language Background & History (4 Questions) 3. Educational History (2 Questions) 4. Current Language Usage & Frequency of Usage (5-point rating scale; 1- Not at all & 5-Very often) 5. Language Proficiency Rating (7-point rating scale; 1- Very poor & 7- Native like)	15 minutes	✓	✓	Descriptive (Qualitative Analysis) - Rating scale for current Language Usage & Frequency of Usage (5-point rating scale; 1-Not at all & 5-Very often) Greater score in one language implies greater use of that language. -Rating scale for proficiency: 7-point rating scale (1- very poor; 7- native-like). Greater score in one language implies higher proficiency in that language.
Language Dominance	Bilingual Dominance Scale (BDS)(Dunn & Fox Tree, 2009)	1. Age of acquisition, 2. L1 & L2 usage 3. Restructuring	15 minutes	✓	✓	Weighted Scoring System Eg: Which country do you currently live in? Score: +4 for predominant language of country. Dominant language is the language which obtains a greater score than the other language

Table 2.4

Background objective measures of language proficiency and print exposure

Objective measures of language proficiency and print exposure						
Objective Measures	Tasks	Materials Used	Details	Time taken	L2(English)	Scores Obtained
Language Proficiency	1.Lexical decision task (Comprehension)	Lex-Tale (Lemhofer & Broersma, 2011)	Visual lexical decision	10 minutes	✓	Objective measure of English vocabulary knowledge. Reaction time and Accuracy Measure (% Accuracy)
	2.Naming (Production)	Boston Naming Test (Kaplan, Goodglass & Weintraub, 1983) &	60 pictures in English	15 minutes	✓	Reaction time and Accuracy Measure (% Accuracy)
Print exposure in L2	1.Grammaticality Judgement Task	Philadelphia Comprehension Battery (Saffran, Schwartz, Linebarger, Martin & Bochetto, 1988)	30 Grammatical sentences 30 Ungrammatical sentences	15 minutes	✓	Total number of correct responses and incorrect responses. (%Accuracy) Total score= 60
	2.Sentence Verification task	Adapted from Royer, Greene & Sinatra (1987	6- passages to read in English 12 sentences for each passage	15 minutes	✓	Total number of correct responses (Sentences having same meaning as in passage) (%Accuracy) Total score =72

2.4.2.1.2 Objective measures. Language proficiency was assessed using a lexical decision task based on LexTale (Lemhöfer & Broersma, 2012) and a picture naming task based on Boston Naming test (Kaplan, Goodglass, & Weintraub, 1983). The participants were objectively assessed on their print exposure in their second language (L2) by administering a grammaticality judgement task taken from the Philadelphia Comprehension battery (Saffran, Schwartz, Linebarger, Martin, & Bochetto, 1988) and a sentence verification task (adapted from Royer, Greene & Sinatra, 1987).

2.4.2.1.2.1 Lexical decision task. Lexical decision task is a visual word identification task where the participant has to decide whether the letter string presented corresponds to a word in the target language or not. The LexTALE has been used as a measure of language proficiency (Lemhöfer & Broersma, 2012; DeBruin, Carreiras & Dunabeitia, 2017) as it is quick to administer and easily implemented. This task was programmed on version 2.0 of E-prime software. Three practice items were presented to familiarise the participants with the task. The stimuli consisted of 60 items with forty words and twenty non-words presented in two blocks of 30 items in each block. The participants were instructed to press the 'm' key if the stimuli presented was a word or the 'z' key if the stimuli presented was a non-word. Both reaction time and accuracy were extracted from E-prime output file.

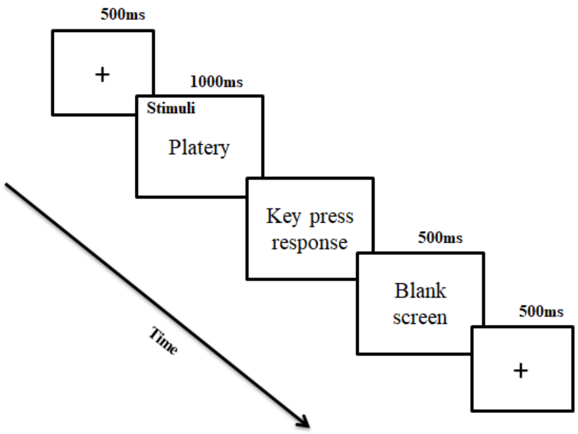


Figure 2.1 Illustration of visual lexical decision task trial

2.4.2.1.2.2 Picture naming task. Picture naming task was used as a proxy for language proficiency assessing expressive vocabulary (Gollan et al., 2012; DeBruin, Carreiras & Dunabeitia, 2017). This task was tested using stimuli from the Boston naming test (Kaplan, Goodglass, & Weintraub, 1983). Sixty-line drawings were used to assess their naming ability in L2. The pictures were presented in two blocks with the first block consisting of 30 pictures followed by 30 pictures in the second block. Both reaction time and accuracy were measured. A typical trial on the picture naming task is schematically represented in Figure 2.2. A short beep of approximately 350 milliseconds was presented simultaneously with the picture stimuli, this acted as the cue for measuring reaction time. The verbal response was recorded with the voice key on E-prime and a Dictaphone.

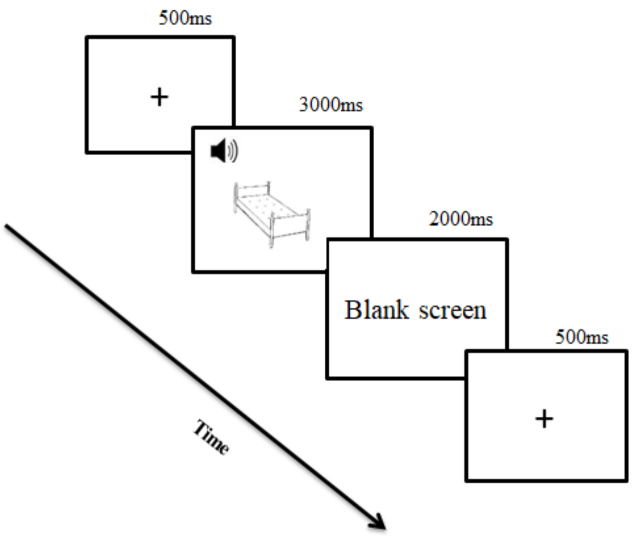


Figure 2.2 Illustration of picture naming trial for Boston Naming Test

2.4.2.1.2.2.1 Reaction time analyses. The recorded verbal responses were analysed using PRAAT software (Boersma & David, 2015). The audio file was time stamped manually to extract the reaction time for each picture stimuli. The reaction time was measured by the researcher from the onset of the beep to the onset of the verbal response. Any hesitations, false starts were ignored. An example of time-stamping a verbal response is given in Figure 2.3. In the current example, the reaction time for the word 'tree' is 810 milliseconds.

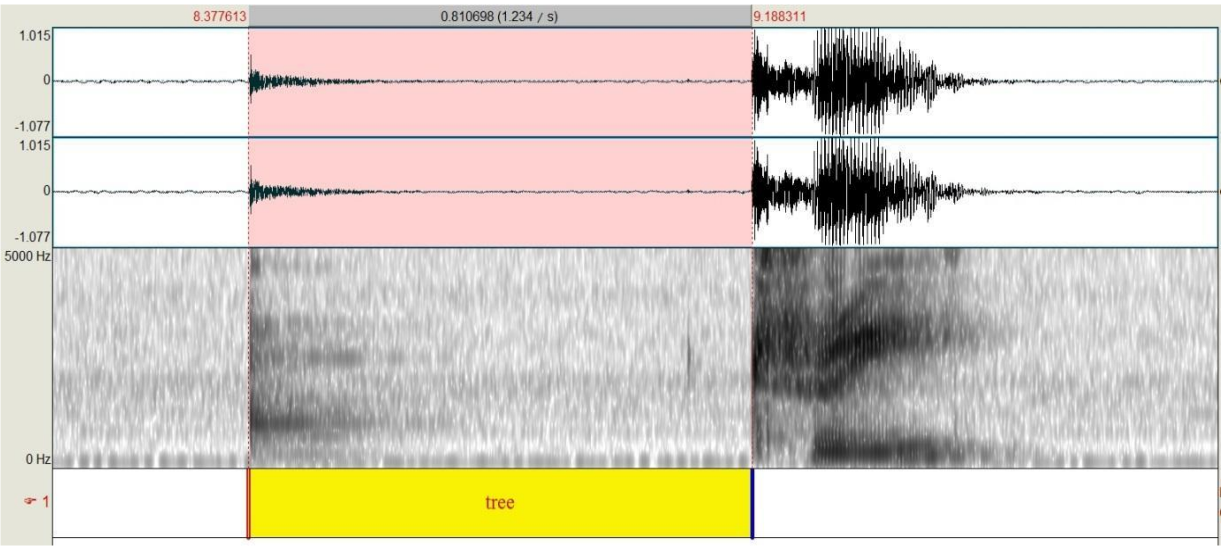


Figure 2.3 An example of time-stamping of verbal response elicited during a picture naming task. The red line to the left indicates the 'onset of the beep' and the blue line to the right denotes the 'onset of the verbal response' (the word 'tree'). The duration between these two lines is the reaction time for the word 'tree' which is 810 milliseconds.

2.4.2.1.2.2.2 Detecting and Excluding Outliers. The standard convention followed for excluding outliers have been to use either mean plus or minus 2, 2.5 or 3 standard deviations (Miller, 1991; Ratcliff, 1993). The problems which can span out with these methods are, the assumption that it is a normally distributed sample, both mean and standard deviation are affected by extreme values (Leys, Ley, Klein, Bernard & Licata, 2013) and this method is not efficient enough to detect outliers in smaller samples (Cousineau and Chartier, 2010). Therefore, in the present study we have used the Median absolute deviation as a more robust measure (Leys, Ley, Klein, Bernard & Licata, 2013) and this overcomes the shortcomings of the previous methods using mean. We have used median plus or minus 2.5 times the Median absolute deviation method for outlier detection for all the reaction time tasks.

2.4.2.1.2.3 Grammaticality judgment task. Grammaticality judgement task is a task where the participant is presented with sentences and then asked to judge whether the sentences are grammatically correct or not. Sentences from the Philadelphia Comprehension Battery (Saffran, Schwartz, Linebarger, Martin, & Bochetto, 1988) were chosen and were presented auditorily through headphones using E-prime software (version 2.0). The participants were presented fifteen sentences for practice. A total of 60 sentences were presented in four blocks with 15 sentences in each block. The stimuli list is given in Appendix 2.3. Each trial consisted of a fixation cross which appeared on the screen for 1000ms followed by the stimuli sentence presented through headphones and the participant responded with a key press. The participants were instructed to respond with a key press of letter 'm' if the sentence was grammatically correct or press 'z' when the sentence was grammatically incorrect. For example, for the following sentence stimulus- 'The farmer is planting corn', the participant was expected to press 'm' which indicates that the sentence is grammatically correct while for the sentence stimulus- 'The girl jumped the pool into', the participant was expected to press 'z' which indicates the sentence is grammatically incorrect. A score of one was given for accurate judgement of the task and a zero for an incorrect response. The maximum score that a participant could receive was 60.

2.4.2.1.2.4 Sentence Verification task (Adapted from Royer, Greene & Sinatra (1987) Sentence verification task measures the comprehension of a specific text (Royer et al, 1987; Hagen et al, 2014). The participants were given a total of six passages to read followed by a series of sentences relating to the passage. There were four types of sentences- originals (exact copies of the sentence in the text), paraphrases (same meaning but the words were changed), meaning change (many words replaced from the original such that the meaning is altered) and distractors (sentence relating to the same topic, but different in words and unrelated in meaning). After reading each passage, the participants were given a set of 12 sentences (3 in each sentence type) relating to the passage. The participants were expected to read each passage and decide whether the information in the statements was already present in the passage they read (originals and paraphrases) or whether it was new information (meaning changes and distractors). See Appendix 2.4 for stimuli. A score of one was given if the correct option was chosen, the maximum score that could be obtained was 72.

2.4.2.1 Results from the background subjective and objective measures of language proficiency, dominance and print exposure. The subjective measures of proficiency (speaking, listening, reading, writing) were non-normally distributed, therefore Mann-Whitney U test was performed. Language use and language dominance scores were normally distributed, independent sample t-tests were performed. All the objective measures of proficiency were normally distributed except sentence verification task. A multivariate ANOVA was performed for lexical decision and picture naming task with reaction time and accuracy as dependent variables; groups as independent variables. Independent sample t-tests were performed for grammaticality judgement tasks and Mann-Whitney U test for sentence verification task.

The mean and standard deviation values and results of the statistical tests of the participants' subjective language profile in L1 and L2 are presented in Table 2.5. There was no significant difference between HPE and LPE on language proficiency ratings in L1 (speaking, listening, reading and writing); indicating that these groups were matched on their L1 proficiency. However, the two groups performed similar on all modalities of proficiency rating in L2 except reading. The proficiency rating for reading in L2 was significantly higher for HPE ($M=6.31$, $SD = 0.80$) compared to LPE ($M=5.25$, $SD =1.73$). Current language use was predominantly English for the HPE; but was balanced usage of L1 and English for LPE. There was no significant difference between L1 and L2 for HPE group on language dominance; suggesting that the participants in HPE were balanced bilinguals. However, there was a significant difference between L1 and L2 for the LPE group on language dominance measure, with L1 (M= 19.50, SD=3.45) being dominant than L2 (M= 14.67, SD =4.75). This suggests that LPE group were L1 dominant. Both the groups acquired reading and writing in L1 around the same age (HPE: M= 4.68, SD=2.3; LPE: 4.75, SD=1.16), however there was a significant difference between HPE and LPE in L2 reading and writing acquisition (HPE: M= 4.68, SD=2.11; LPE: 7.5, SD=2.84).

The two groups were significantly different on the objective language proficiency measures (See table 2.6). The participants in the HPE group (RT: M= 674.59, SD= 65.27; Accuracy: M = 41.23, SD = 7.03) performed significantly better on both the RT and accuracy of lexical decision task compared to the LPE group (RT: M= 737.07, SD= 65.87; Accuracy: M = 33.58, SD = 9.31). This suggests that the HPE were faster and more accurate in lexical decision compared to LPE. There was a statistically significant difference in picture naming accuracy between the two groups, $F(1,32) = 9.17$, $p = 0.005$. The two groups also differed significantly on measures of print exposure in L2 i.e., grammaticality judgement and sentence verification task. In comparison to the LPE, HPE performed significantly better which is indicative of higher print exposure in L2

Table 2.5

Mean (M), Minimum (Min) and Maximum (Max) values and statistical results of Participants' Subjective Language Profile

Subjective Measures	**High print exposure (HPE)**						**Low print exposure (LPE)**						**Statistical results**	
	L1[1]			L2[2]			L1[1]			L2[2]				
	Min-Max	M	SD	Min-Max	M	SD	Min-Max	M	SD	Min-Max	M	SD	L1 comparison across HPE vs. LPE	L2 comparison across HPE vs. LPE
Reading and writing acquisition (in years)	2-12	4.68	2.3	2-10	4.68	2.11	3-6	4.75	1.16	4-13	7.5	2.84	U[6]=105, p = .16	U[6]=54, p = 0.002
Frequency of reading print[7]	1-4	2.31	1.42	1-4	1.63	0.88	1-4	2.41	0.95	1-4	1.83	1.14	U[6]=125, p = .4	U[6]=128, p = .44
Language proficiency rating[7]														
Speaking	2-7	6.02[3]	1.36	4-7	6.06	.86	5.5-7	6.62	.56	3-7	5.41	1.29	U[6]=102.50, p = .24	U[6]=169.50, p = .16
Listening	2-7	6.27[3]	1.26	4.5-7	6.18	.82	5.5-7	6.58	.63	3-7	5.54	1.11	U[6]=120, p = .64	U[6]=178, p = .09
Reading	1-7	5.40[3]	1.99	4-7	6.31	.80	4-7	6.5	.90	1-7	5.25	1.73	U[6]=90, p = .09	U[6]=189.5, p = .03*
Writing	1-7	4.70[3]	2.25	3-7	6.0	1.04	1.5-7	5.95	1.65	1-7	5.37	1.73	U[6]=87, p = .09	U[6]=160, p = .30
Language Use[7]	1.83-5	2.98[4]	0.74	2.83-5	4.10	.71	2.50-4.16	3.27	.58	1.3-5	3.52	1.0	t(32)= -1.14,p =.262	t(32)= 1.95, p = .059
Language Dominance[8]	7-27	18.41[5]	4.51	11-26	17.86	4.63	12-25	19.50	3.45	7-21	14.67	4.75	L1 vs. L2[9] (HPE) t(42)=.39, p= .69	L1 vs. L2[9] (LPE) t(22)= 2.85, p= .009**

[1]-L1 of participants was one of the Dravidian languages (Kannada, Malayalam, Tamil or Telugu); [2]-L2 of participants was always English; [3]- on a scale of one to seven (1= very poor;7= native like), greater score in one language means greater proficiency in that language;[4]-on a scale of one to five (1= not at all; 5= very often), greater score in one language means greater frequency of usage of that language; [5]-maximum possible score was 31, dominant language is the language which obtains a greater score than the other language;[6]- Mann-Whitney U test; [7]- adapted from Munoz, Marquardt & Copeland (1999); [7]-Frequency of reading print (books, newspapers, magazines)on a scale of one to four (1= daily; 2= few times a week ; 3 = weekly; 4=monthly); [8]- adapted from Dunn & Fox Tree, 2009.[9]- For language dominance comparison, we compare L1 and L2 within groups i.e. L1 vs. L2 within HPE & L1 vs. L2 within LPE. **p<.05, **p<0.01.*

Table 2.6

Mean (M), Minimum (Min) and Maximum (Max) values and statistical results of Participants' Objective Measures.

Objective Measures		**High print exposure (HPE) (N=22)**			**Low print exposure (LPE)(N=12)**			**Statistical results**
		Min-Max	M	SD	Min-Max	M	SD	
Language proficiency in L2								
Lexical decision task (Lex-tale)[1]	RT	573.66 - 806.26	674.59	65.27	649.85 - 809.10	737.07	65.87	F(1,32) = 7.06, p=0.01*
	Accuracy	25-53	41.23	7.03	17-47	33.58	9.31	F(1,32) = 7.27, p=0.011*
	% Accuracy	41.67-88.33	68.71	11.45	28.33-78.33	55.9	14.86	
Picture naming[2]	RT	498.78 -1058.90	762.55	174.56	435.96 – 1081.68	634.50	197.49	F(1,32) = 3.81, p = 0.06
	Accuracy	26 – 49	35.41	6.38	20 -42	28.42	6.52	F(1,32) = 9.17, p = 0.005**
	% Accuracy	43.33-81.67	59.01	10.39	33.3-70	47.3	10.41	
Print exposure in L2								
Grammaticality judgement task[3]	Accuracy	42-57	49.09	3.74	33-49	41.17	5.58	t(32) = 4.94, p <0.001***
	% Accuracy	60-95	81.81	6.19	55-81.67	68.6	9.75	
Sentence Verification task[4]	Accuracy	59-69	65.91	2.91	51-62	57.67	3.25	U[5] = 12, p <0.001***
	% Accuracy	81.9-95.8	91.5	3.98	70.83-86.11	80.09	5.61	

[1]- Lex-Tale (Lemhofer & Broersma, 2011) ,measure of English receptive vocabulary knowledge, maximum possible score is 60, higher score (accuracy) indicates better receptive vocabulary knowledge; [2]- Maximum possible score is 60, higher score indicates better expressive vocabulary; [3]-maximum possible score is 60, higher score indicates higher print exposure in L2; [4]- maximum possible score is 72, higher score indicates higher print exposure in L2;[6]- Mann-Whitney U test; ****p<0.001,**p<0.01 *p<0.05.*

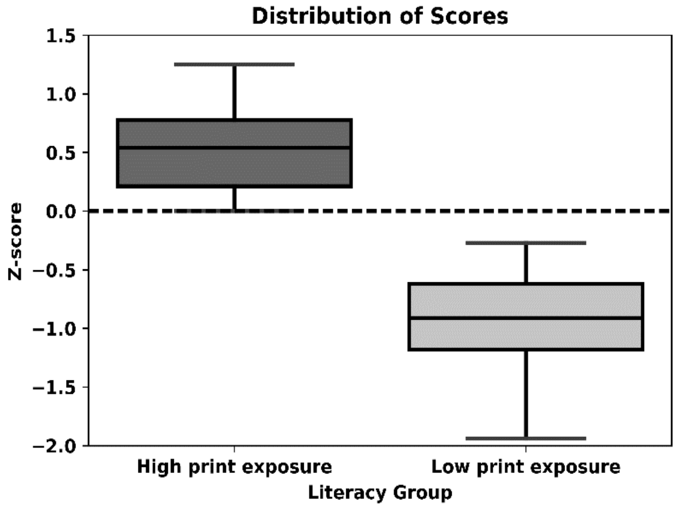


Figure 2.4 Grouping of participants based on z- composite score derived from grammaticality judgement and sentence verification task. 'Zero' was considered as the arbitrary cut-off. Participants with a z-score greater than '0' were grouped as high print exposure (HPE) and participants with a z-score less than '0' were grouped as low print exposure (LPE)

2.4.2.2 Grouping of participants based on L2 print exposure Past research has used several parameters to measure print exposure. For example, Cognitive z-scores and literacy tertiles (Barnes, Tager, Satariano & Yaffe, 2004); reading level as measured by reading comprehension (Weiss et al, 1995), years of education (Tsegaye, DeBleser & Iribarren, 2011). In the current study, we have used both subjective and objective measures to account for the print exposure. The ratings of reading and writing in both languages was used to document print exposure in both languages subjectively. Objectively, print exposure in L2 was measured using grammaticality judgment task and sentence verification task.

We used both the objective measures of print exposure to determine the print exposure in L2. The raw scores obtained from the grammaticality judgement task (out of 60) and sentence verification task (out of 72) for each participant were converted to z-scores (See Figure 2.4). These z-scores were then averaged to derive a z-composite score. The scores ranged from -2.14 to 1.27. Zero was arbitrarily chosen as a cut off. Participants with a z-composite score of less than zero were categorised as low print exposure, and if they had a score greater than zero, they were grouped as high print exposure. This resulted in a total of 22 participants in the high print exposure group and 12 participants in the low print exposure group.

2.4.3 Experimental measures.

The participants were administered a set of oral language production and comprehension tasks, which will be discussed in this section. Table 2.7 summarises the experimental tasks used in the study.

Table 2.7

Experimental measures of oral language production and comprehension and relevant variables used in the analyses. All the experimental tasks were administered in L2 (English).

Tasks		**Materials used**	**Number of Trials**	**Details of stimuli**	**Variables obtained**
			Oral language production		
Verbal Fluency	Semantic Fluency	Animals, clothing and food items	3	Number of items produced in each category within 60 seconds.	**Quantitative** 1.Number of correct responses (CR) 2.Fluency Difference score **Time course** 3.First RT 4.Sub RT 5.Initiation 6.Slope **Qualitative** 7.Cluster size 8.Number of switches
	Letter Fluency	F & S	2	Number of words produced starting with the designated letter within 60 seconds.	
Word Repetition and Non-word Repetition		Psycholinguistic Assessment of Language Processing in Aphasia (PALPA) (Kay, Lesser & Coltheart,1992)		(80 words; 80 non-words) (20 in each of the 4 conditions – high imageability-high frequency, low imageability-low frequency, high imageability- low frequency & low imageability-high frequency).	1. % Accuracy across conditions 2. Total percent accuracy 3. Difference score 4. % errors by condition
			Semantic Comprehension		
Synonymy triplets task		Philadelphia Comprehension Battery (Saffran, Schwartz, Linebarger, Martin & Bochetto, 1988)		15 Verbs 15 Nouns Total= 30	1. % Accuracy across conditions 2. Total percent accuracy
Sentence Comprehension task		The test for Reception of Grammar- Version 2 (TROG-2) (Bishop, 2003)	14 blocks X 4 trials	56 four choice items in 4 blocks with varying grammatical complexity	1. % Accuracy. 2. Percent errors by grammatical structures: Percentage of incorrect responses produced across each of the 14 grammatical structures tested: Reversible above and below, Relative clause in object, Singular/plural inflection, X but not Y, Relative clause in subject, Not only X but also Y, Pronoun gender/number, Comparative/absolute, Neither nor, Reversible passive, Pronoun binding, Centre-embedded sentence, Zero anaphor, Postmodified subject.

2.4.4 Verbal Fluency measures

2.4.4.1 Trials and procedures. All the participants were administered two verbal fluency conditions- semantic and letter fluency in English. They were expected to produce as many words as possible in sixty seconds. For the semantic fluency condition, participants were instructed to produce as many words as possible in three categories- animals, clothing and food. For the semantic fluency condition, the participants were instructed to avoid repetitions. For the letter fluency condition, participants were instructed to produce as many words as possible starting with letters F and S. The restrictions imposed on the letter fluency condition were not to produce proper nouns (e.g., Australia) or numbers (e.g., six) or same word with different word endings (e.g., friend, friends, friendly). Each participant was tested individually. The orders of the fluency conditions were randomised across participants; however, the trials were blocked by condition. A beep was presented at the beginning of the trial to ensure there was a definite starting point for each trial. Responses were recorded using a Dictaphone and later analysed to extract the relevant variables.

2.4.4.2 Data coding and analysis. The responses including repetitions and errors were coded verbatim. Each correct response was time-stamped using PRAAT (Boersma & David, 2015). The time stamping helps mark the onset of the trial (i.e., beep) to the onset of the response. The variables extracted from time stamping were used in the time-course analyses which will be discussed later.

2.4.4.2.1 Total number of correct responses (CR). CR was calculated after excluding the errors. The errors in semantic fluency task were- words not belonging to the target category (eg., *apple* for animal category), repetition of the same words or cross-language intrusions. For the letter fluency task, the errors were words beginning with a different letter (eg., *old* as a response to letter A), repetition of the same words (were counted as a single CR), proper nouns (eg., *Singapore* for letter S) and same words with different word endings (eg., friend, friends, friendly were counted as a single CR) or cross-linguistic intrusions.

2.4.4.2.2 Fluency Difference score (FDS). The FDS was calculated by subtracting the mean letter fluency score ($CR_{\text{letter fluency}}$) from the mean semantic fluency score ($CR_{\text{semantic fluency}}$) and then dividing the difference by the mean semantic fluency score ($CR_{\text{semantic fluency}}$) for each participant.

$$FDS = (CR_{\text{semantic fluency}} - CR_{\text{letter fluency}}) / CR_{\text{semantic fluency}}$$

2.4.4.2.3 Time-course analysis. In line with Luo et al., (2010) recommendation, the following four variables were considered: First RT; Subsequent RT; Initiation parameter; and Slope. Based on the time stamping, CRs were grouped into 5-second bins for every 60 seconds trial which resulted in 12 bins. The group means of CR in each of the twelve bins were calculated for each semantic and letter fluency trial. The means of CRs for each trial were plotted using a line graph (x-variable, bins; y-variable, mean CR). This graph was then fitted with a logarithmic function. An example of a logarithmic function (see figure 2.5) is $y = 2.75 - 0.55\ln(t)$, where y is the estimated value of the function at different points in time (t). Two central measures derived from this plot were – initiation parameter and slope.

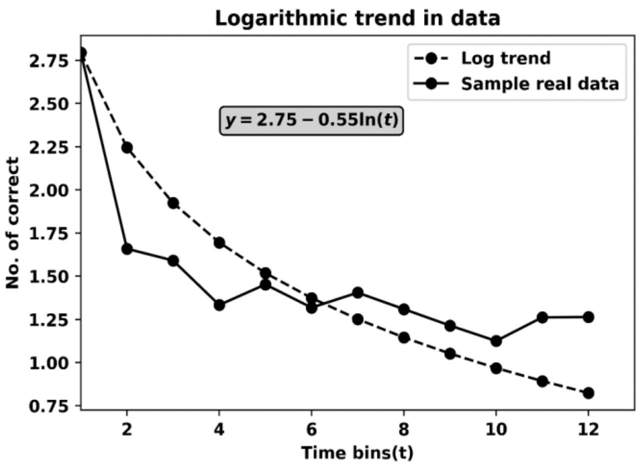


Figure 2.5 Time course of correct responses over twelve 5-second bins. Best fit line is logarithmic function. The solid line represents the mean number of correct (CR) of a sample participant in 60 seconds split into 12-time bins (5-second bin each). The dotted line indicates the best fit line with a logarithmic function used to fit the sample data.

2.4.4.2.3.1 First-RT. The first-RT is the time interval from the beginning of the trial (from the beep) to the onset of the first response. The first response usually takes longer than the subsequent responses and this delay in first response has been attributed to task preparation (Rohrer, Wixted, Salmon, & Butters, 1995).

2.4.4.2.3.2 Subsequent-RT (Sub-RT). Sub-RT is the average value of the time intervals from the onset of first response to the onset of each subsequent response. Thus, Sub-RT provides a good estimate of mean retrieval latency and represents the time point at which half of the total responses have been generated (Sandoval et al., 2010). A longer mean Sub-RT indicates that the performance extends later into the time course, but interpretation of this variable depends on the total number of correct (Luo et al., 2010). In comparing two groups, if one group produces more correct responses than another group and has longer mean Sub-RT, then it could be interpreted that this group has superior control and could continue generating responses longer. If one group produces fewer or equivalent correct responses but has longer mean Sub-RT, then it could be interpreted that this group has an effortful control as it took longer to produce the same or fewer number of items. In contrast, a shorter mean Sub-RT would suggest a faster declining rate of retrieval because of a large proportion of the responses were produced early during the trial.

2.4.4.2.3.3 Initiation parameter. The initiation parameter is the starting point of the logarithmic function that is the value of y when $t = 1$ or $\ln(t) = 0$ (eg., initiation parameter for the above-mentioned logarithmic function is $y = 2.75 - 0.55 \ln(1) = 2.75 - 0 = 2.75$). Initiation parameter indicates the initial linguistic resources or breath of lexical items available for the initial burst when the trial begins and is largely determined by vocabulary knowledge.

2.4.4.2.3.4 Slope. Slope is determined by the shape of the curve and refers to the rate of retrieval output as a function of the change in time over sixty seconds. Slope for the above example would be 0.55. It is representative of how the linguistic resources are monitored and used over time and is largely determined by executive control. Flatter slope indicates that participants were able to maintain their performance across the response period despite greater lexical interference (e.g., avoiding repetition, searching for words from the already exhausted vocabulary source) towards the end of the trial, reflecting better executive control.

2.4.4.2.4 Qualitative analysis. Based on Troyer et al (1997) study, we carried out clustering and switching analyses. Repetitions were included for clustering and switching analyses. Semantic fluency clustering was defined as words produced successively that shared a semantic sub-category. (e.g., goat, sheep and cow belonged to the sub-category of farm animals) Letter fluency clustering was defined as words generated successively fulfilling one of the following criteria (Troyer et al., 1997): words that begin with the same first two letters (e.g., flick, flip); words that differ only by a vowel sound regardless of the actual spelling (e.g., son, sun); words that rhyme (e.g., fame, frame); or words that are homonyms (e.g., sheep, ship). Appendix 2.6 provides details of sub-categories. Owing to clustering of responses, the following variables were generated-

2.4.4.2.4.1 Mean cluster size. Cluster size was calculated beginning with the second word in each cluster. A single word was given a cluster size of zero (e.g., snake belongs to cluster ‘reptiles’ and cluster size of zero), two-word clusters was given a cluster size of one (e.g., cat, dog belong to cluster ‘pets’ with a cluster size of one), three-word clusters was given a cluster size of two (e.g., donkey, buffalo, pig belong to the cluster of ‘farm animals’ with a cluster size of two) and so on. Mean cluster size for a trial was calculated by adding the size of each cluster and dividing the total score by the number of clusters.

2.4.4.2.4.2 Number of switches. Number of switches was the number of transitions between clusters. For example, in semantic fluency the responses lion, tiger; cat, dog; kangaroo, koala bear contains two switches from tiger → cat and dog →kangaroo. Similarly, for letter fluency, the responses frustrate, frown; flick, flip; fun, fundamental; fit contains three switches from frown → flick, flip → fun and fundamental → fit.

2.4.5 Word and non-word repetition

2.4.5.1 Trials and procedures. The participants were presented eighty words and eighty non-words from the Psycholinguistic Assessment of Language Processing in Aphasia (PALPA) (Kay, Lesser & Coltheart,1992). The stimuli were controlled for imageability and frequency with twenty in each of the 4 conditions: high imageability- high frequency (e.g., words: radio, hospital ;Non-words: ragio, hopsital), low imageability-low frequency (e.g., words: analogy, miracle ;Non-words: atalogy, minacle), high imageability- low frequency (e.g., words: cart, spider ;Non-words: calt, spuder) & low imageability-high frequency(e.g., words: concept, opinion ;Non-words: boncept, opunion).The full list of stimuli is provided in the Appendix 2.7. The words and non-words were interspersed in different blocks. Within each block, the words and non-words were pseudorandomised ensuring that not more than four words or four non-words occurred in succession.

The words and non-words were pre-recorded by the researcher and presented auditorily using headphones via the E-Prime (Psychology Software Tools, Pittsburgh, PA). A fixation cross appeared on the screen for 500 ms acting as a cue for the stimuli. The presentation of the stimuli was manually controlled by the researcher based on the comfort of the participants. The participants were instructed to repeat exactly what they heard. Six words and six non-words were presented as practice items prior to the actual trial to familiarise the participants with the task. Responses were recorded with a Dictaphone and later analysed.

2.4.5.2 Data coding and analysis. All responses were transcribed. A response was marked as accurate if it was exactly same as the target stimuli. Total number of correct word repetitions and total number of correct non-word repetitions were calculated after excluding the errors. Total number of correct responses was calculated by adding the total number of correct word repetitions and total number of correct non-word repetitions. Percentage accuracy was computed for word repetition and non-word repetition separately on a maximum value of 80. Total percent accuracy was calculated by averaging the percentage accuracy of word repetitions and non-word repetitions. The error responses were also examined to see if there was a pattern of errors.

2.4.5.2.1 Difference score. The difference score was calculated by subtracting the total number of correct non-word repetitions from the total number of word repetitions for each participant.

2.4.6 Comprehension measures

2.4.6.1 Synonymy triplets task. The stimuli were taken from the Philadelphia comprehension battery (Saffran, Schwartz, Linebarger, Martin & Bochetto, 1988). This consisted of a total of 30 stimuli items which included fifteen nouns and fifteen verbs (See Appendix 2.8)

2.4.6.1.1 Trials and procedure. The stimuli were presented on a power point slide. Each presentation consisted of three nouns or verbs on the screen, the participants were expected to point to two words which were closest in meaning. For example, when the following three words were presented on the screen- (violin, fiddle, clarinet), the participant had to choose violin and fiddle as these words are closest in meaning. To familiarise the participants to the task, four practice items were administered prior to the actual test items.

2.4.6.1.2 Data coding and analysis. A score of one was assigned for the correct response and zero for an incorrect response. Accuracy score was calculated by adding the number of correct responses in each trial excluding the errors. The maximum obtainable score was 30. Percentage accuracy was computed for the total number of correct responses on a maximum score of 30.

2.4.6.1.4 Error analysis. The stimuli included both nouns and verbs and therefore we further looked at examining whether the participants exhibited more errors in nouns or verbs.

2.4.6.2 Sentence comprehension task. The test for Reception of Grammar- Version 2 (TROG-2) (Bishop, 2003) was used to measure sentence comprehension of all participants. It is a receptive language test which assesses understanding of English grammatical contrasts marked by inflection, function words and word order. The test consists of 80 four-choice items arranged in 20 blocks. The blocks are arranged in increasing order of difficulty. Each block consists of four items. (See Appendix 2.9 for stimuli).

2.4.6.2.1 Trials and procedures. The participants were shown four pictures on a page and were instructed to point to the picture that corresponds to the test sentence said. Eg: When the tester said the sentence- *'The girl is sitting'*, the participant was expected to point to the picture that corresponded to what was said out of the four pictures (See figure 2.6). To familiarise the participant with the task, a practice item was administered. No further feedback or assistance was given during the test. The test sentence was repeated if needed. Each participant was tested individually. The responses were noted in the record form.

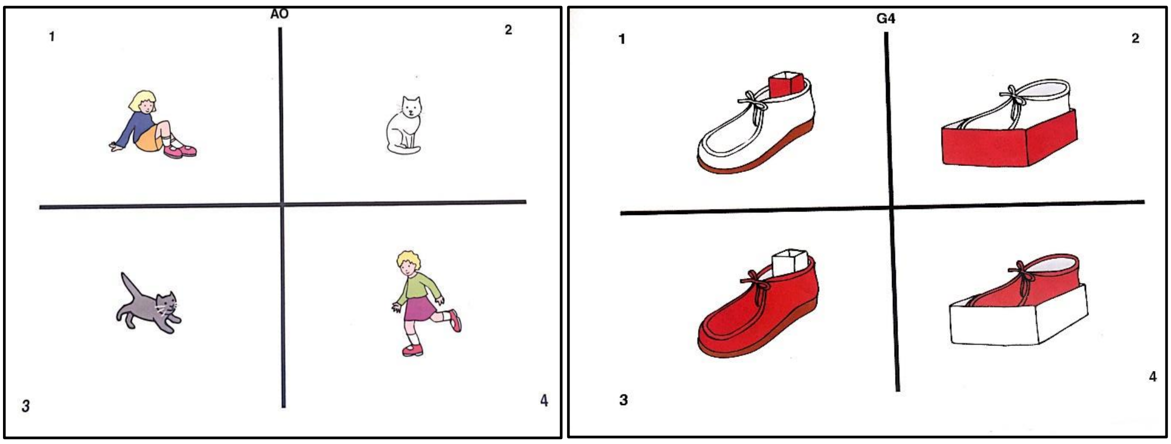


Figure 2.6 Example stimuli for sentence comprehension. On the left panel, the target sentence is 'The girl is sitting', participant is expected to point to 1. On the right panel, the target sentence is 'The shoe that is red is in the box', participant is expected to point to 4.

2.4.6.2.2 Data coding and analysis. One point was given for each correct response and a score of zero for an incorrect response. The following variables were measured-

2.4.6.2.3 Accuracy score. Accuracy score was calculated by adding the number of correct responses in each block excluding the errors. The maximum obtainable score was 80. Percentage accuracy was computed for the total number of correct responses on a maximum score of 80.

2.4.6.2.4 Block-wise error analysis. Each block corresponded to a grammatical structure. Therefore, we looked at errors in each block to examine which grammatical structure was most affected in the participants.

2.5 Statistical Analyses

Normality checks were carried out for all the variables using Kolmogorov- Smirnov test. Parametric statistical tests were performed on normally distributed data set, and for the non-normally distributed data set, non-parametric statistical tests were performed.

In verbal fluency, all the variables were normally distributed. All the variables were measured for each trial for the two fluency conditions for each participant. To arrive at the mean scores for each variable, the trials were averaged in each condition; for semantic fluency, animals, clothing and food items were averaged; for letter fluency, F and S trials were averaged. A two-way repeated measures ANOVA was used on the following variables, number of CR, First RT, Sub-RT, cluster size and number of switches. In the design, Group (High print exposure; Low print exposure) was treated as between -subject factor, and Condition (Semantic; Letter) was considered as within-subject factor. Two separate independent sample t-tests were conducted for initiation parameter and slope for semantic and letter fluency conditions with Group as between-subject factor.

In word and non-word repetition, the number of CR was normally distributed. Therefore, a two-way repeated measures ANOVA was conducted with Group (High print exposure; Low print exposure) as between -subject factor, and Type (Word repetition; Non-word repetition) as within-subject factor. The variables of synonymy triplets and sentence comprehension task were normally distributed. Two separate independent sample t-tests were conducted for the two tasks with Group as between-subject factor. Additionally, in synonymy triplets tasks for noun and verb differences in performance, a two-way repeated measures ANOVA was conducted with Group (High print exposure; Low print exposure) as between -subject factor, and Type (Nouns; Verbs) as within-subject factor.

2.6 Results

In this section, we present the findings of experimental tasks described in section 2.4. We present the results of verbal fluency measures in section 2.5.1, followed by results of word and non-word repetition in section 2.5.2. In section 2.5.3, we present the findings of the semantic comprehension measures and in the last section 2.5.4 we present the findings of correlational analyses of oral language production and comprehension measures with print exposure, years of education and age.

2.6.1 Performance on verbal fluency measures

Differences between HPE and LPE are reported as either as a main effect of Group, main effect of Condition (Semantic vs. Letter) or an interaction of Group X Condition for all the measures of verbal fluency. There was no main effect of Group or interaction with Group X Condition in any of the VF variables.

The CR showed only a main effect of Condition (Semantic: M =19.36, SD =4.32; Letter: M =15.01, SD =4.43) (See figure 2.8). Likewise, for First RT, there was only a significant main effect of Condition (Semantic: M =1.19, SD =0.55, Letter: M= 0.89, SD = 0.58). Sub-RT showed a significant main effect of Condition as well, with a longer sub-RT for letter fluency compared to semantic fluency (Semantic: M =22.89, SD =2.27, Letter: M= 24.05, SD = 2.53).

Initiation parameter and slope were analysed as a function of group after each time course was fitted to multilevel model. The estimated function for each fluency condition and groups are presented in Table 2.9. Figure 2.7 represents the time course of the correct responses by the group for the two fluency conditions. There were no significant group differences for initiation parameter and slope across HPE and LPE.

On cluster size, there was only a significant main effect of Condition, (Semantic: M =1.20, SD =0.38, Letter: M= 0.44, SD = 0.28) (See Figure 2.9). Both groups produced bigger clusters for semantic condition compared to letter condition. There was a main effect of Condition on number of switches, with a higher number of switches on letter condition compared to semantic condition (Semantic: M =8.82, SD =1.80, Letter: M= 10, SD = 2.81) (See Figure 2.10).

Table 2.8

Mean (M), Standard Deviation (SD) and statistical results of performance by group (High print exposure and Low print exposure) and Conditions (averaged across trials) on Verbal fluency measures.

Measures	High print exposure (HPE) (N =22)		Low print exposure (LPE) (N=12)		Total		Statistical results (Group, Condition)		
	M	SD	M	SD	M	SD	Group	Condition	Group*Condition
Semantic	20.58	4.32	17.14	3.47	19.36	4.32	F(1,32) = 2.88, p=0.09, η^2= 0.08	F(1,32)= 18.43, p<0.001***, η^2=0.35	F(1,32)= 2.16, p=0.15, η^2=0.04
Letter	15.27	3.96	14.54	5.35	15.01	4.43			
FDS[2]	0.079	0.071	0.04	0.10	-	-	t(32) = 1.05, p =0.30, d =0.37		
First RT	1.02	0.43	1.07	0.54	1.04	0.47	F(1,32) = 1.84, p= 0.18, η^2 =0.31	F(1,32) = 14.67, p<0.001***, η^2=0.31	F(1,32) = 0.92, p=0.65, η^2=0.004.
Semantic	1.18	0.51	1.21	0.65	1.19	0.55			
Letter	0.87	0.56	0.93	0.63	0.89	0.58			
Sub-RT	23.29	2.04	22.39	1.41	22.97	1.87	F(1,32) = 1.84, p=0.18, η^2=0.05	F(1,32)=14.67, p<0.001***, η^2=0.31	F(1,32) =0.92, p=0.65, η^2= 0.004
Semantic	22.12	2.40	21.46	2.04	21.89	2.27			
Letter	24.46	2.84	23.31	1.70	24.05	2.53			
Initiation semantic	3.34	0.93	3.35	0.54	3.34	0.81	t(32) = - 0.03, p=0.97, d= -0.014		
Initiation letter	2.33	0.48	2.56	0.84	2.41	0.63	t(32) = -0.98, p =0.33, d= -0.35		
Slope semantic	-0.74	0.81	-0.95	0.24	-0.81	0.67	t(32) = 0.84, p=0.40, d= 0.30		
Slope letter	-0.52	0.20	-0.58	0.32	-0.54	0.25	t(32) =0.68, p=0.50, d=0.24		
Cluster size	0.83	0.23	0.80	0.16	0.82	0.21	t(32) =0.35, p =0.72, d =0.12		
Semantic	1.24	0.36	1.13	0.42	1.20	0.38	F(1,32) = 0.12, p=0.72, η^2 = 0.004	F(1,32) = 59.62, p<0.001***, η^2 =0.64	F(1,32) = 0.73, p= 0.39, η^2 =0.64
Letter	0.42	0.24	0.48	0.35	0.44	0.28			
Number of switches	9.61	1.52	9.03	2.33	9.41	1.83	t(32) = 0.88, p =0.38, d = 0.31		
Semantic	9.03	1.51	8.44	2.27	8.82	1.80	F(1,32) = 0.77, p=0.38, η^2 =0.024	F(1,32) = 4.70, p =0.03*, η^2=0.12	F(1,32) = <1, p =0.99, η^2= 0
Letter	10.20	2.51	9.62	3.39	10	2.81			

[1]-number of correct responses, [2]-Fluency Difference Score, ****p*<.001, ***p*<.01, **p*<.05, Condition (Semantic, Letter)

Table 2.9

Best Fitting Multilevel Model Functions for the Time Course of Correct Responses in Verbal Fluency Task.

Measure	High print exposure (HPE) (N=22)	Low print exposure (LPE) (N=12)
Semantic fluency	y = 3.34 – 0.75 ln(t)	y = 3.35 – 0.95 ln(t)
Letter fluency	y = 2.34 – 0.52 ln(t)	y = 2.56 – 0.58 ln(t)

Note: Logarithmic function estimates are obtained from multilevel modelling with all observations.

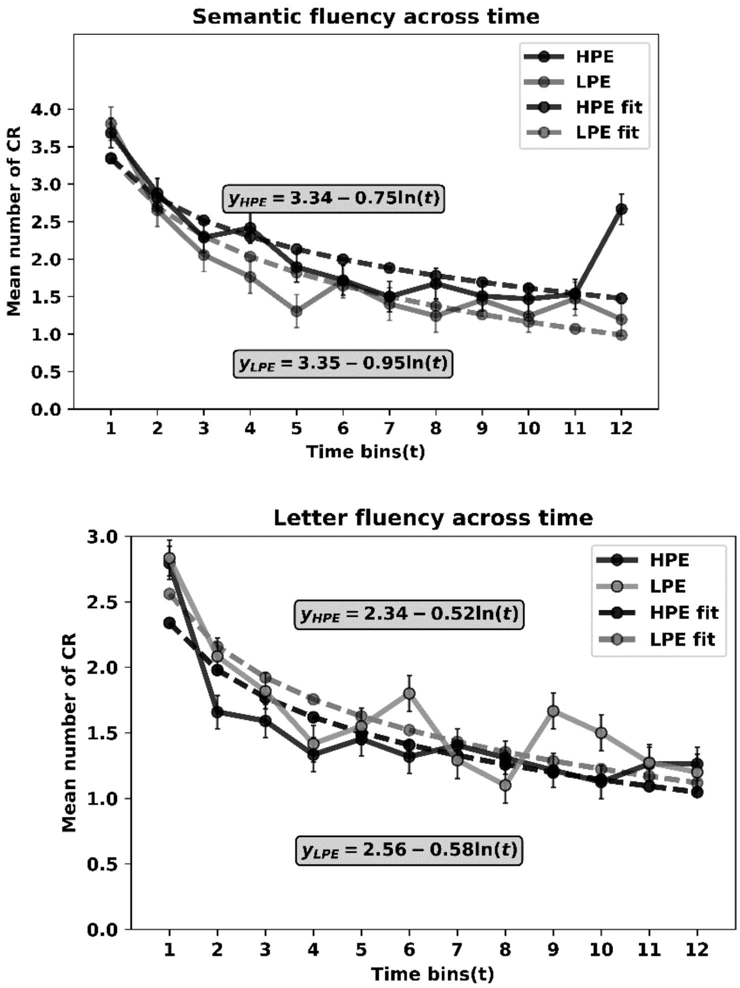


Figure 2.7 Comparison of number of correct responses (CR) produced as a function of 5-second time intervals in the semantic (top panel) and letter fluency (bottom panel) conditions between the groups. Best-fit lines are logarithmic functions. Error bars represent standard error of the mean.

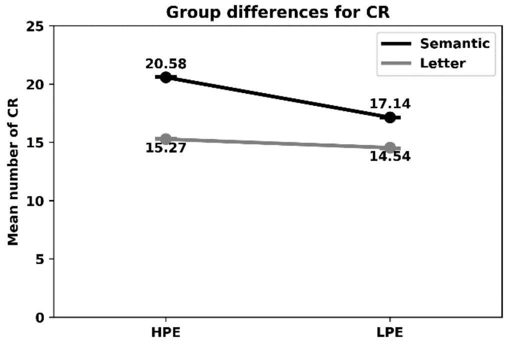


Figure 2.8 Comparison of mean number of correct responses (CR) between groups by fluency condition (semantic and letter). Error bars represent standard errors of the mean.

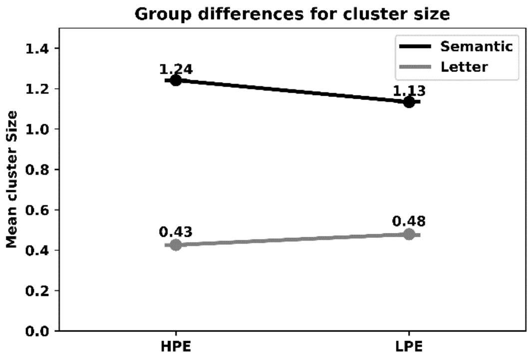


Figure 2.9 Comparison of mean cluster size between the groups by fluency Condition (semantic and letter). Error bars represent standard error of the mean.

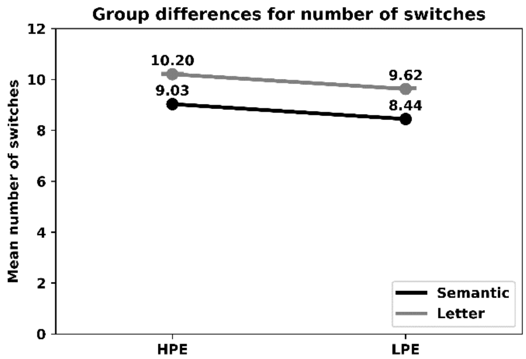


Figure 2.10 Comparison of mean number of switches between the groups by fluency condition (semantic and letter). Error bars represent standard error of the mean

2.6.2 Performance on word and non-word repetition

There was no significant main effect of Group, but a significant main effect of Type (Word repetition > Non-word repetition) (Word repetition: M =96.76, SD =2.48, Non-word repetition: M= 88.08, SD = 6.05) (See figure 2.11) and no interaction of Group X Type. Table 2.10 provides the mean and standard deviation and the statistical results for word and non-word repetition. The errors on non-words made by HPE were mostly non-words similar to the target non-word stimuli and the errors made by LPE were substitution of non-words with real words (lexicalization). Both groups made similar pattern of errors across conditions for both word and non-word repetition with the LPE producing higher percentage of errors compared to HPE. (See Table 2.10 & Figure 2.12). On word repetition, participants in both groups produced highest percentage of errors for low imageability- low frequency words followed by low imageability-high frequency, high imageability- low frequency and the least percentage of errors in high imageability-high frequency words. Conversely, on non-word repetition, participants in both groups made the most errors on low imageability-high frequency non-word condition followed by low imageability-low frequency, high imageability-high frequency and the least on high imageability-low frequency. Additionally, when the errors were split by imageability and frequency, the LPE produced similar pattern of errors on high and low imageability word repetition, however, the LPE produced higher percentage of errors on low imageability non-words (See Figure 2.12).

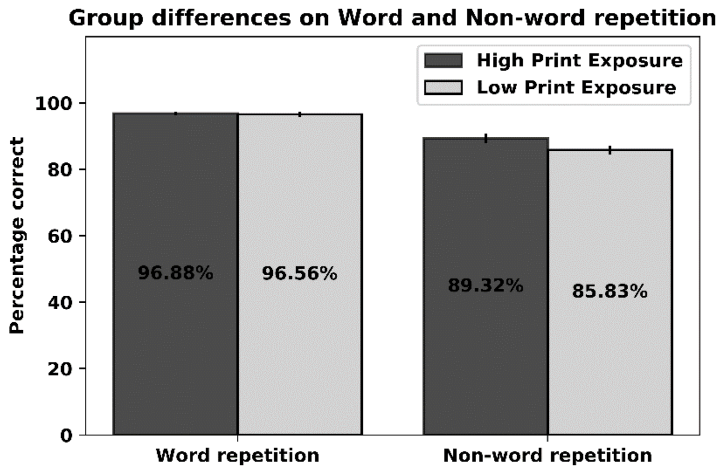


Figure 2.11 Comparison of percent correct between the groups by condition (word repetition and non-word repetition). Error bars represent standard error of the mean.

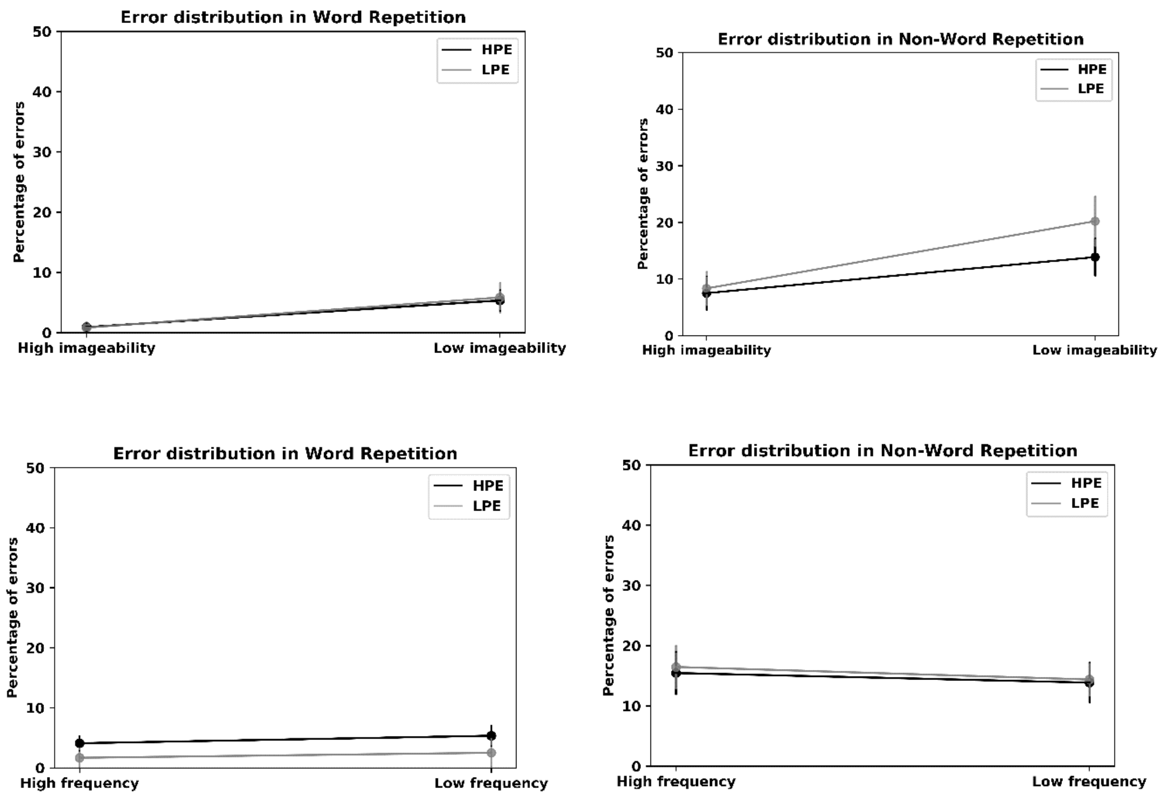


Figure 2.12 Group differences of error distribution in word and non-word repetition distributed by imageability and frequency.

Table 2.10

Mean (M), Minimum (Min) and Maximum (Max) values and statistical results of performance on Word-Non-word repetition and Comprehension tasks.

Experimental Measures		High print exposure (HPE) (N=22) Min-Max	M	SD	Low print exposure (LPE)(N=12) Min-Max	M	SD	Total M	SD	Statistical results Group	Condition or type	Group*condition
Word Repetiton[1]	Raw score	73-80	77.50	1.94	72-80	77.25	2.13	77.41	1.98	F(1, 32) = 2.09, p = 0.15	F(1,32)= 89.53, p< 0.001***	F(1, 32) = 2.69, p = 0.11
	% Accuracy	91.25-100	96.87	2.42	90-100	96.52	2.38	96.76	2.48			
Non-word Repetition[1]	Raw score	57-78	71.45	5.18	62-76	68.67	3.70	70.47	4.84			
	% Accuracy	71.25-97.5	89.31	6.47	77.5-95	85.8	5.46	88.08	6.05			
Total score		66-78	74.47	3.22	70-77.5	72.95	2,24	73.94	2.97			
Total Percent Accuracy		82.5-97.5	95.4	4.03	87.5-96.88	91.18	3.93	92.42	3.71	t(32) = 1.44, p =0.157		
Difference score		0-18	6.05	4.43	3-16	8.58	4.05			t(32) = -1.64, p=0.11		
Comprehension measures												
Synonymy triplets task[2]												
Nouns	Raw score	4-15	8.63	2.66	4-10	6.50	1.97	7.88	2.6			
	% Accuracy	26.7-100	57.5	17.35	26.67-66.67	43.33	12.61	52.54	17.50	F(1,32)= 7.79, p = 0.009*	F(1,32)= 148.70, p<0.001***	F(1,32) = 0.98, p =0.32
Verbs	Raw score	10-15	12.95	1.58	8-13	11.58	1.50	12.47	1.67			
	% Accuracy	66.67-100	86.33	10.34	53.33-86.67	77.2	9.60	83.13	11.15			
Total score		15-30	21.59	3.91	15-23	18.08	2.53	20.35	3.84	t(32) =2.79, p = 0.009**		
Total Percent Accuracy		50-100	71.9	12.73	50-76.6	60.02	8.1	67.84	12.81			
Sentence comprehension[3]	Raw score	41-56	49.86	3.73	32-53	44.92	6.34	48.12	5.29	t(32) =287, p = 0.007**		
	% Accuracy	68.33-93.33	83.3	8.675	53.3-88.3	74.83	10.12	85.992	9.45			

[1]-Maximum possible scores for words and non-words was 80 each; [2]-Maximum possible score was 30; [3]-Maximum possible score was 56; ******p<0.001 **p<0.01 *p<0.0***

Table 2.11

Error distribution[1] on word and non-word repetition task across conditions

	HPE (n=22)				LPE (n=12)			
	Word repetition		Non-word repetition		Word repetition		Non-word repetition	
Condition	M	SD	M	SD	M	SD	M	SD
High imageability- High frequency	0.68	2.28	9.77	8.45	0.00	0	10.42	6.27
High imageability - Low frequency	1.14	2.58	5.23	6.65	1.67	3.11	6.25	6.8
Low imageability - High frequency	4.09	2.87	15.45	8.1	3.33	5.13	22.50	8.29
Low imageability - Low frequency	6.59	6.1	12.27	9.85	8.33	5.52	17.92	8.28

[1]- The error values in the table are in percentages.

2.6.3 Performance on Semantic comprehension measures

On Synonymy Triplets task, there was a significant effect of Group [F (1,32) = 7.79, p = 0.009] with LPE producing fewer accurate responses compared to HPE (HPE: M = 71.90, SD = 12.73; LPE: M =60.02, SD =8.10). There was also a significant main effect of Type (See figure 2.12) (Nouns: M = 52.54, SD =17.50, Verbs: M= 83.13, SD = 11.15), but no significant interaction of Group X Type (See table 2.10). Both groups produced more accurate responses on verbs compared to nouns. HPE produced more accurate responses on both nouns and verbs compared to LPE.

On Sentence comprehension task, there was a significant effect of Group [t (32) =287, p = 0.007] with the HPE performing better than LPE (M= 49.86, SD = 3.73; M = 44.92, SD =6.34). On performing a detailed error analyses of the responses, LPE had a higher proportion of errors than HPE. The proportion of errors differed across the sub-components (See Figure 2.15). The error percentages increased as the grammatical complexity increased - Neither nor: HPE =7.95%, LPE =27.08%; Reversible passive: HPE =7.95%, LPE =18.75%; Pronoun binding: HPE =3.41%, LPE =20.83%; Centre-embedded sentence: HPE = 42.05%, LPE =70.83%; Zero anaphor: HPE =17.05%, LPE =18.75%; Postmodified subject: HPE =14.77%, LPE =31.25%.

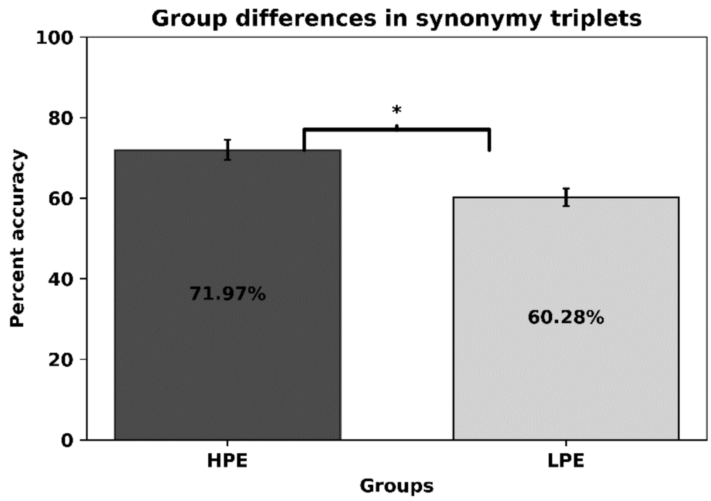


Figure 2.13 Comparison of percent accuracy between the groups by Condition (nouns and verbs). Error bars represent standard error of the mean. ** p<.01.

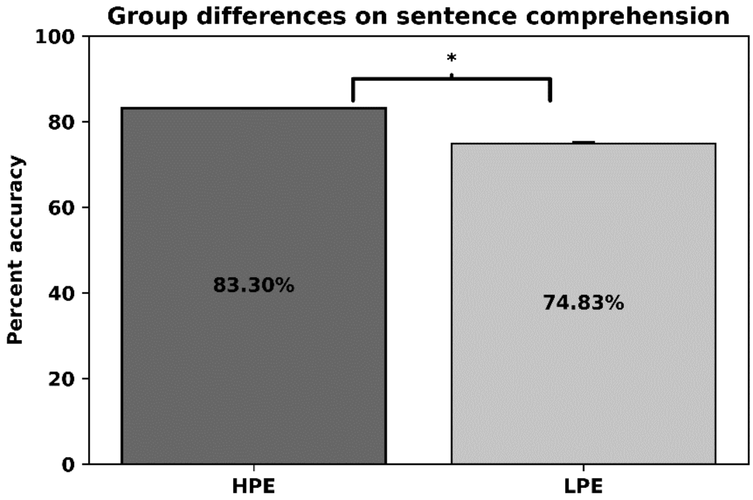


Figure 2.14 Comparison of percent accuracy between the groups on sentence comprehension. Error bars represent standard error of the mean.*p<.05

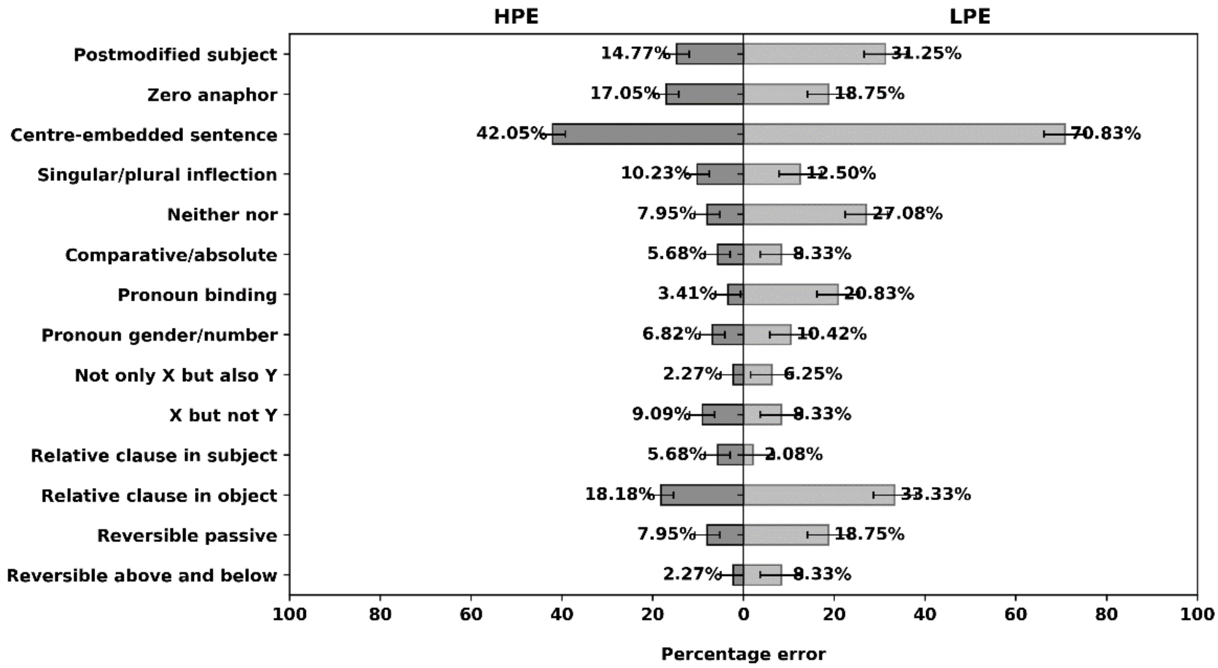


Figure 2.15 Percentage of different types of errors on Sentence comprehension task based on grammatical sub- components. Error bars represent standard error of the mean

2.6.4 Findings of Correlation analyses.

The correlation of oral language production and comprehension measures with measure of print exposure, age and years of education are presented in Table 2.12.

There was a significant moderate positive correlation of measure of print exposure with CR for semantic fluency, total switches and percent correct non-word repetition. Participants with higher print exposure produced higher CR on semantic fluency task, higher number of switches and had a higher percentage of correct responses on non-word repetition. This is clearly evident in the figures where two distinct clusters of data points representing HPE and LPE are seen (See Figure 2.16 and 2.17). These figures are particularly interesting as both the group differences and the difference produced by the measure of print exposure are equally evident. All other correlations with print exposure were non-significant. There was a significant positive correlation of measure of print exposure with both percentages correct of synonymy triplets and sentence comprehension (See figure 2.18). Participants with higher print exposure produced higher percentage of correct responses for both synonymy triplets and sentence comprehension task.

Years of education showed a significant negative correlation with initiation total suggesting that participants with greater number of years of education had smaller initiation values. There was a significant positive correlation between years of education with slope and years of education with Sub RT i.e., participants with higher number of years of education had a larger slope and higher Sub RT (See Figure 2.19). A feature of this figure is that both the HPE and LPE group are equally distributed about the years of education, this shows that our selection and manipulation of data based on print exposure was unbiased and correctly matched for years of education.

Age did not show any significant correlations with any of the oral language production measures. Age showed a significant positive correlation only with percent correct of synonymy triplets task i.e., older participants produced higher percentage of correct responses in the synonymy triplets task. There was a significant positive correlation between years of education and percent correct of synonymy triplets task which implies that participants with higher years of education produced a higher percentage of correct responses in the synonymy triplets task.

Table 2.12

Correlation of oral language production and comprehension measures with measure of print exposure, age and years of education

Oral language production measures	**Measure of print exposure (GJ-SV composite)**		**Age**		**Years of education**	
	R-value	**p-value**	**R-value**	**p-value**	**R-value**	**p-value**
Semantic Fluency (CR)	0.478**	0.004	0.08	0.66	0.09	0.63
Letter Fluency (CR)	0.20	0.26	-0.09	0.62	0.07	0.72
FDS	0.16	0.37	0.09	0.63	-0.02	0.91
Cluster size Total	0.01	0.97	0.24	0.17	0.11	0.53
Switches Total	0.341*	0.048	-0.23	0.19	0.03	0.86
Initiation Total	0.16	0.38	-0.16	0.37	-.358*	0.04
Slope Total	-0.01	0.96	0.13	0.46	.402*	0.02
First RT Total	-0.23	0.20	0.09	0.61	-0.01	0.97
Sub RT Total	0.26	0.13	-0.05	0.77	.367*	0.03
Word repetition (% correct)	0.22	0.21	-0.20	0.26	-0.08	0.65
Non-word repetition (% correct)	.367*	0.03	-0.16	0.38	0.15	0.39
Comprehension measures						
Synonymy triplets (%correct)	.477**	0.004	.443**	0.01	.369*	0.03
Sentence comprehension (% Correct)	.484**	0.004	-0.10	0.59	0.22	0.21

****p<0.001 **p<0.01 *p<0.05.*

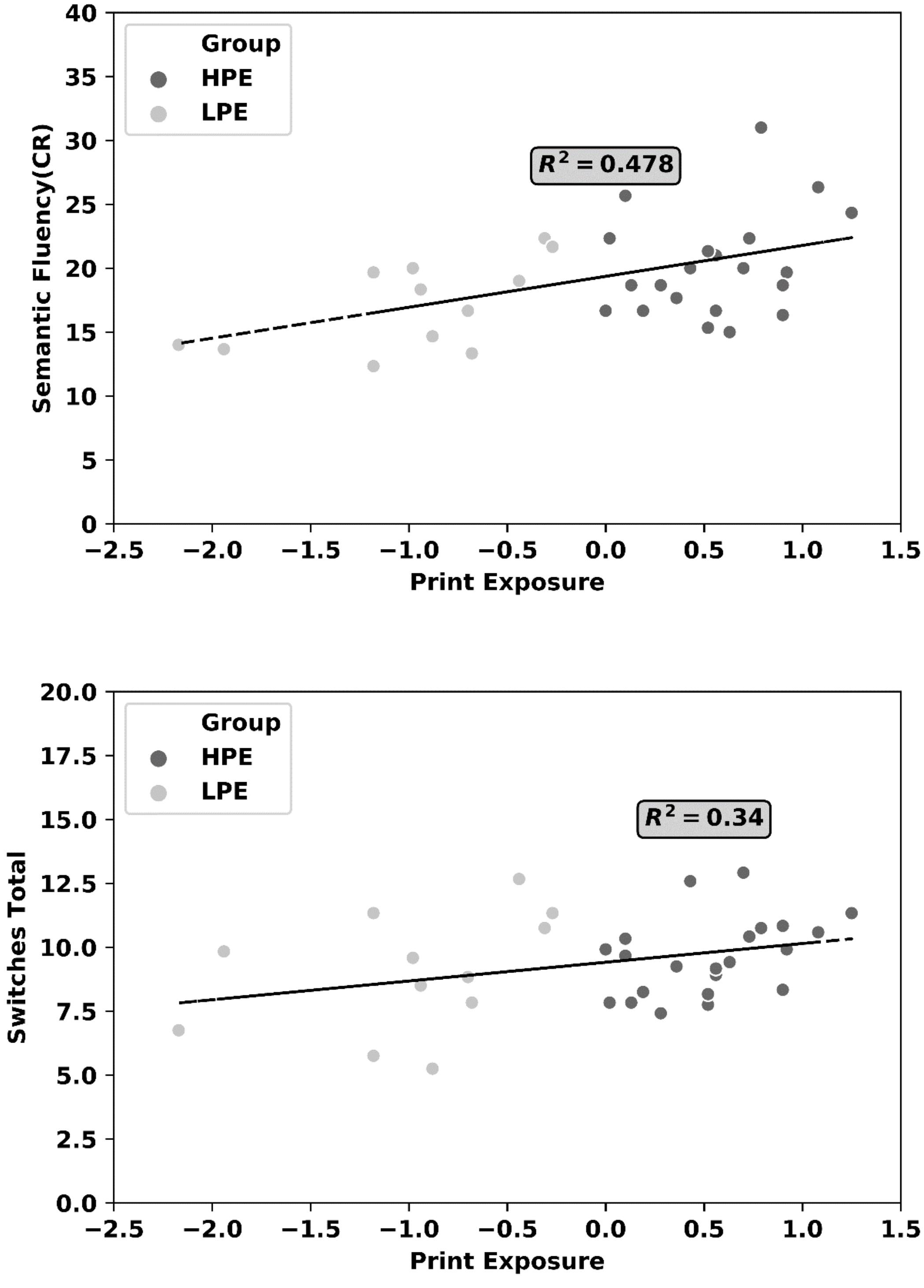


Figure 2.16 Significant correlations between measure of print exposure and semantic fluency (CR) and switches (total).

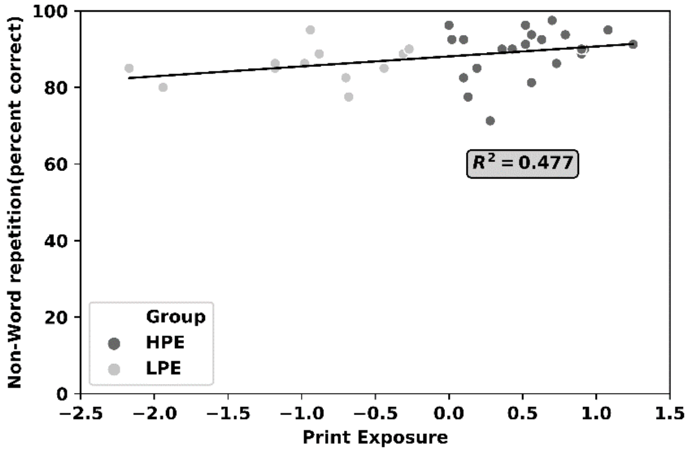


Figure 2.17 Significant correlations between measure of print exposure and percent correct on non-word repetition

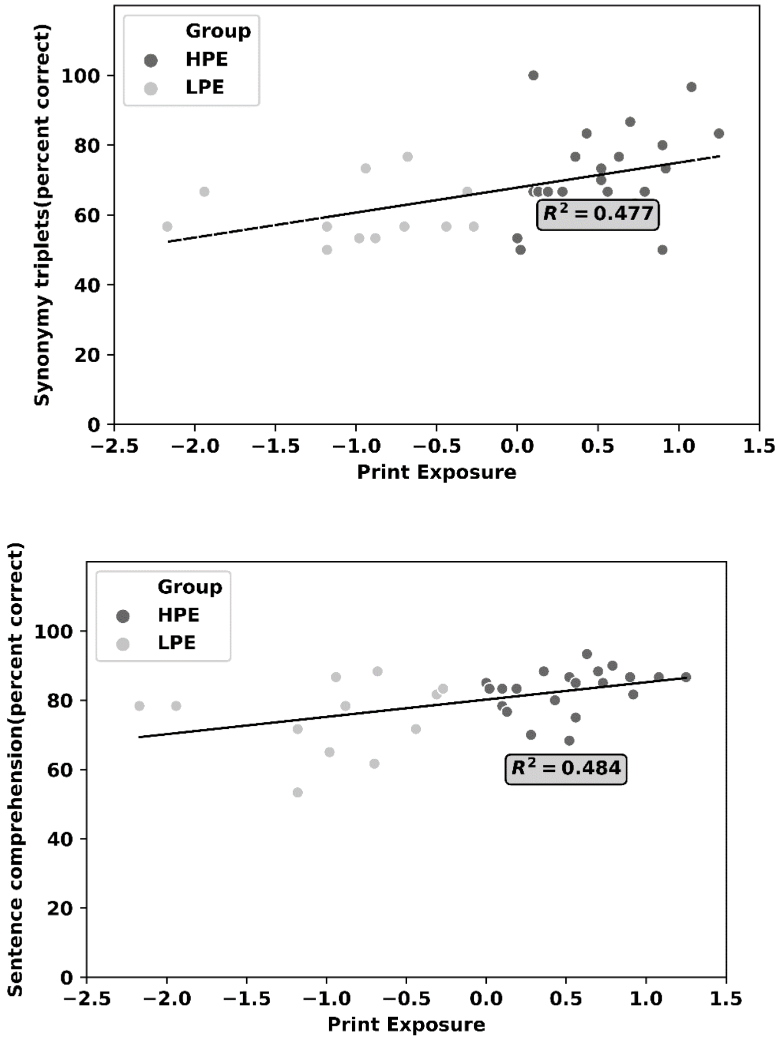


Figure 2.18 Significant correlations between measure of print exposure and percent correct on synonymy triplets task and sentence comprehension.

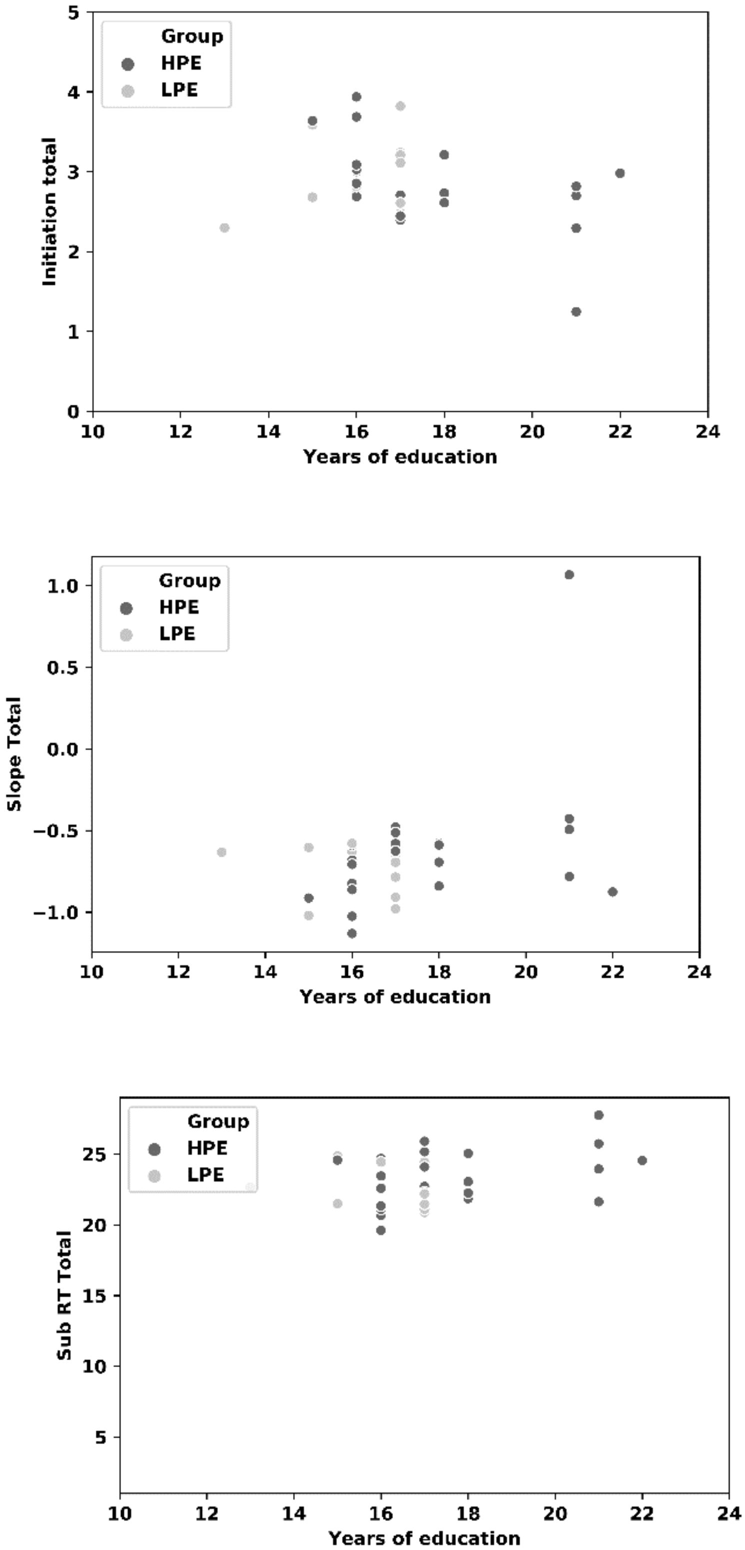


Figure 2.19 Significant correlations between years of education and Initiation (total), Slope(total) and Sub-RT.

2.7 Discussion

2.7.1 Summary of findings

The aim of the current study was to examine the impact of oral language production and comprehension in bi-literate bilingual individuals with a difference in print exposure in L2. To attain this overall aim, the present study determined if there were group differences in oral language production tasks – verbal fluency and word and non-word repetition and comprehension measures – synonymy triplets task and sentence comprehension. We tested a large group of bi-literate bilingual individuals speaking one of the South Indian languages as L1 (Kannada, Malayalam, Tamil, Telugu) and English as L2, who were matched for age, gender, years of education and L1 proficiency. Based on their print exposure in L2 as measured by grammaticality judgement task and sentence verification task, we grouped the participants as belonging to HPE and LPE. The HPE group performed significantly better than LPE on objective measures of language proficiency in L2- lexical decision task and picture naming task.

The key findings are that there were no group differences on measures of verbal fluency, and accuracy of word and non-word repetition. In contrast, the semantic comprehension measures showed significant group differences and significant correlations with measures of print exposure. Table 2.13 provides the summary of findings on oral language production and comprehension measures.

Table 2.13

Summary of findings on oral language production and comprehension measures

Oral language production measures	Group Comparison					Correlation with Print Exposure		Correlation with Years of education	
	HPE (n =22)	LPE (n=12)	Statistically Significant Group Difference	Condition	Group * Condition	Direction of Correlation (+/-)	Statistically Significant Correlation	Direction of Correlation (+/-)	Statistically Significant Correlation
Verbal fluency									
Semantic Fluency (CR)	Higher	Lower	No	Semantic >Letter	No	+	Yes	+	No
Letter Fluency (CR)	Higher	Lower	No			+	No	+	No
FDS	Higher	Lower	No			+	No	-	No
Cluster size Total	Marginally Higher	Lower	No	Semantic >Letter	No	+	No	+	No
Switches Total	Higher	Lower	No	Letter> Semantic	No	+	Yes	+	No
Initiation Total	Lower	Higher	No			+	No	-	Yes
Slope Total	Higher	Lower	No			-	No	+	Yes
First RT Total	Lower	Higher	No			-	No	-	No
Sub RT Total	Higher	Lower	No			+	No	+	Yes
Word and non-word repetition									
Word repetition (% correct)	Marginally Higher	Lower	No	WR>NWR	No	+	No	-	No
Non-word repetition (% correct)	Higher	Lower	No			+	Yes	+	No
Comprehension measures									
Synonymy triplets (%correct)	Higher	Lower	Yes	Verbs>Nouns	No	+	Yes	+	Yes
Sentence comprehension (% Correct)	Higher	Lower	Yes			+	Yes	+	No

2.7.2 Oral language production tasks

The findings on the verbal fluency task does not support the hypothesis i.e., there were no group differences on measures of verbal fluency- CR, FDS, First RT, Sub-RT, cluster size and number of switches, initiation parameter and slope for both semantic and letter fluency. However, semantic fluency (CR) showed a significant positive correlation with print exposure i.e., higher print exposure scores were associated with higher number of correct on semantic fluency. This was an unexpected finding which could be related to semantic knowledge being important factor for reading words (Nation & Snowling, 2004). In our study, participants with higher print exposure read more frequently and performed better on the reading task (sentence verification task) which could mean that they have improved semantic knowledge. We hypothesize that this could have translated into better performance on semantic fluency task.

Switches total showed a significant positive correlation with print exposure i.e., higher print exposure scores were associated with greater number of switches. Switching requires strategic search of subcategories and cognitive flexibility to shift efficiently between subcategories (Da Silva, 2004) and dependent on more controlled processing than those required for clustering (Troyer, 2000; Troyer et al.,1997). In the current study, participants with higher print exposure have produced a greater number of switches, which probably suggests that they have better cognitive flexibility.

The performance on letter fluency was comparable across both groups. Both the groups have acquired orthography and phonology required for letter fluency task, unlike in children where it is still in the acquisition state (Friesen, Luo, Luk, & Bialystok, 2014). In Friesen, Luo, Luk, & Bialystok (2014), they found that number of correct on letter fluency task improved with age in younger children, however in adults it plateaued and remained constant. In addition, as both groups had very high average years of education (17 years), the effect on phonology could be further minimised. Hence, the performance is comparable on letter fluency task. This could be attributed to the findings of Kosmidis et al (2004) where they suggested that education plays a more influential role in phonological rather than semantic word fluency. In our case, both groups are matched for education.

The findings on the word and non-word repetition task does not support the hypothesis; the performance of the two groups were not statistically different however, we found that the participants in HPE produced marginally higher percentage of correct words and non-words compared to LPE. There was a significant effect of type, i.e., word repetition had higher accuracy compared to non-word repetition. This is in-line with previous research on monolingual population (Petersson et al, 2000; Kosmidis et al., 2006) where words were repeated with higher accuracy in both illiterate and literate groups.

Additionally, the error pattern on non-word repetition showed the pattern where the LPE mirrored the HPE on the error pattern but produced higher percentage of errors in comparison to HPE on categories of low imageability items. We could explain this by the fact imageability is a function of semantics (Plaut & Shallice, 1993) and as errors in low imageability items are higher for the LPE, it could imply that semantics are affected. The affected semantics can also be inferred from the moderate positive correlation between semantic fluency (CR) and print exposure.

Another important finding was that of a significant positive correlation between print exposure and non-word repetition. In other words, participants with higher print exposure had a higher percentage of correct responses on non-word repetition. This is supported by studies in monolingual population (eg., Petersson et al, 2000; Kosmidis et al., 2006) where differences in non-word repetition were observed because of print exposure.

2.7.3 Comprehension measures

The findings of both synonymy triplets and sentence comprehension task were in opposition to our hypothesis. There was a significant group difference on synonymy triplets task where HPE produced more accurate responses compared to LPE. Higher print exposure and greater years of education was also associated with significantly higher percentage of correct responses on synonymy triplets task. We can draw support for this finding from research of reading ability in monolingual children. Nation and Snowling (1998) found a significant difference between their groups of normal readers and poor readers on synonym judgement task. We also found a significant difference between HPE and LPE on synonymy triplets task in our study.

On the sentence comprehension task, the participants in HPE were significantly more accurate than the LPE group. This is also reflected in the correlation analyses i.e., higher print exposure was associated significantly with higher accuracy on the sentence comprehension. This sentence comprehension task was a listening task, where sentences were auditorily presented and the participants had to choose the correct picture. Therefore, results from studies in monolingual and bilingual children on listening comprehension are relevant. Hedrick and Cunningham (1995) found that there was a bi-directional relationship between listening comprehension and reading ability. Proctor et al (2005) found that in his bilingual sample of Spanish-English children, children who received literacy instruction in English performed better in listening comprehension task. In our study, we find our literacy proxy (print exposure) to be significantly correlated with listening comprehension as measured by sentence comprehension task. This is mirrored in both the studies that use reading ability and literacy instruction as proxy.

Overall, our study has shown a convergence on all semantic tasks, both in comprehension as well as production. The consistent trend has been that HPE has outperformed LPE on all semantic tasks. Therefore, we suggest a link between print exposure and semantic processing.

2.7.4 Limitations and Future directions

This is a first-of -its-kind study that takes into account print exposure in oral language production task and comprehension in bi-literate bilingual individuals. The lack of group differences could be explained by the fact that although the two groups were different on print exposure, they were not too far apart, i.e., the range of scores on the composite score were not too wide apart which could explain why the performance was similar. The HPE produced fewer semantic clusters but a greater number of switches on letter fluency which is suggestive of superior executive function. However, we would need to look at executive function tasks to establish if this is true. This topic will be taken up in the next chapter.

Many of the measures of oral language production do not belie a direct link with print exposure in bi-literate bilinguals. However, given that there are some significant correlations on semantic fluency (CR), number of switches and non-word repetition task with print exposure we cannot rule out the possibility that print exposure impacts oral language production.

Furthermore, factors beyond print exposure namely language dominance, language proficiency and usage, years of education and age may be contributing to the findings. In the current study, we have documented and profiled the participants based on these variables but have not been able to control all of these factors and exploit the differences in print exposure. Future studies should be directed at controlling all these variables as a whole only manipulating the differences in print exposure. One method of testing for this could be to compare the current data with three groups of bi-literate bilinguals separated by age, years of education and print exposure and examine the effects for each group on oral language production and comprehension task. Each group could be separated by controlling for one of the key variables and manipulating the other two variables. This would help isolate the effects of the variables much more clearly.

Chapter 3 Impact of print exposure on narratives in bi-literate bilingual healthy adults.

3.1 Abstract

Background. Research has shown that print exposure has an impact on language production even at connected speech in monolinguals. Among bilinguals, research demonstrates a positive relationship between oral language skills such as narration and learning to read in bilingual children (for example, Miller et al., 2006). Currently, little is known about the relationship between print exposure and oral language production in adults. Consequently, the impact of print exposure on narrative characteristics have not been explored in Indian bi-literate bilingual adults.

Aim. The aim of the present study was to examine the impact of print exposure on L2 narrative production in bi-literate bilingual healthy adults.

Methods and procedure. We used the same participants as in Chapter 2. We grouped the thirty-four participants of our study into two groups: HPE (n=22) and LPE (n=12). We compared the performance of these participants on a range of narrative measures namely – utterance level, morpho-syntactic, lexical and repair measures. A wordless picture book 'Frog, where are you?' story (Mayer, 1969) was used to elicit the oral narratives from the participants. The narratives were transcribed in a systematic manner and each of the variable used in the narrative analysis was generated using CLAN.

Findings. There were significant group differences and significant correlations for total number of words, verbs per utterance and repetitions which highlight that increased print exposure in L2 is associated with higher number of words in the narrative, higher verbs per utterance and fewer repetitions in L2 oral production.

Conclusions and Implications. Our study provides important quantification regarding the relationship between print exposure and narrative characteristics in bi-literate bilingual adults.

In general, the results support our hypothesis that print exposure has an impact on the narrative characteristics (total number of words, verbs per utterance and repetitions).

3.2 Introduction

3.2.1 Effect of print exposure on oral language production (word level and connected speech) in monolinguals.

Research has shown that print exposure and reading ability contribute to differences in lexical and syntactic verbal output measures as well as measures of verbal fluency. However, most of the research on these relationships has occurred in the monolingual population. Therefore, we focus on reviewing the studies with monolingual populations exploring the relationship between print exposure and several verbal output measures.

Katz et al (2012) examined the ability of a lexical decision task and a naming task to predict decoding, sight word recognition, fluency, vocabulary and comprehension (i.e., reading skills) and phonological awareness and rapid naming (i.e., speech factors closely related to reading). This study recruited a cohort of 99 college students with varying reading abilities. In this study, lexical decision tasks provide insight to the cognitive processes used in identifying printed text; therefore, performance on such tasks is presumably related to levels of print exposure. It was hypothesised that the performance on the lexical decision task would reflect the levels of print exposure.

Reading ability was measured using the following tests- the Woodcock-Johnson III Diagnostic Reading Battery (Woodcock, Mather, & Schrank, 2004), the Test of Word Reading Efficiency, Form A (Torgesen, Wagner, & Rashotte, 1999) and the Gray Oral Reading Test-4, Form A (Wiederholt & Bryant, 2001). Vocabulary size was measured using the Peabody Picture Vocabulary Test, Form A (Dunn & Dunn, 2007) and subtests from the Woodcock-Johnson Diagnostic Reading Battery (Woodcock, Mather & Schrank, 2004) and the Weschler Abbreviated Scale of Intelligence (Weschler, 1999). Findings suggested that participants with larger vocabularies had lower reaction times on lexical decision task; however, this correlation was not very strong. The interpretation of this finding is that, higher print exposure would naturally increase vocabulary size. One of the drawbacks is lack of use of a standardised tool such as

LexTale (Lemhöfer, & Broersma, 2012) and this does not facilitate easy comparison with other similar studies.

Another study by Cunningham and Stanovich (1991) looked at the impact of print exposure on verbal fluency and vocabulary. This study recruited children from fourth, fifth and sixth grades with cohort sizes of 34, 33 and 67 children in each grade respectively. A modified version of the Title Recognition Test (TRT) (Stanovich & West, 1989) was used as a proxy to measure print exposure. The TRT consisted of 39 items in total of which 25 were genuine book titles and 14 foils for titles. The titles were chosen to be books outside the curriculum to probe reading outside the classroom. Children were asked to read the list of titles and mark the titles they identified as books. Within their cohort, children were divided into high print exposure group (high TRT) and low print exposure group (low TRT) based on a median spilt of the scores.

As a next step, the low print exposure from each cohort were combined to form a larger set of low print exposure cohort (low TRT) and similarly for the high print exposure group (high TRT). The results revealed that TRT was significantly correlated to measures of verbal fluency (number of correct) and vocabulary (as measured by the Peabody Picture Vocabulary Test – Revised (Dunn & Dunn, 1981)). This suggests that TRT uniquely predicts both verbal fluency and vocabulary. The limitations of the study are firstly the TRT requires a tailor-made set of items for each school making it difficult to generalise and use it as a standard tool in research. Secondly, while the TRT may have been a good measure of print exposure then (early 90s), it does not account for the gamut of print resources available in the present day (e.g. online resources, e-books etc). Finally, to adapt this to adults is still more challenging considering the range of print resources used by adults such as books, online resources, newspapers and academic reading material.

Montag and MacDonald (2015) examined the effects of print exposure on spoken language production using the frequency of relative clauses in child-directed speech and children's literature in a corpus analyses and a picture description task in English. The written corpus yielded higher number of passives compared to objective-relative clauses. Consequently, in the written corpus analyses the study infers that children with higher print exposure experience passive constructions more frequently. In the picture description part of the study- 30 undergraduate students, 30 eight-year olds and 30 twelve years olds were tested. Print exposure was measured differently for adults and children.

For adults, they used the Author Recognition Task (Acheson, Wells and MacDonald, 2008); and for children, a modified version of the Title Recognition Test (Cunningham and Stanovich, 1991) was used. For the three groups a picture description task was used to elicit object and passive relative clauses. Results showed text exposure and age predicted production choices; older individuals and those with higher rates of text exposure produced more passive constructions. The authors conclude that print exposure can prime spoken production.

In sum, literature suggest print exposure predicts measures such as verbal fluency, syntactic verbal output. However, it is not clear whether the same relationship exists in the bilingual population. Currently, the impact of print exposure on narrative characteristics have not been explored in bi-literate bilinguals.

From the methodological perspective, measurement of print exposure using measures such as TRT has its limitations and a more robust measurement tool for print exposure is necessary. There is a question of whether the use of standardised assessments which tap skills related to reading and print exposure e.g. grammaticality judgement and sentence verification tasks would provide better measures which can be consistently used in research. Therefore, we fill this gap in our study by employing grammaticality judgement and sentence verification tasks as measures of print exposure.

3.2.2 Print exposure in bilinguals

Literature to date focusing on the impact of print exposure on bilingualism has been on literacy acquisition in bilingual children where bilinguals outperform monolinguals (Bialystok, Luk & Kwan,2005; Geva & Siegel, 2000). The extent of this advantage may be related to the two languages having a shared writing system (Bialystok, Luk & Kwan, 2005). Leikin, Schwartz, and

Share (2010) concluded bi-literacy offers cross-linguistic benefits to phonemic awareness and spelling. Strong oral proficiency in L2 has shown an associated strength in reading comprehension skills (Giambo & Szecsi,2015). Miller et al (2006) in a large cohort study (1500 Spanish-English bilingual children) examined whether oral narrative ability could predict reading ability. Oral narratives were elicited using the 'Frog Where are you?' (Mayer, 1969) story in a re-tell task and analysed using Systematic Analysis of Language Transcripts software (Miller & Iglesias, 2003-2004). Reading comprehension was measured using a subtest of the Woodcock Language Proficiency Battery – Revised Spanish and English Version (Woodcock, 1991) and the Test of Word Reading Efficiency (Torgesen, Wagner, & Rashotte, 1999) to measure word reading.

The narratives were quantified using the following four measures- 'mean length of utterance', as a measure of morpho-syntactic complexity, 'number of different words' as a measure of lexical diversity, 'words per minute' as a measure of fluency and 'narrative scoring scheme' as a measure of coherence. Regression analyses revealed that the narrative measures significantly accounted for the variance in both reading measures in both languages. The oral language skills predicted reading measures within a language and across languages i.e., Spanish oral narrative skills predicted both Spanish and English reading skills, and English oral narrative skills predicted both English and Spanish reading skills. This demonstrates that there is a positive relationship between oral language skills such as narration and learning to read in bilingual children. However, in children the literature has shown that the association between oral narrative skills and reading is not language specific. For example., Chang (2006) found that literacy skills and later language skills could be predicted by measuring early oral narrative skills. Little is known about the relationship between print exposure and oral production in adults.

3.2.3 Narratives in bilinguals and gaps in the literature

It has been suggested that connected speech exhibits language properties that can be analysed only through narrative analysis (Pavlenko, 2008). Therefore, narrative analysis is considered as a valid means of probing language skills (Bishop & Edmundson, 1987; Botting, 2002).

Most of the literature focuses on comparing bilingual narratives with monolingual narratives. Pearson (2001) using a cohort of 79 English monolingual and 89 Spanish-English bilingual children between 5-11 years of age compare the expression of false belief using Frog story in both English and Spanish. Findings suggest that bilinguals report false belief about half as often as monolinguals. However, they are known to make more errors in noun clauses and their narratives are less episodically structured (Shrubshall, 1997). Significant differences have been revealed concerning the use of planning components, tense and aspect marking, extended aspectual categories (Bennett-Kastor, 2002) and lexical diversity (Dewaele and Pavlenko, 2003).

Typically, findings regarding the length of narrative, proportion of evaluative clauses is mixed. While Chen & Yan (2010) found bilingual narratives were shorter, Dewaele & Pavlenko (2003) reported no such difference. Similarly, with regard to evaluative clauses, Chen and Yan (2011) found bilinguals used a higher proportion of evaluative clauses than monolinguals, Shrushball (1997) found the converse. It remains unclear which aspects of bilingualism may cause this difference. However, Stavans (2003) has suggested cultural and linguistic factors as a probable cause.

In addition to this, studies of bilingual children have looked at relationship between narrative production and reading ability between languages. For example, Miller et al (2006) (described in section 3.2.2) show that narrative measures such as mean length of utterance', as a measure of morpho-syntactic complexity, 'number of different words' as a measure of lexical diversity, 'words per minute' as a measure of fluency and 'narrative scoring scheme' as measure of coherence predict reading measures in both languages. Little is known about the relationship between print exposure and oral production in adults.

Based on the literature discussed above, there is a gap in understanding whether there is a relationship between print exposure and narrative production for bi-literate bilingual adults in their L2? The present study endeavours to explore this question by studying the relationship between healthy bi-literate bilingual adult's print exposure in L2 and their oral narratives in L2.

3.2.4 Narrative analysis

For narrative analysis, 'Frog Where are you Story?' (Mayer, 1969) is widely used. The reason for use of this tool is that it provides a standardised protocol for administration and it gives an opportunity to discuss findings across studies. It is also used in conjunction with Computerized Language Analysis (CLAN) (MacWhinney, 2016) which allows multiple analyses of utterance level measures, morpho-syntactic measures, lexical measures, and measure of repair.

Table 3.1

Linguistic variables used in the narrative analysis

Utterance Level Measures	**Morpho-syntactic Measures**	**Lexical Measures: Lexical Diversity**	**Lexical Measures: Open Class Words**	**Lexical Measures: Closed Class Words**	**Measures of Repair**
Total Number of Utterances	Verbs per Utterance	Type Token Ratio (TTR)	Percentage of Nouns	Percentage of Prepositions	Number of Retraces
			TTR Nouns		
Total Number of Words	Percentage of Auxiliaries	Vocabulary Diversity (VocD)		Percentage of Conjunctions	Number of Repetitions
			Percentage of Verbs		
Percentage of Grammatical Errors	Percentage of Third Person Singular			Percentage of Pronouns	
	Percentage of Past Tense		TTR Verbs	Percentage of Wh-Words	
	Percentage of Past Participle		Percentage of Adverbs		
				Percentage of Determiners	
			Percentage of Adjectives		
	Percentage of Present Participle				
	Percentage of Plurals				

3.3 Current investigations, research questions and predictions

The same participants recruited for study 1 (Chapter 2, section 2.3) were participants in the current study. The participants were split into two groups- high print exposure (HPE) and low print exposure (LPE). The two groups were matched on other background measures as explained in chapter 2. In the current study, the participants were 34 healthy bi-literate bilingual adults. Print exposure was measured using a grammaticality judgement task from The Philadelphia Comprehension Battery' (Saffran, Schwartz, Linebarger, Martin & Bochetto, 1988) and a sentence verification task adapted from Royer, Greene & Sinatra (1987). Narratives were elicited using the 'Frog, where are you?' story (Mayer, 1969).

The goal of the present study was to examine the impact of print exposure on oral narrative production in bi-literate bilingual healthy adults using the Frog story (Mayer, 1969). Analysis included morpho-syntactic and lexical measures based on findings from research with monolingual populations and the notion that a narrative's quality is influenced by lexical and syntactic competence (Leikin, Ibrahim, & Eghbaria, 2014). Measures of repair were analysed as an indication of fluency.

For the present study, measures concerned with narrative samples in their entirety are termed 'utterance level measures' and relate to the quantity of utterances / words used and grammaticality. Table 3.1 summarises the linguistic variables analysed in the current study. We compared the performance of these participants on a range of narrative measures namely – utterance level, morpho-syntactic, lexical and repair measures.

To address this aim, we posed the following research questions:

1. To investigate the narrative characteristics in the L2 oral narratives of healthy bi-literate bilingual adults with high print exposure in L2 (HPE) and low print exposure in L2 (LPE) on the narrative measures of utterance level, morpho-syntactic, lexical and repair measures.

   We hypothesised that HPE L2 oral narratives will have significantly a greater number of utterances, more morpho-syntactically rich, more lexically diverse and have lesser repairs as compared to LPE L2 oral narratives.

2. To investigate if there is a relationship between print exposure in L2, age and years of education and narrative measures (utterance level measures, morphosyntactic measures, lexical measures and repair measures) of L2 oral narratives.

   Based on the available literature, we predicted that there will be significant and positive correlations between print exposure in L2 and the following measures – utterance level (except percentage of grammatical errors where we expect a significant negative correlation with print exposure), morpho-syntactic and lexical measures of L2 oral narratives. There will be a significant and negative correlation between print exposure in L2 and the number of repairs used in L2 oral narratives.

3.4 Methods

3.4.1 Participants and grouping of participants

Based on the z-composite score generated from the measures of print exposure (grammaticality judgement task and sentence verification task), we grouped the 34 participants of our study into two groups: high print exposure (HPE) (n=22) and low print exposure (LPE) (n=12). Refer to section 2.4.1 for further details.

3.4.2 Oral narrative task

3.4.2.1 Procedure. Participants were presented with the 'Frog, where are you?' story (Mayer, 1969) which is a wordless picture book. Participants were instructed to generate their own story in English (L2) based on the pictures. They were allowed some preparation time to look at the pictures and formulate a story before beginning their narrative. The instructions were as follows, "This is a story of a boy, a dog and a frog. I would like you to take time to go through the pictures and tell me a story based on the pictures in English, while you look through them". Oral narratives were recorded on a dictaphone. No prompts were given during the narration.

3.4.2.2 Transcription of oral narratives. A systematic process was used to transcribe and prepare narratives for input into CLAN. Audio files were transcribed verbatim to text files. Narrative words were extracted using applicable and relevant guidelines from Quantitative Production Analysis (QPA; Berndt, 2000): A training manual for the analysis of aphasic sentence production (Berndt, 2000). Narratives were segmented based on the guidance outlined in the QPA. The details of the QPA and an example transcript with the procedures employed during the transcription are outlined in Appendix 3.1.

3.4.2.3 Reliability analysis. Prior to coding the data in CLAN, an example transcript taken from the CHILDES website (MacWhinney, 2016) was coded independently by two students also using CLAN for a dissertation project and who assisted in the transcription of the narratives. The inter-coder reliability was 84.211% (see Appendix 3.2). Despite some differences; coders were consistent within their own sample e.g. coder 1 always treated 'your' as a pronoun whereas coder 2 always treated 'your' as a determiner. To maintain objectivity and reduce human error in the transcription and coding process, this was an essential process (Pavlenko, 2008).

3.4.2.4 Data coding and CLAN. Each utterance is represented in the 'Speaker tier' SP01 using the codes detailed in Table 3.2. Each utterance in the 'Speaker tier / SP01' has a corresponding 'Morphology tier' %mor where word classes and morphemes are coded (See Table 3.3).

Example of a coded utterance-

*SP01: the dog is running to escape from them.

%mor: det|the n|dog aux|be-3S v|run-PRESP inf|to v|escape prep|from pro|them.

Table 3.2

Codes used in the Speaker Tier in CLAN

Code	Meaning	Example
.	Complete Utterance	*SP01: The rat came out.
[/]	Repetition	*SP01: He fell off the [/] the cliff.
[//]	Retracing	*SP01: <The girl> [//] the boy woke up
[+ gram]	Ungrammatical Utterance	*SP01: The boy are happy. [+gram]

Table 3.3

Codes used for word class and inflectional affixes

Word Class	Code	Affix	Code
Adjective	adj	Noun suffix s, es (Plurals)	pl
Adverb	adv		
Conjunction	conj	Noun suffix ‘s (Possessives)	poss
Determiner	det		
Infinitive Marker to	inf	Verb suffix s, es (Third Person Singular)	3S
Noun	n		
Proper Noun	n:prop	Verb suffix ed, d (Past Tense)	PAST
Number	det:num	Verb suffix ing (Present Progressive)	PRESP
Preposition	Prep	Verb suffix ed, en (Past Participle)	PASTP
Verb	v		
Auxiliary Verbs	aux		
Wh-Words	wh		

3.4.2.5 CLAN analysis. Each of the variable used in the narrative analysis was generated using CLAN commands. The CLAN commands used to generate the variables is given in Appendix 3.3 and the definition of each variable is listed in Table 3.4.

Table 3.4

Definitions of Narrative Variables used in the study.

Variable	Definition
Total Utterances	Includes all utterances used, plus utterances with xxx (unintelligible).
Total Words	Total word tokens as counted by FREQ
Percentage Grammatical Errors	(Number of utterances coded as erroneous or ungrammatical / Total Utterances) x 100 Below is the criteria used to determine the grammaticality of an utterance: **Grammatical error – [+ gram]** – includes agrammatic and paragrammatic utterances: • telegraphic speech • speech in which content words (mainly nouns, verbs, and adjectives) are relatively preserved but many function words (articles, prepositions, conjunctions are missing (adapted from Brookshire, 1997) • utterances with frank grammatical errors (without requiring that each utterance be a complete sentence with a subject and predicate) • utterances with errors in word order, syntactic structure, or grammatical morphology (Butterworth and Howard, 1987) • utterance level grammatical errors as opposed to word level agreement errors or missing parts of speech
Verbs per Utterance	Roughly corresponds to clauses per utterance. Includes verbs, copulas, and auxiliaries followed by past or present participles; does not include modals.
Percentage of Auxiliaries	(Total number of Auxiliaries used / Total Words) x 100
Percentage of Third Person Singular	(Total number of Third Person Singulars used / Total Words) x 100
Percentage of Past Tense	(Total number of Past Tenses used / Total Words) x 100
Percentage of Past Participle	(Total number of Past Participles used / Total Words) x 100
Percentage of Present Participle	(Total number of Present Participles used / Total Words) x 100
Percentage of Plurals	(Total number of Plurals used / Total Words) x 100
Type Token Ratio (TTR)	Type: total word types as counted by FREQ. The default does not include repetitions and revisions / Token: total word tokens as counted by FREQ. The default does not include repetitions and revisions.
Vocabulary Diversity (VocD)	The approach taken in the VOCD program is based on an analysis of the probability of new vocabulary being introduced into longer and longer samples of speech or writing. This probability yields a mathematical model of how TTR varies with token size. By comparing the mathematical model with empirical data in a transcript, VOCD provides a new measure of vocabulary diversity called D. The measure has three advantages: it is not a function of the number of words in the sample; it uses all the data available; and it is more informative, because it represents how the TTR varies over a range of token size. The measure is based on the TTR versus token curve calculated from data for the transcript as a whole, rather than a particular TTR value on it.
Percentage of Nouns	(Total number of Nouns used / Total Words) x 100

3.5 Statistical analysis

Mean and standard deviation was calculated for all variables across both the groups. Group comparisons were carried out with print exposure (HPE and LPE) as independent variables and the linguistic variables of the narrative as dependent variables (as listed in Table 3.1). In this design, Group was a between subject factor. All variables were tested for normality using Shapiro-Wilk's test. Independent sample t-test was performed on normally distributed data set and Mann-Whitney U test was performed for non-normally distributed data set. An Alpha level of 0.05 was used to determine the level of significance. Where p values were between 0.05-0.08, the results were identified as trends.

Correlation analysis was carried out to examine the relationship among age, years of education, print exposure and linguistic variables of the narrative (as listed in Table 3.1). Measure of print exposure was normally distributed ($p > 0.05$). Pearson's correlations were carried out for linguistic variables which were normally distributed ($p > 0.05$) and Spearman's correlations for linguistic variables which were not normally distributed ($p < 0.05$).

The minimum, maximum, mean, standard deviation and results of group comparisons on utterance level measures and morphosyntactic measures are presented in Table 3.5. The minimum, maximum, mean, standard deviation and results of group comparisons on lexical measures are presented in Table 3.6. The minimum, maximum mean, standard deviation and results of group comparisons on repair measures are presented in Table 3.7. The correlation analyses among the narrative variables, measure of print exposure, age and years of education is presented in Table 3.8.

3.6 Results

In this section, we present the findings from the narrative task described in section 3.4.2. We present the results of group comparisons of oral narratives in section 3.6.1, followed by the findings of the correlational analyses of oral narrative task with print exposure, years of education and age in section 3.6.2.

3.6.1 Group comparisons on oral narratives

Differences between HPE and LPE were reported as group differences on each of the narrative measures- utterance level, morpho-syntactic, lexical and repair measures.

There were no significant group differences for Total Utterances and Percentage of grammatical errors. The Total words showed a significant group difference $t(32) = 2.14$, $p = .04$, $d = .77$, with the HPE producing a higher number of words compared to LPE. (HPE: $M = 433.04$, $SD = 154.06$; LPE: $M = 326.75$, $SD = 85.45$). Table 3.5 below provides the mean and standard deviation and the group comparisons for the utterance level and morpho-syntactic measures.

Table 3.5

Minimum, Maximum, Mean, Standard deviation and Group comparisons of Utterance level and Morpho-syntactic variables

Utterance level Variables	**HPE =22**			**LPE =12**			
	Min-Max	Mean	SD	Min-Max	Mean	SD	Group Comparison
Total utterances	24-78	42.95	12.44	28-48	37.5	6.57	t(32) =1.37, p =.18, d=.18
Total words	194-890	433.04	154.06	200-495	326.75	85.45	t(32) =2.14, p =.04*, d=.77
Grammatical errors (%)	0-56.81	19.61	14.55	6.06-86.20	29.54	21.00	U = 94.5, p =.18
Morpho-syntactic Variables							
Verbs per utterance	1.35-2.57	1.88	0.31	1.17-2.40	1.61	0.36	t(32) =2.20, p =.03*, d=.79
% Past participle	0-1.56	0.62	0.35	0-1.84	0.60	0.53	t(32) =.12, p =.89, d=.04
% Auxiliaries	0.37-6.93	3.16	1.81	1.5-9.20	3.77	2.39	U = 118.50, p =.63
% Third person Singular	0-10.89	2.71	3.49	0-10.145	3.73	3.46	U = 107.50, p =.38
% Past tense	0.59-16.49	10.02	4.57	0.20-13.91	7.00	5.26	U = 177, p =.11
% Present Participle	1.63-7.25	3.57	1.49	0.50-7.66	3.88	1.91	U = 116.50, p =.58
% Plurals	1.01-4.83	2.64	1.11	0.5-6.74	2.37	1.54	U = 153, p =.46

*$p<.05$

There was a significant group difference only for verbs per utterance [t (32) =2.20, p =.03*, d=.79] with the HPE producing higher number of verbs per utterance than LPE (HPE: M =1.88, SD = .31; LPE: M = 1.61, SD= .36). All other morpho-syntactic measures were non-significant (See Table 3.5).

Group comparisons showed no statistically significant differences between the HPE and LPE groups for lexical diversity (See Table 3.6). There were no significant Group differences between the HPE and LPE groups for both open class and closed class words. Table 3.6 provides the mean and standard deviation and the group comparisons for the open class and closed class words.

There were no significant group differences between HPE and LPE for both the repair measures (See Table 3.7). However, the LPE group produced higher number of repetitions than HPE group (HPE: M =4.81, SD = 5.45; LPE: M = 7.16, SD= 4.93).

Table 3.6

Minimum, Maximum, Mean, Standard deviation and Group comparisons of lexical measures (lexical diversity, Open class and Closed class)

Lexical Measures	**HPE =22**			**LPE =12**			
	Min-Max	Mean	SD	Min-Max	Mean	SD	Group Comparison
Lexical Diversity							
TTR	0.26-0.45	0.32	0.04	0.28-0.4	0.33	0.03	U = 109.50, p =.42
VocD	0.29-0.47	0.36	0.04	0.32-0.44	0.36	0.04	U = 117.50, p =.61
Open class							
% Nouns	17.67-26.29	21.54	2.69	17.73-31.77	22.57	3.55	t(32) =-.91, p =.36, d=-.33
TTR Nouns	0.26- 0.63	0.43	0.09	0.29-0.47	0.40	0.05	t(32) =.93, p =.35, d=.33
% Verbs	16.12-21.45	18.89	1.39	15.65-22.62	18.56	1.89	t(32) =.54, p =.58, d=.19
TTR verbs	0.46-0.77	0.6	0.07	0.50-0.83	0.62	0.09	t(32) =-.83, p =.41, d= -.29
% Adverbs	3.86-10.13	7.52	1.76	3.37-10.50	6.82	2.42	t(32) =.92, p =.36, d =.33
% Adjectives	0-7.30	3.26	1.65	1.52-6.37	3.22	1.51	t(32) =.06, p =.94, d =.024
Closed class							
% prepositions	7.15-12.64	9.93	1.29	6.58-13.08	9.9	1.69	t(32) =.05, p =.95, d=.02
% Conjunctions	1.54-6.45	4.02	1.17	1.50-6.54	3.96	1.59	t(32) =.11, p =.91, d= .04
% Determiners	7.41-21.48	15.02	3.76	1.87-21.29	14.80	4.75	t(32) =.14, p =.88, d=.05
% Pronouns	6.85-17.53	11.20	2.77	5.86-18.25	11.27	3.56	t(32) =-.05, p =.95, d=-.02
% Wh-words	0-0.02	0.011	0.005	0-0.01	0.009	0.0068	t(32) =1.06, p =.29, d= .38

Table 3.7

Minimum, Maximum, Mean, Standard deviation and Group comparisons of Repair measures

Repair measures	**HPE =22**			**LPE =12**			Group Comparison
	Min-Max	Mean	SD	Min-Max	Mean	SD	
Number of retraces	0-42	9.5	8.56	2-16	9.58	4.5	U = 114.50, p =.53
Number of repetitions	0-19	4.81	5.45	0-17	7.16	4.93	U = 88.50, p =.119

3.6.2 Findings of Correlation analyses

The correlation analyses are reported as a relationship of print exposure, age and years of education with each of the narrative variables. None of the narrative variables correlated significantly with age. The correlation analyses among the narrative variables, measure of print exposure, age and years of education is presented in Table 3.8.

There was a significant positive correlation between print exposure and Total Words i.e. participants with higher print exposure used more words (See Figure 3.1). There was a significant negative correlation between print exposure and percentage of grammatical errors i.e. participants with higher print exposure produced fewer grammatical errors. Correlations between print exposure and Total Utterances were not significant. There was a significant negative correlation of years of education with total utterances i.e., participants with higher education used fewer utterances (See Figure 3.5). None of the other utterance variables correlated significantly with years of education.

There was a significant positive correlation between print exposure and verbs per utterance i.e. participants with higher print exposure used more verbs per utterance. There was negative correlation between print exposure and percentage of present participle i.e. participants with higher print exposure used the present participle tense less often (See Figure 3.2). All other correlations were not significant. Only the percentage of Auxiliaries showed a significant negative correlation with years of education suggesting that participants with higher number of years of education produced fewer auxiliaries (See figure 3.5).

Table 3.8

Correlation of narrative variables with measure of print exposure, age and years of education.

Narrative variables	Measure of print exposure (GJ-SV composite)		Years of education		Age	
	R-value	p-value	R-value	p-value	R-value	p-value
Utterance level measures						
Total utterances	0.24	0.16	-0.38*	0.02	0.21	0.22
Total words	0.46**	0.006	-0.16	0.34	0.24	0.15
Grammatical errors (%)	-0.56**	0.001	-0.11	0.53	-0.18	0.3
Morpho-syntactic measures						
Verbs per utterance	0.49**	0.003	0.18	0.28	0.1	0.55
% Past participle	-0.14	0.4	-0.09	0.59	0.14	0.4
% Auxiliaries	-0.02	0.87	-0.41*	0.01	0.09	0.6
% Third person Singular	0.01	0.95	-0.19	0.27	-0.29	0.08
% Past tense	0.04	0.82	0.08	0.62	0.05	0.75
% Present Participle	-0.34*	0.04	-0.26	0.12	0.12	0.49
% Plurals	-0.03	0.84	0.05	0.77	0.28	0.1
Lexical measures						
TTR	-0.12	0.49	0.442**	0.009	-0.14	0.4
VocD	0.07	0.69	0.27	0.11	-0.23	0.18
Open class						
% Nouns	-0.37*	0.03	-0.09	0.6	-0.16	0.35
TTR Nouns	0.36*	0.03	0.2	0.25	0.08	0.62
% Verbs	-0.05	0.75	-0.1	0.57	-0.16	0.36
TTR verbs	0.03	0.85	0.33	0.05	-0.24	0.16
% Adverbs	0.42*	0.013	-0.02	0.9	0.13	0.45
% Adjectives	0.31	0.06	0.13	0.44	0.25	0.14
Closed class						
% prepositions	-0.01	0.94	0.12	0.46	-0.01	0.95
% Conjunctions	0.2	0.24	0.18	0.29	0.08	0.64
% Determiners	-0.11	0.52	0.14	0.41	-0.17	0.92
% Pronouns	0.06	0.73	-0.17	0.32	-0.17	0.33
% Wh-words	0.27	0.12	-0.15	0.38	0.19	0.27
Repair measures						
Number of retraces	-0.33	0.057	-0.3	0.08	0.05	0.75
Number of repetitions	-0.34*	0.04	-0.12	0.5	0.025	0.88

****p*<.001, ***p*<.01, **p*<.05

There was a negative correlation between print exposure and TTR and a positive correlation between print exposure and VocD, neither were significant. There was a significant negative correlation between print exposure and percentage of nouns i.e. participants with higher print exposure produced fewer nouns in their narratives. There were significant positive correlations between print exposure and TTR for nouns, print exposure and percentage of adverbs. i.e. participants with higher print exposure produced a wider variety of nouns and more adverbs in their narratives (See Figure 3.3 for correlations of print exposure with lexical measures). Correlation of print exposure and measures of closed class words did not yield any significant results.

There was a significant positive correlation between years of education and TTR i.e., participants with greater number of years of education had a higher TTR (See Figure 3.5).

There was a significant negative correlation between print exposure and number of repetitions i.e. participants with lower print exposure used more repetitions in their narratives (See Figure 3.4). Print exposure also showed a negative trend with number of retraces. There were no significant correlations between years of education and the repair measures.

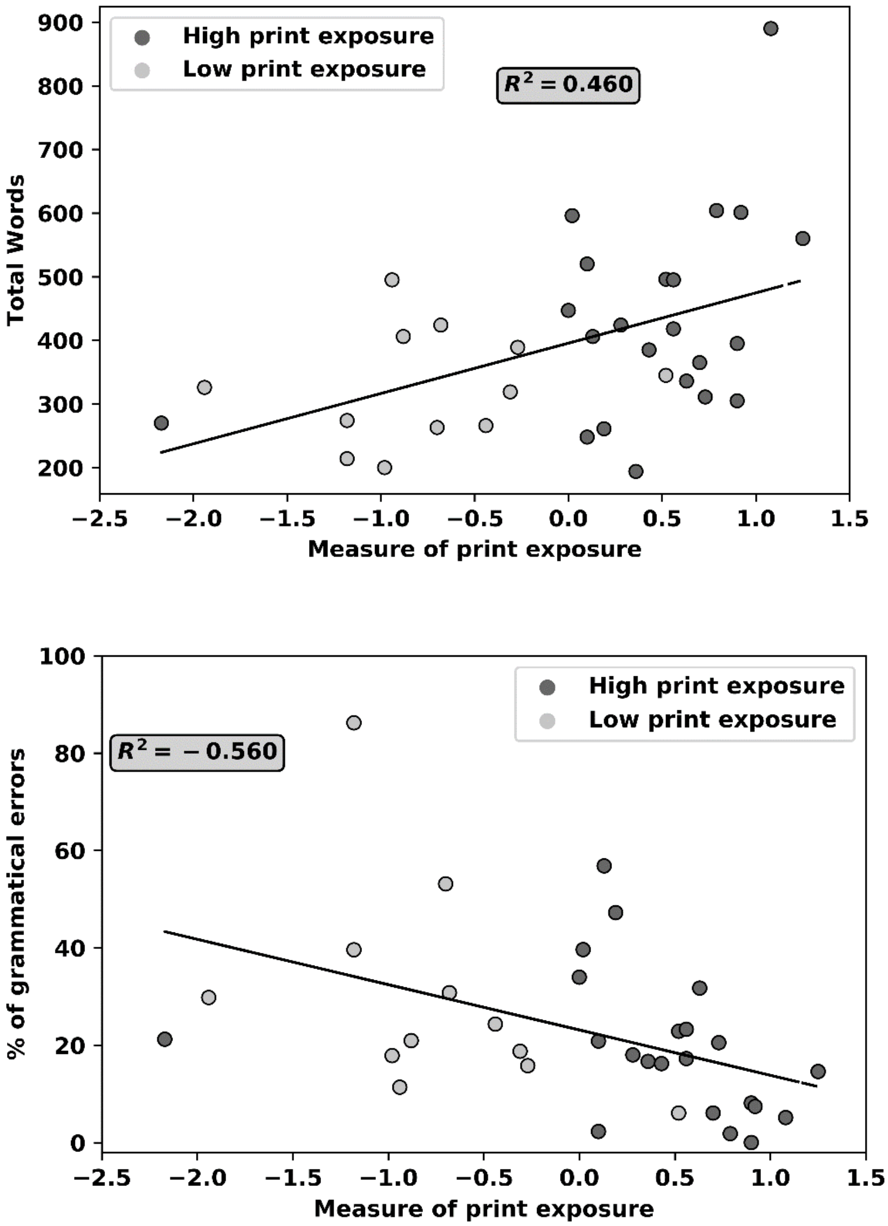


Figure 3.1 Significant correlations between measure of print exposure and Utterance level measures (Total words, % Grammatical errors)

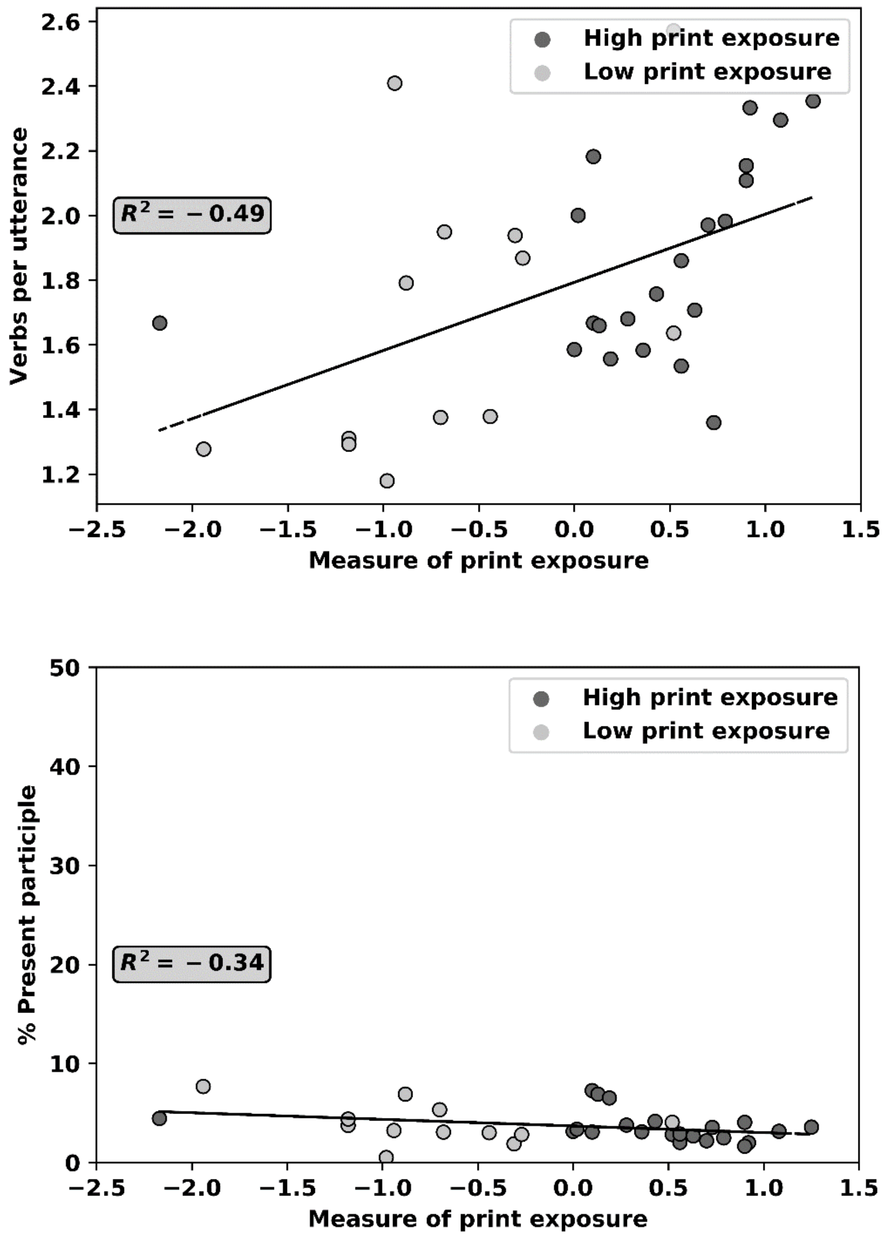


Figure 3.2 Significant correlations between measure of print exposure and morpho-syntactic measures (verbs per utterance, % Present participle)

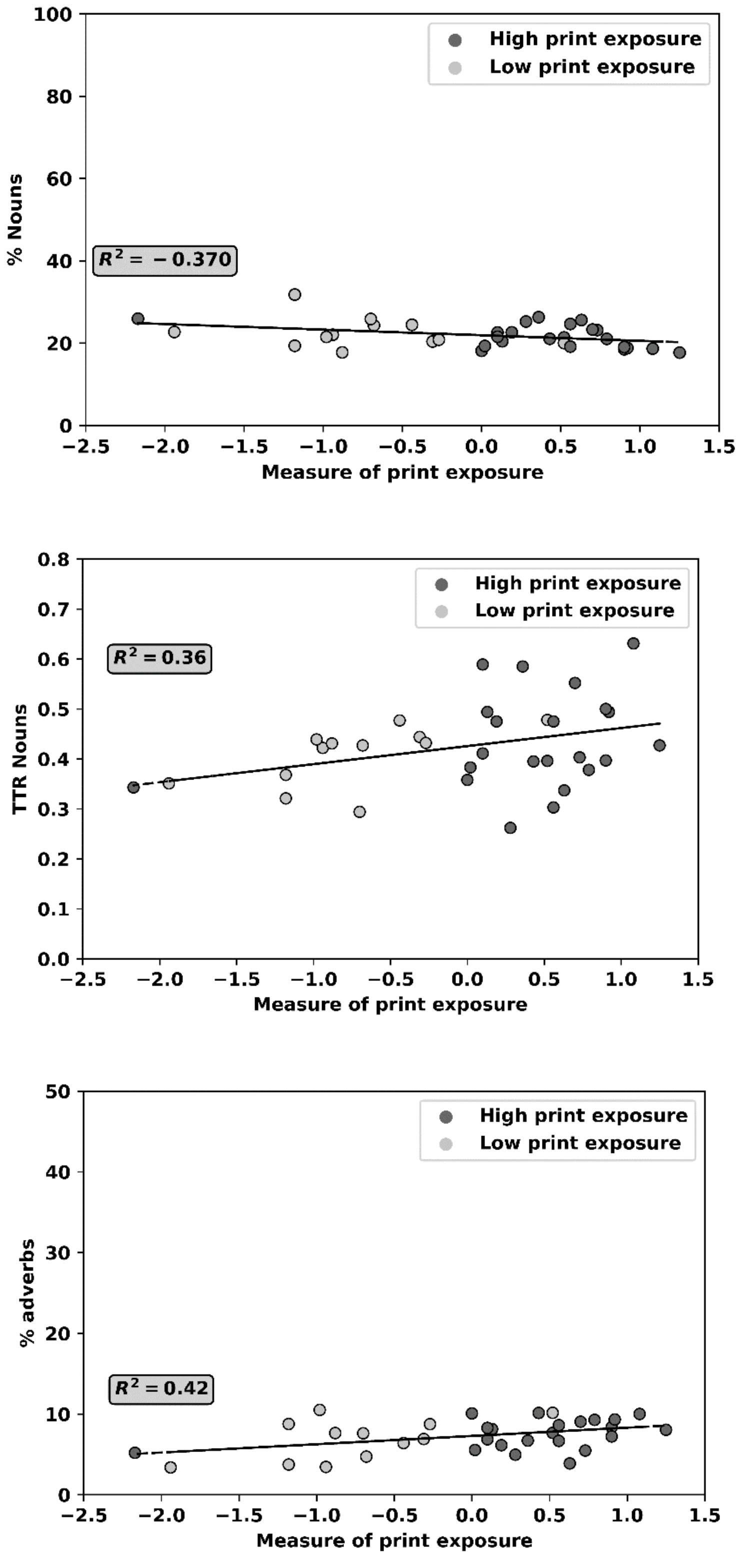


Figure 3.3 Significant correlations between measure of print exposure and lexical measures (% Nouns, TTR Nouns, % Adverbs

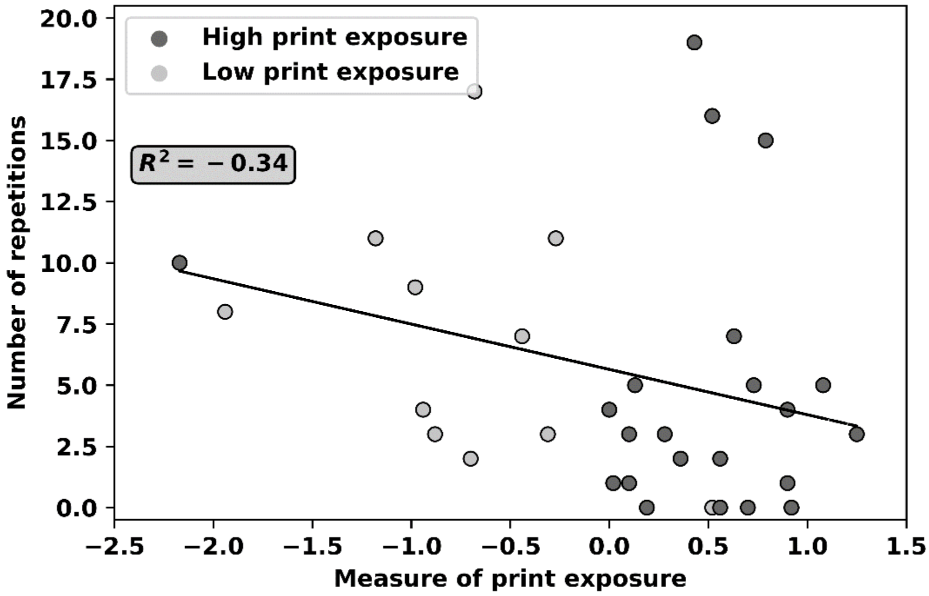
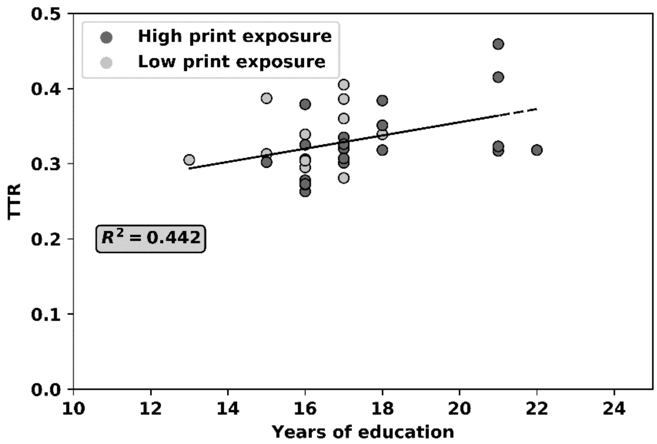
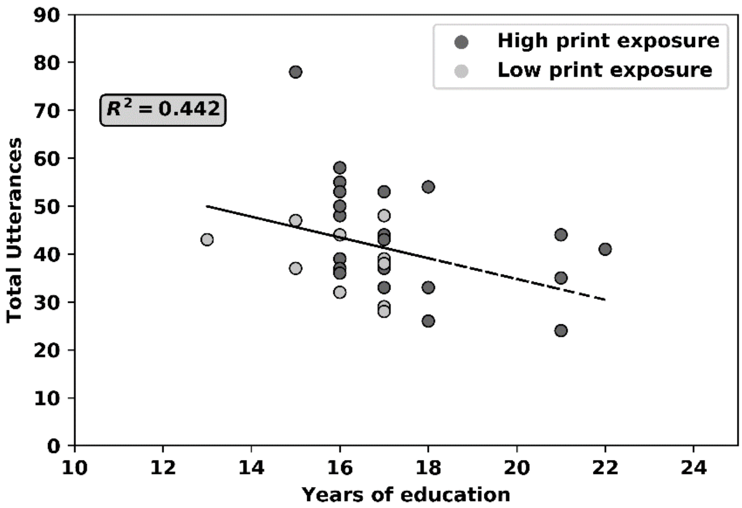


Figure 3.4 Significant correlations between measure of print exposure and repair measures (number of repetitions)





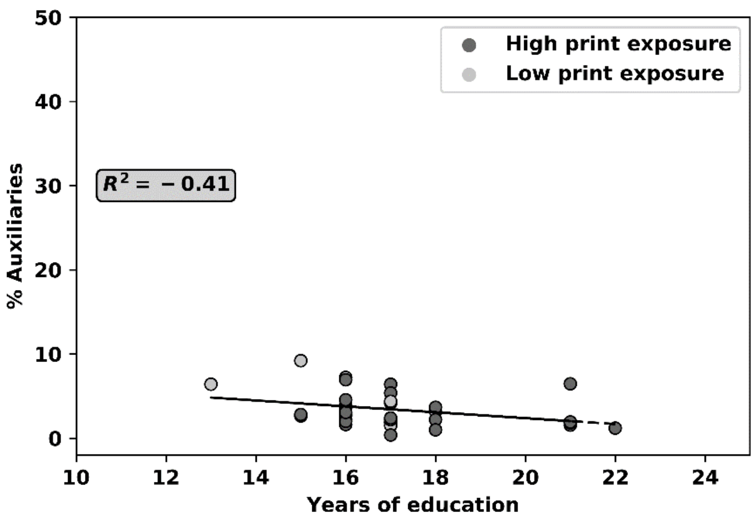


Figure 3.5 Significant correlations between years of education and Total utterances, % of auxiliaries, TTR.

3.7 Discussion

3.7.1 Summary of findings

The main findings are the results for total words, verbs per utterance and the results for number of repetitions. Table 3.9 provides the summary of findings of all the narrative variables. There were significant group differences and significant correlations for all three variables and highlight that increased print exposure in L2 is associated with higher number of words in the narrative, higher verbs per utterance and fewer repetitions in L2 oral production.

Findings also suggest increase in L2 print exposure is associated with using- more words, fewer grammatical errors, less present participle morphemes, more adverbs, fewer nouns, a more diverse range of nouns and fewer repetitions. Additionally, results also inform that increased number of years of education is related to the use of fewer utterances, fewer auxiliaries and a higher TTR.

Table 3.9

Summary of Findings of the Narrative Variables

Narrative Variables	Group Comparison			Correlation with Years of education		Correlation with Print Exposure	
	HPE (n =22)	LPE (n=12)	Statistically Significant Difference	Direction of Correlation (+/-)	Statistically Significant Correlation	Direction of Correlation (+/-)	Statistically Significant Correlation
Utterance Level Measures							
Total Utterances	Higher	Lower	No	-	Yes	+	No
Total Words	Higher	Lower	Yes	-	No	+	Yes
% Grammatical Errors	Lower	Higher	No	-	No	-	Yes
Morpho-syntactic Measures							
Verbs per Utterance	Higher	Lower	Yes	+	No	+	Yes
% Auxiliaries	Lower	Higher	No	-	Yes	-	No
% Third Person Singular	Lower	Higher	No	-	No	+	No
% Past Tense	Higher	Lower	No	+	No	+	No
% Past Participle	Higher	Lower	No	-	No	-	No
% Present Participle	Lower	Higher	No	-	No	-	Yes
% Plurals	Higher	Lower	No	+	No	+	No
Lexical Diversity							
TTR	Same	Same	No	+	Yes	-	No
VocD	Same	Same	No	+	No	+	No
Lexical Measures: Open Class Words							
% Nouns	Lower	Higher	No	-	No	-	Yes
TTR Nouns	Higher	Lower	No	+	No	+	Yes
% Verbs	Higher	Lower	No	-	No	-	No
TTR Verbs	Lower	Higher	No	+	No	+	No
% Adverbs	Higher	Lower	No	-	No	+	Yes
% Adjectives	Marginally Higher	Lower	No	+	No	+	No
Lexical Measures: Closed Class							
% Prepositions	Marginally Higher	Lower	No	+	No	-	No
% Conjunctions	Marginally Higher	Lower	No	+	No	+	No
% Pronouns	Lower	Higher	No	-	No	+	No
% Wh-Words	Higher	Lower	No	-	No	+	No
% Determiners	Higher	Lower	No	+	No	-	No
Measures of Repair							
Number of Retraces	Same	Same	No	-	No	-	No
Number of Repetitions	Lower	Higher	No	-	No	-	Yes

The findings of total words support the hypotheses showing significant differences between the two groups and by a significant positive correlation, higher print exposure scores were associated with using more words. Measuring verbosity would provide a richer utterance level measure. However, firstly it is difficult to objectively measure the verbosity (Hussain, 1992), secondly there is a natural variation in participants' verbosity. For instance, in a study with Pakistani students speaking English as L2, Husain (1992) concluded that the spoken English is verbose because of the written English study material that the students are exposed to.

The findings of percentage of grammatical errors support the hypothesis with a significant correlation showing higher print exposure scores were associated with fewer grammatical errors. It was expected that participants with higher print exposure had lower grammatical errors, since grammaticality judgement was one component used to measure print exposure in the current study. This supports the idea that higher print exposure in L2 amounts to better grammatical competence in spoken L2, which is in line with the findings of Sparks in Dąbrowska (2012) where L1 print exposure predicts L1 language achievements

The findings of verbs per utterance support the hypothesis by a significant group difference between HPE and LPE as well as a significant positive correlation between print exposure and verbs per utterance. This is in line with our finding of one of the tasks of comprehension (synonymy triplets task) where print exposure was associated with better verb comprehension compared to noun comprehension. A sentence is considered grammatically incomplete without a verb; therefore, they are essential in sentence production and comprehension (Reyes & Thompson, 2012). Findings also corroborate with monolingual literature (Montag & MacDonald, 2015) and can be accounted for by the following. Reading requires structural and conceptual linguistic knowledge to decode simple sentences and to extrapolate meaning from more complex sentences (Nippold et al, 2009). The sentence structure of written language is more formal than spoken language and is often embedded via constructions such as dependent clauses (Curenton & Justice, 2004). It is known that reading increases familiarity with complex structures (Guasti, 2004) and therefore these morpho-syntactic structures are more likely to emerge in an individual's oral production (Montag and MacDonald, 2015).

Robinson (1995) found that in L2 oral narrative production, using a simpler 'here and now' condition as opposed to a more complex 'there and then' condition resulted in greater average utterance length. In the current study, for both groups it was noticed that the past tense was used most often. This was followed by the present participle tense which was followed by the past participle tense. Participants were not explicitly instructed on the tense of type to be used. This implies tense of narration needs to be considered as a potential factor affecting morpho-syntactic complexity in L2 oral narratives.

There was a significant negative correlation between print exposure in L2 and percentage of the present participle implying that participants with higher print exposure are less likely to use present participle. This result could be either because the participant chose to not to use the present participle which is an earlier acquired simpler tense from (Brown, 1973) or it could have been a random choice of tense as the participants were not restricted to use a particular tense form in narration. Hence, this does not preclude the inability to use complex tense forms, but rather may reflect a tense choice.

The findings of lexical diversity do not support the hypothesis. Even though, VocD is arguably a more valid measure, accounting for differing lengths of narratives (Malvern et al, 1997), we did not find any significant difference between the two groups. Cunningham and Stanovich (1991) and Guasti (2004) found that higher print exposure enlarges vocabulary size, so it might be worthwhile considering comparison of VocD scores with other vocabulary measures.

Higher print exposure was associated with significantly higher percentage of adverbs, and fewer but more diverse range of nouns. The reduction in noun use could be attributed to the relative increased use of adverbs. Adverbial clauses occur most often in written language (Curenton & Justice, 2004). Their increased use by participants with higher print exposure could be taken as evidence of increased syntactic complexity. The findings of closed class words did not support the hypothesis.

The findings of the number of repetitions support the hypothesis i.e., participants with higher print exposure in L2 used fewer repetitions in their L2 oral narratives. This implies that the narratives were more fluent. This mirrors relationships known to exist between print exposure and verbal fluency with monolingual speakers (Cunningham & Stanovich, 1991) and provides evidence that print exposure impacts fluency in open utterance level tasks.

Levelt's model (1989 in Ratner, 1997) of speech production involves multiple stages- conceptualisation, formulation and articulation. Disruption at any stage can result in 'normal dysfluencies' (repetition of whole words/phrases, filled pauses and revisions, (Guitar, 2013).

The second stage -formulation stage involves grammatical and phonological encoding. A sentence is constructed as a pre-verbal message which is transformed into linguistic structures, words are selected from the lexicon and are assigned syntactic roles. Therefore, grammatical competence influences fluency. Based on this model and the findings of the current study, it is natural to expect that participants with higher print exposure make fewer grammatical errors as they are assumed to be more familiar with the complex morpho-syntactic structures. They therefore use lower rates of repetitions in the oral narratives.

3.7.2 Limitations

3.7.2.1 Sample size. Recruiting more participants would have produced more reliable results. The unequal size of the two groups (HPE: 22; LPE: 12) may have resulted in non-significant results of Group comparisons. This may have driven the discrepancies in results where there were significant correlations, but no significant group differences on some variables.

3.7.2.2 Methodology and analyses. Some methodological improvements could have yielded better results. Including other subjective measures of print exposure such as self-rated L2 reading and writing habits, would have strengthened the representation of participant's print exposure (Acheson et al, 2008).

Linguistic variables studied were partly limited by two aspects- the possible outputs of the selected analysis tool (CLAN) and by the degree of coding that could be completed in the allotted time. Alternative tools e.g. Sketch Engine (Kilgarriff et al, 2004) may have facilitated inclusion of more or alternative variables. Additional coding of word level errors (e.g. case errors) and subdivisions of words classes (e.g. comparative vs superlative adjectives) would have allowed for a finer level of analysis. In this study, the reliability of coding was carried out using an unrelated transcript. This could have been improved by using a sample of the narratives.

In the current study, group comparisons and correlations were carried out. A next step to this would be a regression analysis exploring the relative contribution of other independent variables such as age, gender, years of education and print exposure in L2 to each of the narrative variables. Adding these improvements to the current study, would makes its scope far beyond what is feasible given comprehensiveness of the study and the time constraints.

3.7.3 Future Directions

Further research could explore the nature of grammatical errors made; using CLAN, this would require classification, coding and analysis of errors at the word level in the speaker tier to identify error types (e.g. errors of agreement / omission) and the structures affected (e.g. plurals / past tenses / possessives).

Measuring verbs per utterance provided a quantitative measure of syntactic complexity; qualitative classification of structures (e.g. actives / passives) would give a richer description of syntactic complexity. Alternatively, use of sketch engine tool could add more variables into the analyses.

Measuring and analysing different features of print exposure in L2, such as frequency, types of print (academic literature / newspapers / novels) and duration since first exposure, could provide insight as to which aspects of print exposure in L2 are driving the differences observed in L2 oral narratives. Further, it is important to adequately measure print exposure in L1 using an objective measure and control for the same during the analyses.

The typological similarities or differences across languages determine interaction of the language pairs (Sorace & Serratrice, 2009). Therefore, this makes it difficult to generalise the findings across bilingual populations. This could be addressed by replication of this study using different language pairs.

Chapter 4 Impact of print exposure on executive functions in bi-literate bilingual healthy adults

4.1 Abstract

Background Research has indicated that print exposure has a positive impact on generalised executive functions such as immediate recall (Ardila & Rosselli ,1989), Stroop task (Barnes, Tager, Satariano & Yaffe ,2004) and working memory (Silva et al., 2012). This literature focuses on impact of print exposure on executive function tasks in monolingual population. On the other hand, some research has shown that bilinguals exhibit an advantage over monolinguals on tasks of non-verbal executive functions such as the Simon task (Bialystok, Craik, Klein, & Viswanathan, 2004), Stroop task (Bialystok, Craik, & Luk, 2008) and task-switching (Prior & Gollan, 2011). As a significant portion of the world's population is bilingual, it is important to characterise the impact of literacy as measured by print exposure on executive function tasks in bilinguals. However, none of the bilingual studies report whether these bilinguals were bi-literates or consider print exposure as a factor in examining executive function. Therefore, it remains to be determined if print exposure in a bi-literate bilingual population would show similar effects on non-verbal executive function tasks.

Aim The current study examines the impact of print exposure in non-verbal executive functioning in bi-literate bilingual healthy adults.

Methods We used the same participants as in Chapter 2. We grouped the thirty-four participants of our study into two groups: high print exposure (n=22) and low print exposure (n=12). We administered a set of non-verbal executive function tasks tapping into inhibitory control (Spatial Stroop and Flanker tasks), working memory (visual n-back and auditory n-back) and task switching (colour-shape task). For the inhibitory control and task switching tasks, we extracted the RT and accuracy to measure the Stroop effect, conflict effect and switch cost. For the n-back tasks, we used D prime for analyses.

Findings There were no significant group differences or correlation of print exposure with any executive function measure except auditory N-back. For both the 1-back and 2-back conditions, the participants in HPE performed better than participants in LPE. Additionally, there was a significant correlation between print exposure and d prime score on the auditory 2-back condition.

Conclusions and implications Our results do not allude to a direct link of print exposure with executive function measures of inhibitory control and task switching within bi-literate bilinguals. Although, there seems to be a link of print exposure with working memory when testing using an auditory stimuli, this does not hold true for the visual N-back task. This research attempted to account for the impact of print exposure on non-verbal executive functions in bi-literate bilingual adults. Future research comparing verbal and non-verbal executive function measures in the same population will help us determine if print exposure has a differential impact on verbal and non-verbal executive functions.

4.2 Introduction

Executive functions are known by various terms such as cognitive control or executive control. Royall et al (2002) generalises executive functions as a broad set of cognitive skills required for "planning, initiation, sequencing, and monitoring of complex goal directed behaviour". On the other hand, there is a school of thought that defines executive functions as a family of mental processes that are used when focussing on a specific task without relying on intuition or instinct (Diamond, 2013; Burgess & Simons 2005, Espy 2004, Miller & Cohen 2001). The generally agreed upon core executive functions are inhibitory control, working memory (WM), and cognitive flexibility (also called set shifting, mental flexibility, or mental set shifting (Miyake et al., 2000; Miyake & Friedman, 2012; Lehto et al, 2003; Diamond, 2013). This is a more holistic i.e., an inclusive categorisation that takes into account all the different domains of cognition.

For instance, Miyake & Friedman (2012) view executive functions as a case for unity in diversity, where individual components (Figure 4.1a) are unified by the fact that they are correlated with each other but are still separable. Figure 4.1b depicts the loading of al the executive function tasks into a common EF factor and additional sub-units for updating and shifting. While this explains the different components of executive functions and their interdependencies, there exists external factors such as bilingualism, literacy and other demographic variables which impact executive functions. Consequently, a significant body of research consisting of many studies has examined the interplay between these external factors and the components of executive functions [(Ardila et al. (2010); Barnes, Tager, Satariano & Yaffe, (2004); Silva et al., (2012); Bialystok, Craik, Klein, & Viswanathan (2004); Bialystok, Craik, & Luk, (2008)].

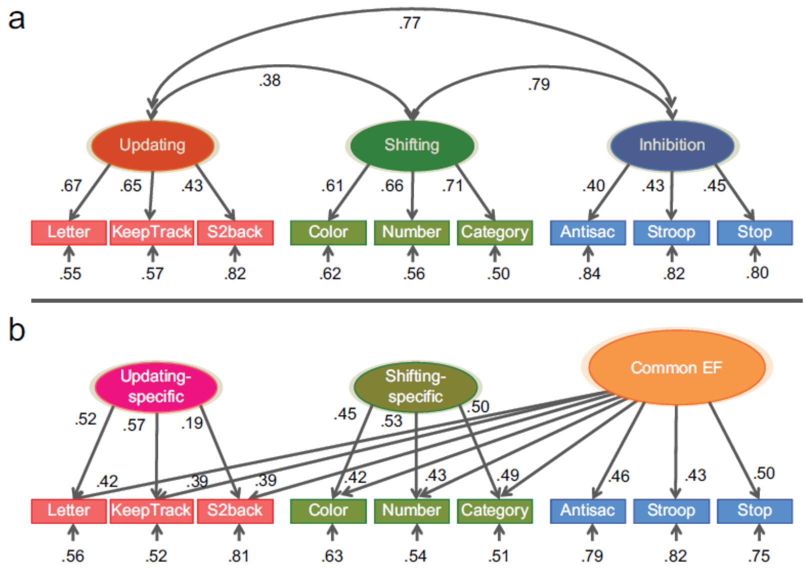


Figure 4.1 Illustrating two ways of representing executive function (Miyake and Friedman, 2012) (a) Individual components of executive functions, separable from each other. (b) Common executive function variable with additional updating and shifting sub-components.

Each external factor impacts the executive functions differently. Studying literacy skills provides a better understanding of the organisation of cognition. For instance, learning to read improves the performance of verbal and visual memory (Folia and Kosmidis,2003), executive functions[1] (Barnes, Tager, Satariano & Yaffe,2004), improved working memory, [See Ardila et al. (2010) for critical review; Silva et al., (2012)]. Furthermore, research on bilingualism has shown that bilinguals exhibit an advantage over monolinguals on tasks of non-verbal executive functions such as the Simon task (Bialystok, Craik, Klein, & Viswanathan, 2004), Stroop task (Bialystok, Craik, & Luk, 2008) and task-switching (Prior & Gollan, 2011). There are also reports suggesting that bilingual advantage in executive function may be very restricted to a particular task as most studies use only a single measure of executive function and others who have used multiple measures lack convergent validity (Paap & Greenberg,2013).

[1] Executive functions here refer to generalised executive functions.

Paap et al (2015) suggests that the minority number of publications that suggest a bilingual advantage in executive function may be due to the insensitivity of the dependent variables measuring executive function or Type 1 errors, confounds in demographic factors such as genetics, socio-economic status and immigration status (Valian, 2015), and questionable statistical tests. Among these demographic factors, extent of literacy as measured by print exposure could be a potential factor impacting executive functions in bilinguals. The degree of bi-literacy is different across bilinguals. Interest in bi-literacy has emerged only recently; it's effect on linguistic and cognitive performance remains largely unknown (Reyes, 2012). Our study examines the validity of this relationship between print exposure and executive functions in bi-literate bilinguals.

Given the impact of print exposure (literacy) and bilingualism on executive functions, in this chapter we will discuss our methods and results of exploring the impact of print exposure on executive functions within a bi-literate bilingual population. In the review of the current state of the art, we discuss the impact of print exposure on executive functions (4.2.1), debate on bilingualism and executive functions (4.2.2), gaps in the literature with respect to impact of print exposure on executive functions in bilinguals (4.2.3).

4.2.1 Impact of print exposure on executive functions

We will explore the literature related to the impact of print exposure (literacy) on executive functions in mutually exclusive groups of illiterate and literate populations.

Ardila & Rosselli (1989) tested two groups consisting of extreme literates and extreme illiterates on a neuropsychological battery of visuo-spatial and memory abilities to determine if they performed statistically significant. Their study consisted of 200 normal right-handed subjects split into groups based on three variables- education level, age and sex. The illiterate population were those who had no opportunity to go to school and their parents were also uneducated. The literate population were chosen from among the professionals who had attended either university or school. The following visuo-spatial and memory tasks were administered- digit retention, memory curve, delayed verbal recall, sentence repetition, immediate and delayed logical memory, immediate recall of the Rey-Osterrieth complex figure, immediate reproduction of a cube, visuospatial memory, sequential memory and immediate memory of sentences. They found that literates were better (in accuracy) than illiterates in all tasks except immediate memory of sentences. The authors claim that literacy improves an individual's ability to perform cognitive tasks.

Manly et al (1999) examined the effects of print exposure using a neuropsychological test battery in adults over 65 years with 0- 3 years of education in Spanish speakers. A total of 251 participants were recruited for this study. Print exposure was measured by self-report. The tasks administered (that are relevant to the current chapter) are verbal list learning and memory [Selective Reminding Test ; Buschke & Fuld, 1974], nonverbal memory [multiple choice version of the Benton Visual Retention Test (BVRT); Benton(1955)], orientation [items from the Mini Mental State Examination (MMSE); Folstein et al., 1975], verbal reasoning [Similarities subtest of the Wechsler Adult Intelligence Scale–Revised (WAIS–R); Wechsler, 1981] nonverbal reasoning (Identities and Oddities subtest of the Mattis Dementia Rating Scale; Mattis, 1976), visuo-construction (Rosen Drawing Test; Rosen, 1981), and visuo-perceptual skills (multiple choice matching of figures from the BVRT; Benton, 1955). They found that overall, literates outperformed illiterates in neuropsychological test scores. Specifically, they found that illiterates obtained significantly lower scores than literates on BVRT matching and recognition, WAIS–R Similarities subtest and MMSE Orientation. They attribute the higher BVRT matching and recognition scores to visuospatial decision making rather than nonverbal memory. They did not find an effect of print exposure on delayed recall.

Folia and Kosmidis (2003) investigated whether memory differences between illiterates and literates were an artefact of the assessment tool, rather than an intrinsic difference between the groups. They recruited 54 right-handed women grouping them into 3 groups based on years of education: 19 women with zero years of education; 20 age matched women with 1-9 years of education and the remaining 15 with greater than 9 years of education (mean of 10 years). They subjected these groups to different memory tasks- a word list learning test (a modification of the California verbal learning test, Delis, Kramer, Kaplan, & Ober, 1987) and an object learning test. These memory tests consisted of 16 words/3-dimensional objects that were exposed to the participants for 10 seconds. Each learning was followed by a recall of as many words/objects as possible. This was followed by a delayed free recall and cued recall.

Variables of interest were: number of words/objects recalled on the first learning trial, number of words/objects recalled on the fifth learning trial, number of words retrieved after 20 min on free recall, number of words/objects retrieved on cued recall, number of words/objects recognized correctly among verbally presented distracter stimuli as belonging to the original items and number of semantic clusters used during delayed free recall. The illiterate group performed the worst in the study on all the tasks, however, specifically the illiterates performed poorly on first trial, delayed recall, recognition and semantic clustering. In contrast, all three groups performed similarly on object learning task, but the illiterates did not use semantic clustering strategies or recall as many words after a 20-min delay as the other groups. The authors conclude that the poor memory performance among illiterates can be attributed both to the nature of the task, as well as to the use of different retrieval mechanisms.

A study by Silva et al (2012) compared verbal and non-verbal working memory in illiterates and literates differentiated based on years of education and screening of literates on reading of text and comprehension questions. This study consisted of 38 healthy female volunteers who were divided into literate and illiterate groups, each group comprising of 19 participants. The task administered were digit and spatial span tasks (forward and backward) from the Wechsler Memory Scale–Third Edition (WMS–III; Wechsler, 1997). They found that the literacy effect was seen in forward digit span favouring the literates whereas the spatial span showed similar performances across the two groups. In the backward span tasks, there was a general decrease in performance compared to the forward tasks in both the groups however the performance of the illiterate group was significantly poorer than the literate group. Their forward digit span findings imply that literacy impacts the phonological loop component of working memory. The authors attribute the better performance of the literates on the backward span tasks to more efficient functioning of the central executive in literates.

Barnes, Tager, Satariano & Yaffe (2004) examined the impact of literacy on four cognitive measures: global (MMSE), executive function and attention (trail making, Stroop interference test and digit symbols test), verbal learning and memory (California Verbal Learning Test), and verbal fluency (letter ‘‘s,’’ animals). The study recruited 664 community-living adults aged 65 years or older English speakers. The participants were grouped as illiterates and literates based on the performance on North American Adult Reading Test (NAART) where they had to pronounce words with irregular spellings. Based on the performance on NAART, the participants were divided into three literacy tertiles- low (M = 26 words), middle (M= 39 words) and high (M= 50 words). In all sub- groups, literacy was strongly associated with all measures of cognition. This association was linear and largely unchanged for years of education and age. They found that individual with higher literacy performed better on all measures of cognition. In addition, they found that literacy was a predictor than education of cognitive abilities.

Within the literature we have reviewed, we have noticed that print exposure/ literacy seems to have a higher impact on verbal executive function tasks. In general, literature notes that literates perform better than illiterates on visuospatial (Ardila & Rosselli, 1989), verbal working memory (Silva et al, 2012, Folia and Kosmidis, 2003), general executive functions (Barnes et al, 2004). However, literates and illiterates perform comparably on non-verbal memory tasks (Folia and Kosmidis, 2003). A major drawback is that all of the above literature focuses on impact of print exposure/ literacy on executive function tasks in monolingual population. As a significant portion of the world’s population is bilingual, it is important to characterise the impact of literacy as measured by print exposure on executive function tasks in bilinguals. Studies in this regard are reviewed in the following section (4.2.2).

Additionally, each of the above studies tap into a specific cognitive domain which are independent of each other or tend to club these within a broad umbrella of neuropsychological batteries (general executive functioning). None of the studies use all the different domains of executive functions in a holistic manner (Refer figure 4.1). Studies by Teuber (1972) and Duncan, Johnson, Swales, & Freer, (1997) have asked whether all executive functions can be viewed in a holistic manner. In response to this question, Miyake & Friedman (2012) have grouped the processes of executive function under three domains- updating information (working memory), inhibitory control and task switching (cognitive flexibility). This is a more holistic i.e., an inclusive categorisation that takes into account all the different domains of cognition.

4.2.2 Debate of bilingual advantage in executive functions

In reviewing the literature summarising the effects of bilingualism on executive function, there has been evidence that the so-called cognitive advantage of bilinguals is not very conclusive (Zhou & Krott, 2016). For instance, in monolingual vs. bilingual comparisons, the performance on non-verbal inhibition tasks have had mixed results (de Bruin et al., 2015; Hilchey & Klein, 2011; Paap & Greenberg, 2013; Paap, 2014). Between groups of bilinguals and monolinguals they found the younger bilinguals were less and older bilinguals were more skilled than older monolinguals in performing in conditions that focused on all three of the executive components manipulated in the experiment. In this section, we focus on reviewing literature pertaining to impact of bilingualism on individual components of executive functions.

4.2.2.1 Debate on bilingual advantage in inhibitory control Costa, Hernandez and Sebastian-Galles (2008) have tested the Attentional Network task (ANT) on a population of Catalan-Spanish bilinguals and Spanish monolinguals. The goal of their study was to examine if there is a bilingual advantage in attentional abilities. They studied this by measuring their abilities to resolve conflict between congruent and incongruent information and to switch between different types of trials. The attentional component of executive control is likely to be impacted by bilingualism and may also involve inhibitory control. They used the ANT developed by Fan, McCandliss, Sommer, Raz, and Posner (2002) to assess the attentional capabilities.

Participants were asked to indicate whether a central arrow points to the right or left (the target stimulus is presented above or below a fixation point). This arrow is presented along with two flanker arrows pointing to the same (congruent trials) or different direction (incongruent trials). The alerting network is studied by presenting a cue before stimulus to prime their participant responses. The hypothesis to using this sort of cueing is that bilingualism inherently causes a smaller conflict effect as bilinguals have a stronger inhibitory control component. Their results showed that bilinguals responded faster with a smaller conflict effect and smaller switch cost. In our study, we have included a Flanker task and a switching task measuring conflict effect and switch cost respectively to examine whether print exposure in addition to bilingualism has the same impact.

A study by Bialystok et al (2008) studied the effects of aging and bilingualism on an executive control task. This study builds on the results that the Simon task has shown a bilingual advantage on children, young adults and older people (Martin & Bialystok, 2003; Bialystok, 2006; Bialystok, Craik, Klein, & Viswanathan, 2004; van der Lubbe & Verleger, 2002). Consequently, this study tried to identify the precise executive processes that are advantaged in bilinguals. To this end, three executive processes—response suppression(ability to withhold a response to a habitual cue as in the go/no-go task (Casey et al., 1997; Diamond, 1988)) inhibitory control(the ability to identify the relevant cue when two conflicting ones are present) , and task switching(the ability to identify the correct set of instructions between two sets in response to a cue and execute them correctly) —were investigated with a modified antisaccade task. The choice of tasks is motivated by studies of behavioural and imaging data.

Studies using both behavioural and imaging data have provided evidence for the difference between task switching and inhibitory control (Sylvester et al., 2003; Ward, Roberts, & Phillips, 2001) and between response suppression and inhibitory control (Bunge, Dudukovic, Thomason, Vaidya, & Gabrieli, 2002). A total of 96 participants were included in the study, who were split into 4 groups of monolingual young adults (mean age 20.7 years, mean education of 14.4 years), bilingual young adults(mean age of 20.8 years, mean education of 14.6 years), monolingual older adults(mean age 70.4, mean education of 15.4 years), and bilingual older adults(mean age of 71.3 and mean education of 16.6 years). An adapted version of antisaccade task used by Friesen and Kingstone (1998) was used to isolate the effects of response suppression, inhibitory control, and task switching on the other hand eye movement time was measured with the prosaccade task.

The authors claim that in terms of the unitary nature of executive control components, the results support the interpretation that executive control is a unitary construct but compatible with accounts claiming that control depends on a set of related factors, both at the level of cognitive processes (e.g., Miyake et al., 2000) and at the level of neural (typically frontal) processes and mechanisms (e.g., Stuss et al., 2005; Stuss & Levine, 2002). Additionally, given the fact that faster response times were elicited for older bilinguals where conflicting stimuli were present, provides further evidence that bilingualism may act as a form of extended training in aspects of executive control.

Kousaie & Phillips (2012) examined the bilingual advantage using three tasks – Stroop, Simon and Flanker task. They compared two groups of adults – monolinguals (n=25) and bilinguals (n=26). They studied the effect of bilingualism on the Stroop, Simon and Eriksen flanker task (Eriksen & Eriksen, 1974) in order to validate the bilingual advantage in control mechanisms. In their investigation, the authors found no bilingual advantage in any of the three tasks in contrast to Bialystok et al. (2008) where bilingual advantage was demonstrated in both the Stroop and the arrows version of Simon task.

The authors argue that compared to Costa et al. (2009) their task was not able to elicit any advantage probably because the difficulty level of each task remained the same and consequently did not pose enough of a challenge for the bilingual effect to be demonstrated. They also imply that as a large number of trials were involved the bilingual advantage could also have been eliminated by the practise effect (for a review see Hichley and Klien, 2011). To study if this is true, they carried out certain supplemental analyses such as examining raw RT and interference effect between neutral and incongruent trials but still found no bilingual advantage/difference.

A significant limitation of the study is that it did not include the immigrant population in contrast with say Costa et. al. (2008, 2009). Additionally, the ANT used by Costa et al. (2009) includes cued and non-cued conditions that measures three attentional networks: alerting, orienting and executive control, therefore this methodological difference could probably explain the difference in findings.

To summarise, from the methodological perspective, all of the studies summarised above employ non-verbal inhibitory control tasks. There is some evidence of positive impact of bilingualism on inhibitory control (Bialystok et al., 2008; Costa et al, 2008) and other evidence of a null effect (Kousaie & Philips, 2012). Consequently, multiple viewpoints exist on whether a bilingual advantage exists in inhibitory control. In our study, we have sought to investigate the impact of print exposure on inhibitory control using non-verbal inhibitory tasks (spatial Stroop and Flanker) in a bi-literate bilingual population incorporating print exposure as an additional variable.

4.2.2.2 Debate on bilingual advantage in working memory There has been evidence that bilinguals have performed poorly on verbal memory tasks. A study by Fernandez et al (2007) examined the effects of aging and bilingualism on memory performance in bilingual adults. They recruited 104 participants divided into 4 groups- 2 groups of bilinguals (younger and older adults) and 2 groups of monolinguals. The background tasks administered were language background questionnaire, Peabody Picture Vocabulary test (Dunn & Dunn, 1997) and digit span task. The experimental task included a free recall task using five items from five semantic categories (animals, fruits, musical instruments, tools and kitchen items). Each word was presented auditorily and a set of distractor words were visually presented. They found that bilinguals recalled fewer words than monolinguals in a free recall task with the older adults performing poorer than younger adults in both monolinguals and bilinguals.

There is not enough evidence to suggest that bilinguals are at an advantage on working memory. A study by Soveri et al (2011) tested whether tasks measuring different executive functions (inhibition, updating, and set shifting) could be predicted by the frequency of language switches (as measured by a language switching questionnaire). The goal of this study is guided by the hypothesis, that bilinguals with lifelong practise in processes that engage executive functions may have positive effects in executive function performance (e.g., Bialystok et al., 2006a; Carlson and Meltzoff, 2008) and their performance will be modulated by the degree of usage in everyday life (Costa et al, 2009). This modulation is however, not easily explained without understanding the underlying mechanisms that cause the bilingual advantage.

The study was made up of 38 participants (12 men and 26 women, age range of 30-75 with a mean age of 52.84) all of whom were Finish-Swedish bilinguals. They were administered the Simon task and flanker task (adapted from Eriksen and Eriksen, 1974) to measure inhibition, the spatial N-back (Carlsson et al., 1998) was used to measure working memory updating and number-letter task (Rogers and Monsell, 1995) was used to measure shifting abilities. The authors found a significant association between the predictor age of L2 acquisition and the Simon effect as the outcome variable, indicating that younger age of L2 acquisition resulted in a smaller Simon effect in RTs. However, none of the other predictors showed any other significant result. A side result however was that the authors found that the language switching frequency in bilinguals (from the questionnaire of measuring degree of bilingualism) predicted the mixing cost (error rate) in the shifting task within the Number-letter task. This the authors claim was due to the bilingual experience of managing two languages. They also found age to be a significant predictor of working memory updating (N-back task) and the mixing cost in set shifting. Younger bilinguals showed significantly lower costs on number-letter task. It was clear to the authors that set shifting task showed most sensitivity to the bilingual advantage.

N-back requires online monitoring and updating working memory (Monk et al, 2011). The N-back task has been extensively used as a measure of working memory (Monk et al., 2011; Kane et al, 2007; Jaeggi et al, 2010). However, given that the relationship between bilingualism and working memory is not very clear (Dong et al., 2015), Therefore in our study, we try to explore the relationship between an extraneous factor (print exposure) and working memory updating using the N-back task. In our study, we use D prime (D') as a way to validate the results of the N-back task as D prime is less prone to confounding factors such as demographic factors as compared to digit span and letter-number sequencing (Haatveit et al, 2010).

4.2.2.3 Debate on bilingual advantage in task-switching. A study by Prior & McWhinney (2010) investigated the possibility that lifelong bilinguals may have enhanced ability to shift between mental sets. They examined task switching ability in bilinguals using the colour-shape task which consisted of a set of non-switch and switch trials in a sandwich design. They defined switch costs as the measure of difficulty in switching from one task set to another. The choice of task was driven by the difficulty of the task and even young high-performing participants are known to incur large costs (for a review, see Monsell, 2003). Therefore, probability of encountering ceiling effects is low and more likely to elicit group differences in performance. A total of 92 participants were recruited, 45 of these were monolinguals (mean age: 18.7years) and 47 were heterogenous bilinguals (19.5 years) having acquired both languages before the age of 6. They found that bilinguals were significantly faster and accurate on switch trials and had smaller switch costs than monolinguals. The authors suggest that bilinguals had a greater success in activating a task set in response to a cue and overcame faster the residual interference or activation from the previous trial (Meiran et al., 2000; Philipp et al., 2009).

One other study by Prior and Gollan (2011) examined the degree of bilingual advantage in task switching in order to ascertain by how much role does a bilingual language use play in producing a switch advantage. In order to probe this, they compared task switching and language switching between three groups of participants – 47 English Monolinguals, 47 Spanish-English bilinguals and 43 Mandarin- English bilinguals. The authors hypothesised that the Spanish-English bilinguals would perform better on language and task switching tasks as they are considered more balanced bilinguals than Mandarin-English bilinguals (Bialystok, Craik & Ruocco, 2006).

The non-linguistic task switching involved the colour and shape task (adapted from Prior & Mcwhinney,2010). For the language switching task, the stimuli consisted of digits from 1-9 which were presented in two single language blocks, followed by three mixed language blocks and two more single language blocks. They found that the Spanish-English bilinguals incurred a smaller switch cost both for language- and task-switching (when controlled for parental education) compared to Mandarin-English bilinguals and monolinguals. The authors attribute the smaller switch cost in both language and task switching to a "tight- link" between language and general task switching ability. However, the results also indicate that the bilingual advantage is not uniform across all bilingual populations and additional factors such as parental education, socio-economic status need to be considered.

Calabria (2011) also examined the switching costs in a linguistic switching task (naming in L1 and L2) and non-linguistic switching task (colour-shape task) in high proficient Catalan-Spanish bilinguals. The participants were 14 bilinguals with a mean age of 23 years. The linguistic switching task consisted of 8 pictures selected from Snodgrass & Vandarwart (1980) with four cognate words and four non-cognate words. The participants were required to name in Catalan and Spanish indicated by a Spanish or Catalan flag. The non-linguistic switching task was a shape colour task where three shapes were displayed on the screen. The participants had to match the top two shapes in the screen with the bottom shape on the screen based on either colour or shape indicated by a cue. They found that the switching costs for the linguistic task was symmetrical while the switching cost was asymmetrical for the non-linguistic switching task. This suggests that language switching performance does not correlate with non-linguistic switching task (Paap et al., 2015).

Few studies such as Prior & McWhinney (2010) and Prior & Gollan (2011) have found that language switching correlates with task switching, contrastively authors such as Paap et al 2015 and Calabria (2011) have found no positive correlation between the two switches. Authors have added that other factors such socio-economic status (Prior & McWhinney, 2010), parental education (Prior & Gollan, 2011) and language proficiency (Calibria, 2011) also have an impact on switching ability. We have sought to investigate an extraneous factor such as print exposure might impact switching ability in bi-literate bilinguals. We have used the non-verbal task switching paradigm by computing the switch costs described in Prior & McWhinney (2010) to examine whether print exposure could contribute to task switching ability in bi-literate bilingual healthy adults.

4.2.2.4 Bilingual advantage and script differences Another variable in testing for bilingual executive function advantage is the script differences between the two languages (Paap et al.,2015; Coderre & Heuven, 2014). Codere & van Heuven (2014) tested the hypothesis that similar-script bilinguals have more effective domain-general executive control with three bilingual groups with differing amounts of overlap between languages. Three groups of bilinguals were included consisting of 19 German-English speakers (high amounts of orthographic and phonological overlap), 22 Polish-English speakers (lesser amount of orthographic and phonological overlap) and 17 Arabic-English speakers (no orthographic and very little phonological overlap).

A monolingual group of 18 participants was also tested for comparison. All tested participants lived in England at the time of testing. The participants were administered the Stroop task and the Simon task. Monolingual participants performed one session, consisting of the English Stroop task and the Simon task. Bilingual participants performed two experimental sessions on consecutive days; each session consisted of the Simon task and the Stroop task in one language (L1 or L2). The Stroop and Simon tasks were chosen because they measure contrasting properties; while the Stroop task is a linguistic measure of the interference effect of language in bilinguals (e.g. Brauer, 1998; van Heuven et al., 2011 find this effect to be larger when the script is similar), the Simon task is a non-linguistic measure of bilingual advantage. To assess the bilingual global RT advantage, the authors compared not just the global RTs (collapsed over congruent, incongruent, and control conditions) but also RTs to the control condition.

Overall, the authors found the smallest Stroop interference effects in the Arabic-English bilinguals, however, there were no group differences in Simon interference effects. The authors suggest that these contradictory results probably imply that the Stroop interference effect was not driven by script similarity. Since the Simon task does not show any significant interference, the authors conclude that, script similarity does not offer any inhibitory control advantage in any group. Conversely when consulting the results of the global RTs, the Arabic-English bilinguals had the longest RTs. This, the authors claim, could suggest less effective executive processing abilities in different-script bilinguals. The authors finally conclude that in-spite of a bilingual advantage, script similarity could modulate executive control abilities across bilingual groups.

To summarise, script can become an important factor that modulates linguistic inhibitory control measures across bilingual groups. The aim of this study is to measure the isolated impact of print exposure on executive functions in bi-literate bilinguals without considering script or any other linguistic extraneous factors. Therefore, in our study we have chosen non-verbal spatial Stroop and Flanker(arrow) tasks as inhibitory control tasks.

An alternative view endorsed by Paap et al (2015) is that there is no convergent opinion that the bilingual advantage exists in executive functions. In a meta-analysis of published data De Bruin, Treccani, and Della Sala (2015) provided evidence that a publication bias resulting from the combined effects of researchers deciding what to submit and editors deciding which articles to publish have led to an underreporting of null and negative results. Consequently, a perceptive body of research that reports significant bilingual advantage exists (Bialystok, 2004,2008; Kroll & Bialystok, 2013 etc).

Paap et al (2015) additionally suggests that the minority number of publications that suggest a bilingual advantage in executive function may be due to the insensitivity of the dependent variables measuring executive function or Type 1 errors, confounds in demographic factors such as genetics, socio-economic status and immigration status (Valian, 2015), and questionable statistical tests.

Authors such as Paap and Sawi (2014) found little or no convergence between measures of inhibitory control. This is in opposition to Miyake et al (2000) that showed significant correlations between the task variables assumed to require inhibition. Paap et al (2015) point out that different variants of the Stroop task do not correlate with one another (Shilling, Chetwynd, & Rabbitt, 2002). Similarly, different versions of the flanker task do not correlate with one another (Salthouse, 2010). An important drawback mentioned by Paap et al (2015) is that the bilingual advantage in executive function may be very restricted to a particular task as most studies use only a single measure of executive function and others who have used multiple measures lack convergent validity (Paap & Greenberg,2013). Therefore, two or more measures under each domain of executive function are necessary to evaluate the bilingual advantage. If both the measures converge, then a bilingual advantage can be posited.

Hence, in our study not only do we use multiple measures of non-verbal executive functions, we also consider the additional factor of L2 print exposure in bilinguals.

4.3 The current investigation, research questions and predictions

Based on the discussion of literature above, it is clear that print exposure in monolinguals has a significant impact on executive function measures mostly evaluated using neuropsychological test batteries (generalized executive functions). On the other hand, research on bilinguals has largely reported mixed results on the bilingual advantage in executive functions. Studies have also shown that script differences play some role in predicting performance in executive functions. However, none of the bilingual studies report whether these bilinguals were bi-literates or consider print exposure as a factor in examining executive functions. Consequently, the current study addresses this limitation by examining the impact of print exposure in executive functions in bi-literate bilingual healthy adults.

The same participants recruited for study 1 (Chapter 2, section 2.3) were participants in the current study. The participants were split into two groups- high print exposure (HPE) and low print exposure (LPE). The two groups were matched on other background measures as explained in chapter 2. We compared the performance of these participants on a set of executive function tasks measuring inhibition (spatial Stroop and Flankers task), working memory (visual and auditory N-back) and task switching (colour-shape switching task). We quantified the performance on spatial Stroop, Flankers task and colour-shape task based on mean reaction time and mean accuracy. We also calculated the Stroop effect, conflict effect for spatial Stroop and Flankers task respectively. For the N-back task, the performance was quantified using D prime.

Inhibitory control is exercised when two conflicting mental representations, each associated with an opposite response, is presented and attention is to be paid to only one based on the cues (Bialystok, 2008). This sort of control or conflict resolution is required in the Simon and Stroop tasks wherein a misleading cue in the stimulus has to be correctly ignored while choosing the correct response. Bilinguals are expected to exercise such control every day, where misleading representations and responses (from language not in use) conflict with their currently active system (the language that they use in that time frame). Thus, in supressing their conflicting response they exercise inhibitory control. Task switching is the ability to hold in mind two sets of instructions and execute the correct task in response to a cue (Bialystok, 2008). This ability may be similar to the need to hold two language representations in mind and switch between them to respond in the appropriate language when the context signals the need for a language. For the current study, we have used two non-verbal executive function tasks under each domain except task switching. We have tested inhibitory control using Spatial Stroop task and Flanker task, working memory using visual and auditory N-back and task switching using colour shape task. We chose just one task to measure task switching as the task tend to incur large costs, are more difficult and may be more sensitive to group differences (see Monsell, 2003). The summary of measures of executive functions used in the current study is presented in Table 4.1.

Table 4.1

Measures of executive functions used in the current study

Executive function measures	**Type of trials/conditions**	**Components measured in each task**	**Definition**
		Measures of inhibition	
Spatial Stroop task	Neutral, congruent and incongruent	Stroop effect (for RT and accuracy)	-The average of difference between incongruent and congruent trials. - Smaller Stroop effect suggests smaller difference between incongruent and congruent trials indicating better inhibitory control.
Flanker task	Neutral, congruent and incongruent	Conflict effect (for RT and accuracy)	-The average of difference between incongruent and congruent trials. - Lower conflict effect in participants indicates better response inhibition.
		Measures of working memory	
Visual N-back	1-back and 2-back	D prime (d') score	-D-prime (d') (Macmillan & Creelman,1990) is a sensitivity measure of the participant's performance in discriminating updating trials from fill trials. *d'* = Hit rate- False alarm rate -Larger d' score indicates better performance.
Auditory N-back	1-back and 2-back	D prime (d') score	
		Measure of task switching	
Colour-shape task	Switch and non-switch	Switch cost (for RT and accuracy)	-The average of difference between switch trials and non-switch trials. -Lower switch cost means smaller difference between switch trial (difficult condition) and non-switch trial (easier condition).

The overarching goal of the present study was to examine the impact of executive function in bi-literate bilingual healthy adults based on differences in print exposure in their L2. To address this aim, we used a set of executive function tasks and posed the following research questions:

1. To determine the differences in measures of inhibition (spatial Stroop and Flankers task), working memory (visual and auditory N-back) and task switching (colour-shape task) between HPE and LPE participants.

   We hypothesised that the participants in HPE group would perform better than LPE group on the two measures of inhibition. We expected, participants in the HPE group to have a smaller Stroop effect and conflict effect on the spatial Stroop and Flanker task respectively. We anticipated that the HPE would have a larger D-prime compared to LPE group on both 1-back and 2-back conditions suggesting a better working memory. We hypothesised that the participants in the HPE would be quicker and more accurate on the switch trials compared to LPE. We expected that the switch cost would be smaller for HPE compared to LPE.

2. To determine the relationship between print exposure in L2, age and years of education with measures of inhibition, working memory and task switching.

   We anticipated that there will be a significant and positive correlation between print exposure in L2 and performance measures of inhibition, working memory and task switching (i.e., Stroop effect, conflict effect, D-prime, switch cost). Based on previous literature (Bialystok et al, 2008), we hypothesised that there would be significant and negative correlation between age and performance measures of inhibition, working memory and task switching. We also expected that there would be a significant and positive association between years of education and performance measures of inhibition, working memory and task switching.

4.4 Methods

4.4.1 Participants and grouping of participants

Based on the z-composite score generated from the measures of print exposure (grammaticality judgement task and sentence verification task), we grouped the 34 participants of our study into two groups: high print exposure (n=22) and low print exposure (n=12). Refer to section 2.4.1 for further details.

4.4.2 Experimental tasks

4.4.2.1 Measures of inhibition

4.4.2.1.1 Spatial Stroop. The Stroop task is the most classic experimental paradigms used to study interference control or inhibition (Bialystok et al., 2008). There have been evidences to suggest that spatial location of a stimuli can interfere with the response time (Lu and Proctor, 1995). The spatial Stroop requires the participant to press a left or right key corresponding to the direction of the arrow on the screen (eg., ← or →). There is a response conflict created when the location of the arrow is incongruent from the direction of the arrow. In the present study, we resorted to using the Spatial Stroop task as we wanted the stimuli to be non-linguistic or minimally dependent on language.

4.4.2.1.1.1 Trials and procedures. The spatial Stroop task was programmed on version 2.0 of E-prime software. In the current study, the spatial Stroop task consisted of presenting the stimulus in three conditions- neutral, congruent and incongruent conditions. The stimuli consisted of arrows facing either right or left direction. For the neutral condition, the arrows always appeared in the centre of the screen. For the congruent condition, the arrow pointing right always appeared on the right side of the screen and the arrow pointing left appeared on the left side of the screen. For the incongruent condition, the arrow pointing right always appeared on the left side of the screen and vice versa for the left pointing arrow, thus creating a response conflict for the participant (See Figure 4.2). There was a total of 48 trials in each condition. In total, there were 144 trials. Each condition was presented as a separate block. The participant was instructed to respond with a key press on the SR box corresponding to the direction to which the arrow is pointing irrespective of the location of the arrow as quickly as possible in each condition. Eighteen practice trials were presented to familiarise the participants to the task. The order of conditions was counterbalanced across participants.

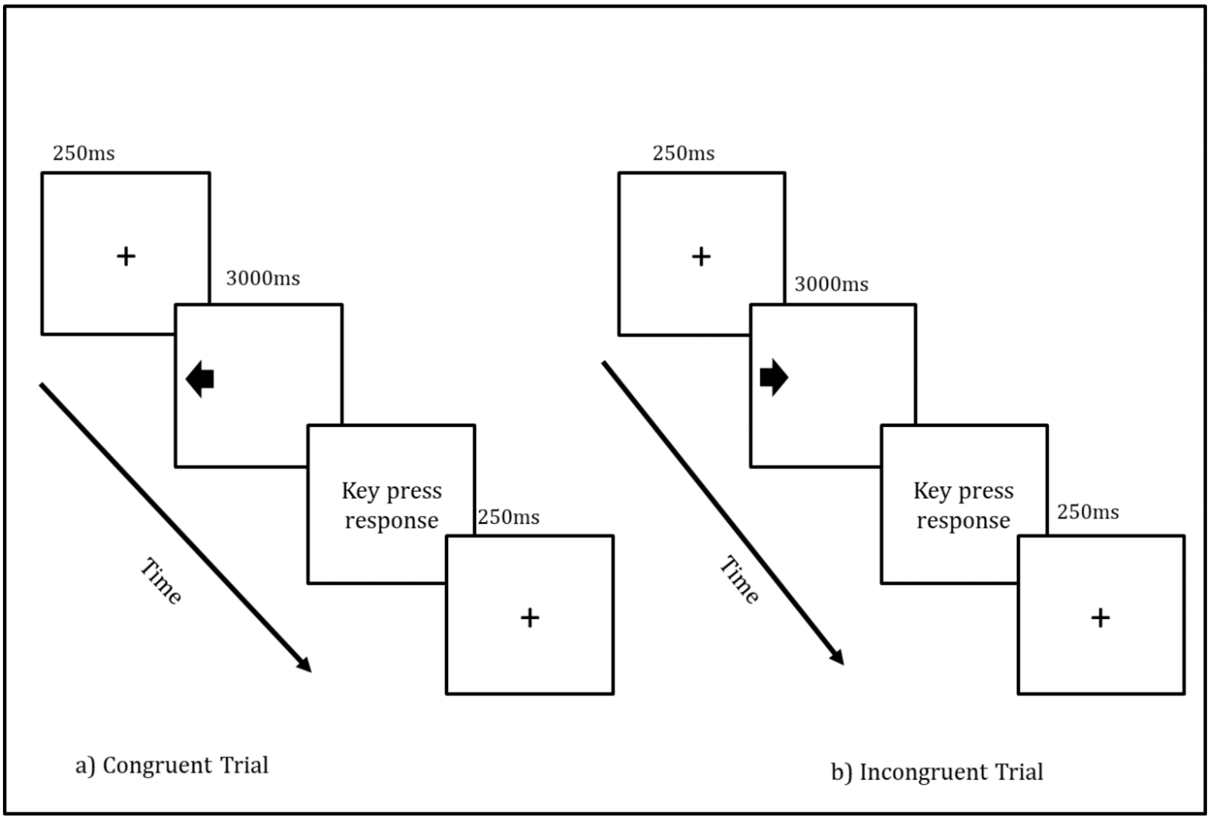


Figure 4.2 An example of an experimental trial in the Spatial Stroop task [(a) Congruent: An arrow pointing left appears on the left side of the screen, participant expected to press the left arrow key (no response conflict); b) Incongruent: An arrow pointing right appears on the left side of the screen, participant expected to press the right arrow (response conflict)]

4.4.2.1.1.2 Mean Reaction time (RT) and Mean accuracy. RT and accuracy were measured for each condition separately. The mean RT for participants was calculated by averaging the reaction time over all trials in each condition. The mean accuracy for participants was calculated by averaging the number of correct responses over all trials in each condition.

For the following task which included RT measures, we have used median plus or minus 2.5 times the Median absolute deviation method for outlier detection and exclusion for all the reaction time tasks.

4.4.2.1.1.3 Stroop effect for reaction time (SE_{RT}) and mean accuracy (SE_{ACC}). We derived the Stroop effect in RT and accuracy for each participant by taking the average of difference between incongruent and congruent trials. Smaller Stroop effect suggests smaller difference between incongruent and congruent trials indicating better inhibitory control.

$$SE_{RT} = RT_{INCONGRUENT} - RT_{CONGRUENT}$$

$$SE_{ACC} = \%Accuracy_{INCONGRUENT} - \%Accuracy_{CONGRUENT}$$

4.4.2.1.2 Flanker task. The Flanker task has been used to measure the response competition paradigm (Eriksen, 1993). In this task, the participants have to respond to one task relevant stimulus while suppressing the task irrelevant stimulus (Flanker arrows) (Stins et al., 2007). There is a constant need to suppress the dominant response and select the appropriate response. In the congruent condition, the target arrow and flanker arrows all point the same direction, with the reaction time being faster and more accurate. While, the target arrow points to a different direction than the flanker arrows in the incongruent condition which results in the reaction time being slower and less accurate.

4.4.2.1.2.1 Trials and procedures. The Flanker task was programmed on version 2.0 of E-prime software. The Flanker task typically consisted of stimuli presented in 3 conditions- neutral, congruent and incongruent conditions across four blocks presented in a randomised order. The stimuli were an array of five arrows presented on the screen. The neutral condition included only the target arrow (eg: ----->-----).In the congruent condition, the task irrelevant stimulus (Flanking arrows) were all in the same direction as the target arrow (eg: "< < < < <") and in the incongruent condition the flanking arrows were in the opposite direction to the target (eg: "> > < > >").The participants were instructed to press either the right arrow key or the left arrow based on the direction of the central arrow stimulus on the screen ignoring the other flanker arrows. Twelve practice trials were presented to familiarise the participants with the task. For the practice trials, a fixation cross appeared on the screen for 250ms. After an inter-stimulus duration of 500ms during which time a blank screen appeared on the screen, the stimuli were presented for 5000ms. Corrective feedback was given for the practice trials. For the experimental trials, the fixation cross remained on the screen for 250ms, following an inter-stimulus interval of 500 ms, the stimuli were presented for 5000ms followed by the next trial. A schematic representation of the experimental trial is given in Figure 4.3. A total of 132 trials were presented with 120(40 trials in each condition) being experimental trials and 12 were fill trials.

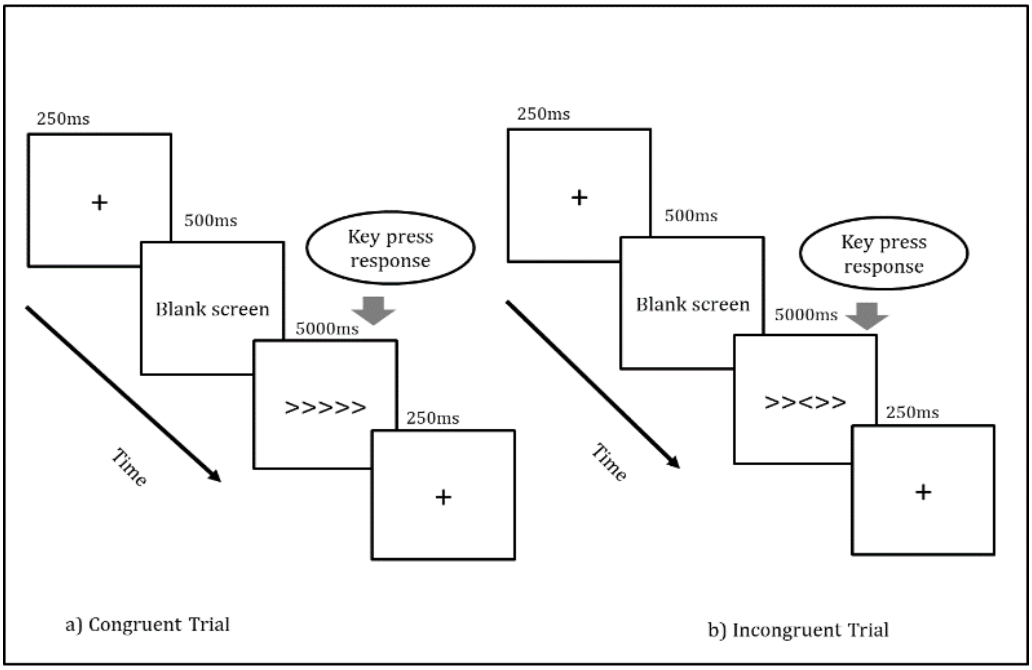


Figure 4.3 An example of an experimental trial in the Flanker task [(a) Congruent trial: The target arrows and the Flanker arrows all pointing in the same direction (no-response conflict) b) Incongruent trial: The target arrows and the Flanker arrows point in different directions (response conflict present)]

4.4.2.1.2.2 Mean Reaction time (RT) and Mean accuracy. Reaction time and accuracy were measured for each condition separately. The mean reaction time for participants was calculated by averaging the reaction time over all trials in each condition. The mean accuracy for participants was calculated by averaging the number of correct responses over all trials in each condition.

4.4.2.1.2.3 Conflict effect for reaction time (CE_{RT}) and mean accuracy (CE_{ACC}). The conflict effect for reaction and mean accuracy was derived for each participant by taking the average of difference between incongruent and congruent trials. Lower conflict effect in participants indicates better response inhibition.

$$CE_{RT} = RT_{INCONGRUENT} - RT_{CONGRUENT}$$

$$CE_{ACC} = \%Accuracy_{INCONGRUENT} - \%Accuracy_{CONGRUENT}$$

4.4.2.2 Measures of working memory. The N-back task has been used by many researchers to assess working memory (Carlson et al.,1998; Callicott et al.,1999; Martinkauppi et al.,2000). N-back refers to how far back in the sequence of stimuli that the subject had to recall (Callicott,1999). In the current study working memory was assessed with the digit n-back task using two memory load conditions (1-back, 2-back) presented in two modalities - visual and auditory. The task was programmed on version 2.0 of E-prime software.

4.4.2.2.1 Visual n-back

4.4.2.1.2.1 Trials and procedures. Series of digits from 1 to 9 were presented visually in a random order on the center of the screen. Each trial consisted of the stimuli presented for 500 ms with an inter-stimulus gap of 1500ms. During this period a blank screen appeared on the screen. The subject is expected to recollect the previously viewed information while simultaneously updating and encoding the new information. In the one-back condition, the subject was expected to press any key when the number that appeared on the screen is same as the one that occurred one trial before. In the two-back condition, the subject was expected to press any key when the number on the screen is same as the one that occurred two trials before. A schematic representation of the 1-back and 2-back experimental trial is given in Figure 4.4. There was a total of 116 trials in the one-back task presented in four blocks. Each block consisted of 9 updating trials (target) and 20 fill trials (non-target). The two-back task included a total of 112 trials distributed across four blocks, with 9 updating trials and 19 fill trials.

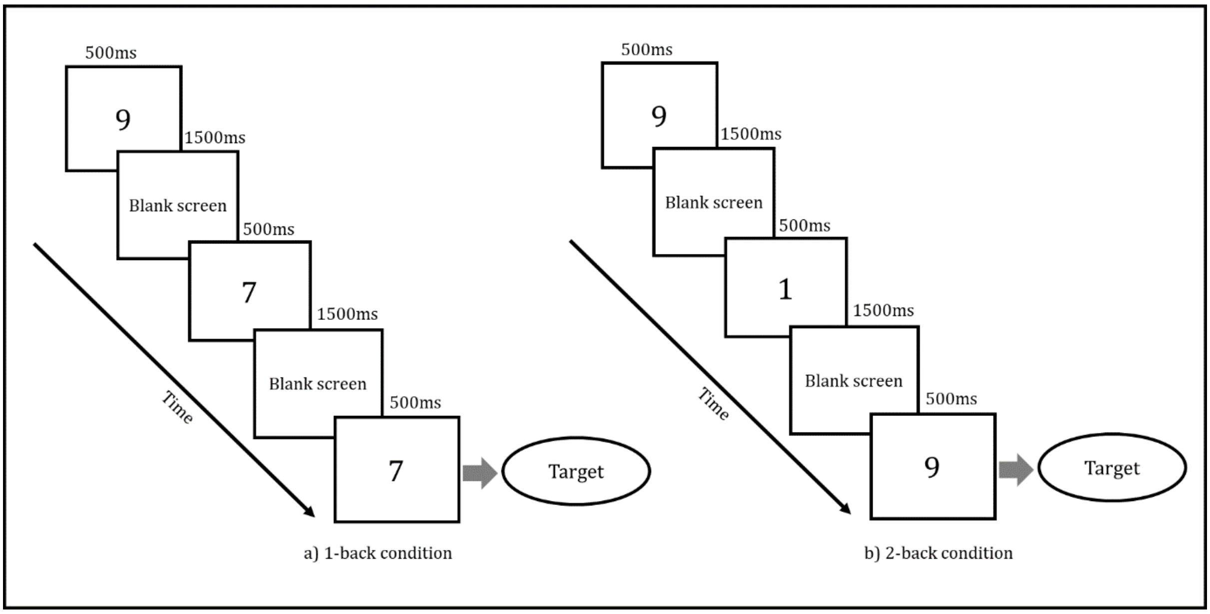


Figure 4.4 Schematic of an experimental trial in N-back task (a) 1-back condition: In the example the digit '7' occurred one trial before, making the digit '7' the target (b) 2-back condition: In the example the digit '9' occurred two trials before, making the digit '9' the target.

4.4.2.1.2.2 Data analyses using D-prime(d'). We categorise responses into four types- hits (signal is present), misses (signal is present, but participant incorrectly indicates that there is no signal), false alarm (participant incorrectly responds with a hit) and correct ignore (where the participant correctly ignores a no signal) (Haatveit et al., 2010). In our experiment, 'signal' refers to 'updating trials' and 'no signal' refers to 'fill trials'. We used D-prime (*d'*) (Macmillan & Creelman,1990) as a sensitivity measure of the participant's performance in discriminating updating trials from fill trials. *d'* is calculated using the formula:

$$d' = \text{Hit} - \text{FA}$$

where Hit represents the proportion of hits when a signal is present (hits/ (hits + misses)), also known as the hit rate, and FA represents the proportion of false alarms when a signal is absent (false alarms/ (false alarms + correct ignore)), the false-alarm rate.

4.4.2.2.2 Auditory n-back

4.4.2.2.2.1 Trials and procedures. A series of digits from 1 to 9 were presented aurally in a random order using the Version 2.0 of E-prime software. This task is similar to the visual n-back task except that the stimuli are presented in the auditory mode through headphones. In the one-back condition, the participant was expected to press any key when the number that he/she heard is same as the one that occurred one trial before. Similarly, in the two-back condition, the subject was expected to press any key when the number that the participant heard was same as the one that occurred two trials before. There was a total of 117 trials in one-back condition with 9 updating trials and 20 fill trials in blocks 1-3 and 9 updating trials and 21 fill trials in block 4. The two-back condition included 113 trials with 9 updating trials and 19 fill trials in blocks 1-3 and 9 updating trials and 20 fill trials in block 4. The same procedure applied for analysing the visual N-back task was used to analyse auditory N-back task. (Refer to section 4.4.2.1.2.2).

4.4.2.3 Measure of Task switching

4.4.2.3.1 Colour-shape task. Colour-shape task is a task measuring switching ability where the participants switch between shape decision and colour decision (Prior & MacWhinney, 2010). For the current study, we adapted Prior and MacWhinney's (2010) colour-shape switch task. Target stimuli was a set of bivalent stimuli which consisted of circles and triangles in two colour combinations- red and green. Participants had to judge the shape or colour of the stimuli based on the relevant cue. Colour cue was indicated by the colour gradient and shape cue by a row of small shapes in black. When the colour cue was presented, the participant was expected to judge the colour of the target stimulus (red or green) and when the shape cue was presented, the participant responded to the shape of the target stimulus (circle or triangle).

4.4.2.3.1.1 Trials and procedures. The task was administered using version 2.0 of E-prime software. The experimental trial began with the fixation cross appearing on the screen for 500 ms followed by a cue at 2.8° above the fixation cross for 500 ms. This was followed by a blank screen for about 300 ms. Following which, the target stimuli which were either a red or green circle (2.8°*2.8°) and red or green triangles (2.3°*2.3°) was presented. The participants were instructed to press a key on the Serial-response box corresponding to red/green colour or circle/triangle shape. The cue and the target remained on the screen until the participant responded or for a duration of 2000ms. This was followed by a 1000ms blank screen before the onset of the next trial.

This task was conducted by dividing the trials into switch and non-switch trials (See figure 4.5). A switch trial consisted of a colour stimulus preceding a shape stimulus (colour to shape) or vice versa (shape to colour). This accounted for 72 trials (fifty percent). Conversely, in the non-switch trial, a colour stimulus was followed by a colour stimulus (colour to colour) and similarly for shape stimuli (shape to shape). These formed the remaining 72 trials. Twenty practice trials were presented followed by 48 experimental trials across three blocks.

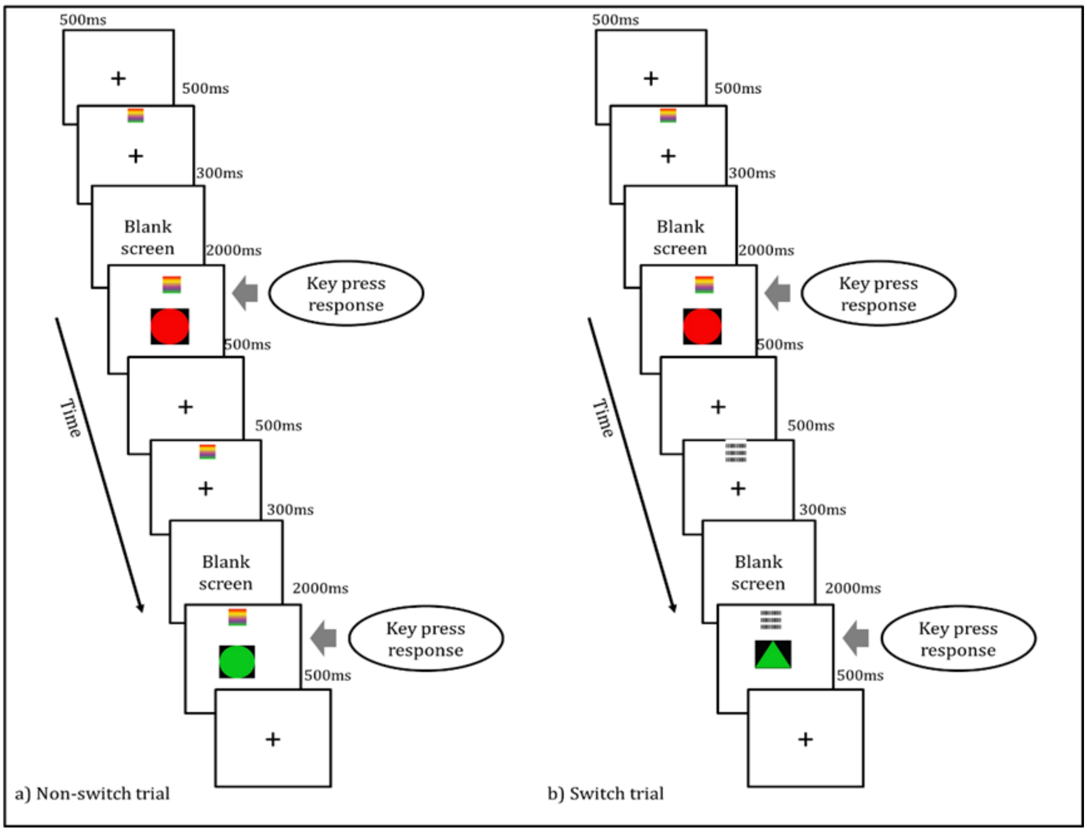


Figure 4.5 Schematic of an experimental trial in the Colour-shape task: The response to the stimulus is determined by the cue presented prior to the stimulus. In (a) both cues presented (along with the fixation cross) are colour cues; and in (b) the first cue is the colour cue and the second is the 'shape cue'. [(a)Non-switch trial: A colour stimulus is followed by a colour stimulus; the participant is expected to respond to the colour of the stimulus and not to shape. b) Switch trial: A colour stimulus is followed by the shape stimulus; In the first instance the participant is expected to respond to colour and then to shape.]

4.4.2.3.1.2 Mean Reaction time (RT) and Mean accuracy. Reaction time and accuracy were measured for the switch and non-switch trials. The mean reaction time for participants was calculated by averaging the reaction time over all trials in each condition (switch and non-switch). The mean accuracy for participants was calculated by averaging the number of correct responses over all trials in each condition.

4.4.2.3.1.4 Switch cost for reaction time (SC_{RT}) and mean accuracy (SC_{ACC}). Switch costs are defined as the measure of difficulty in switching from one task set to another (Prior & Mchwhinney, 2010). Experimentally, this is measured as a difference in response time between switch and nonswitch trials. We derived the switch cost in reaction time and accuracy for each participant by taking the average of difference between switch trials and non-switch trials.

$$SC_{RT} = RT_{SWITCH\ TRIAL} - RT_{NON\text{-}SWITCH\ TRIAL}$$

$$SC_{ACC} = \%Accuracy_{SWITCH\ TRIAL} - \%Accuracy_{NON\text{-}SWITCH\ TRIAL}$$

Lower switch cost means smaller difference between switch trial (difficult condition) and non-switch trial (easier condition). This is a measure of efficient shifting ability (Prior & MacWhinney, 2010).

4.4.3. Detecting and Excluding outliers

We have used median plus or minus 2.5 times the Median absolute deviation method for outlier detection for all the reaction time tasks. Refer to section 2.4.2.1.2.2.2 in Chapter 2 for further details.

4.5 Statistical Analyses

Mean and standard deviation was calculated for all the tasks across both the groups. All variables were tested for normality using Kolmogorov- Smirnov test. Parametric statistical tests were performed on normally distributed data set, and for the non-normally distributed data set, non-parametric statistical tests were performed where possible. An Alpha level of 0.05 was used to determine the level of significance and effect sizes were measured by partial eta-squared (η2) with small, medium, and large effects defined as .01, .06, and .16, respectively (Cohen, 1977).

To determine the differences in performance across the groups on the Stroop effect and Conflict effect in Flanker task for RT and accuracy, a Mann-Whitney U test was performed, as these variables were non-normally distributed. To determine the group differences on measures of working memory (visual and auditory N-back) and condition (1-back, 2-back), two separate two-way repeated measures ANOVA was carried out; with the D-prime as a dependent variable and Group as an independent variable. In this design, the condition (1-back, 2-back) was a within-subject factor and Group (HPE vs. LPE) was a between subject factor. To determine the group differences in switch cost for RT and accuracy, two separate independent sample t-tests were conducted with Group as a between-subject factor.

The mean, standard deviation and results of group comparisons on measures of inhibition, working memory and task switching are presented in Table 4.2, 4.4, and 4.4, respectively. The correlation of executive function measures with measure of print exposure, age and years of education are presented in Table 4.5.

4.6 Results

In this section, we present the findings from the experimental tasks discussed in 4.4.2. We present the findings from measures of inhibition in section 4.6.1, followed by results of working memory in section 4.6.2. In section 4.6.3, we present the findings of task switching and in the final section 4.6.4, we present the findings of correlational analyses of executive function measures with print exposure, years of education and age.

4.6.1 Performance on measures of inhibition

Differences between HPE and LPE on measures of inhibition are reported as an effect of group on the Stroop effect from Spatial Stroop task and the Conflict effect on the Flanker task. There were no significant group differences for either RT and mean accuracy for spatial Stroop and Flanker task.

Table 4.2

Minimum (Min) and Maximum (Max), Mean (M) values and group comparisons on Measures of inhibition.

Measures of inhibition		High print exposure (HPE) (N=22)			Low print exposure (LPE)(N=12)			Total	
		Min-Max	M	SD	Min-Max	M	SD	M	SD
Spatial Stroop[1]									
Neutral	RT	329.18 - 698.18	457.14	99.56	343.97 – 634.74	461.92	86.04	458.73	93.93
	Accuracy	43-48	47.05	1.29	44-48	46.73	1.42	46.93	1.32
Congruent	RT	246.63 – 677.29	371.72	102.85	291.39–539.80	390.29	82.42	377.91	95.62
	Accuracy	44-47	46.68	0.78	46-47	46.82	0.40	46.72	.67
Incongruent	RT	342.31 -1031.00	588.48	169.18	342.65 -945.55	558.68	169.90	578.55	167.35
	Accuracy	25-48	43.32	6.14	35-48	44.27	4.47	43.63	5.58
								Group Comparisons	
Stroop effect[2] (RT)		51.15-541.15	216.76	125.68	49.48-469.19	168.39	119.87	U[5] = 87, p = .19	
Stroop effect[2](accuracy)		-21 - 1	-3.36	5.90	- 12-1	-2.55	4.56	U[5] = 103, p = .48	
Flanker task								M	SD
Neutral	RT	391.35-694.19	485.17	66.95	352.64-669.61	495.80	81.22	488.92	71.26
	Accuracy	37-40	39.50	0.85	38-40	39.17	0.71	39.38	.81
Congruent	RT	398.13-686.44	497.49	65.15	359.78-701.60	509.69	91.31	501.80	74.26
	Accuracy	39-40	39.95	0.21	38-40	39.83	0.57	39.91	.37
Incongruent	RT	464.76-871.13	587.92	87.38	448.18-776.41	635.26	104.03	604.63	94.83
	Accuracy	35-40	38.59	1.68	23-40	36.17	5.25	37.73	3.51
								Group comparisons	
Conflict effect[3](RT)		21.19 – 184.69	90.42	42.55	40.07 – 260.86	125.56	67.54	U[7]= 91, p = .14	
Conflict effect[3] (accuracy)		-5 - 1	-1.36	1.73	-17 - 0	-3.67	4.99	U[7] = 92, p = .14	

[1]-One participant in LPE did not perform the task; [2]-Difference between incongruent and congruent Stroop trials; [3]-Difference between incongruent and congruent Flanker trials. Condition (Neutral, Congruent, Incongruent)

Table 4.3

Minimum (Min) and Maximum (Max), Mean (M) values and statistical results of performance Measures of working memory

Measures of working memory	**High print exposure (HPE) (N=21)**[1]			**Low print exposure (LPE)(N=12)**[1]			**Total**		**Group Comparisons**		
	Min-Max	M	SD	Min-Max	M	SD	M	SD	Group	Condition	Group*Condition
				Visual N-back[2]							
1-back	3.01-4.70	3.99	.46	2.67-4.70	3.95	.65	3.97	.53			
2-back	1.36-4.39	2.64	.69	1.90-3.45	2.68	.48	2.65	.61	F (1,31) =.000021, p =.99, η²=.71	F (1,31) =77.58, p <.001**, η²=.71	F (1,31) =.09, p =.76, η²=.001
Total	2.66-4.11	3.34	.41	2.38-3.96	3.34	.41					
				Auditory N-back[2]							
1-back	2.73-4.70	4.22	.54	2.23-4.44	3.73	.62	4.05	.61			
2-back	1.48-4.68	3.33	.91	1.63-4.14	2.58	.74	3.07	.92	F (1,30) = 7.64, p =.01*, η²=.20	F (1,30) =44.41, p <.001**, η²=.59	F (1,30) =.74, p =.39, η²=.01
Total	2.31-4.56	3.76	.61	1.93-4.29	3.15	.60					

[1] – One participant in HPE did not perform the visual N-back task and two participants did not perform auditory N-back. [2] – The values outlined in the table for both tasks is the D-prime value. ****p<.001, **p<.01, *p<.05.*

4.6.2 Performance on measures of working memory

Differences between HPE and LPE on the visual and auditory N-back task are reported as a main effect of Group (HPE, LPE), Condition (1-back, 2- back) or an interaction of Group X Condition. On the visual N-back, there was only significant effect of Condition (1-back: M= 3.97, SD=.53;2-back: M=2.65, SD=.61), with the participants performing better (having a higher d') on 1-back than 2-back. On the auditory N-back, there was a significant main effect of Group with the HPE performing better (larger D-prime) than LPE (HPE: M =3.76, SD = .61; LPE: M = 3.15, SD=.60). There was also a significant main effect of Condition (1-back: M=4.05, SD=.61;2-back: M=3.07, SD=.92), but no interaction of Group X Condition (p=.39) (See figure 4.6)

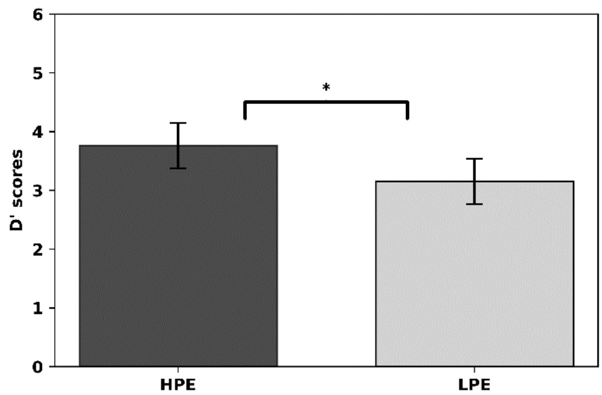


Figure 4.6 Comparison of d' scores of auditory N-back (average of 1-back and 2-back). Error bars represent standard error of the mean. * p<.05

4.6.3 Performance on measure of task switching

Differences between HPE and LPE were not significant on switch cost for both mean reaction time [t (32) =1.70, p =.09, d =.61] and mean accuracy [t (32) =-.35, p =.72, d =-.12].

Table 4.4

Minimum (Min) and Maximum (Max), Mean (M) values and group comparisons of performance on Measure of task switching.

Measure of task switching[1]		**High print exposure (HPE) (N=22)**			**Low print exposure (LPE)(N=12)**			**Total**	
		Min-Max	M	SD	Min-Max	M	SD	M	SD
Non-switch trial	RT	459.60-1009.70	792.47	140.64	639.47-1257.82	876.08	218.78	821.98	173.75
	Mean accuracy	61-72	68.64	3.09	62-72	68.5	2.9	68.58	2.98
Switch trial	RT	502.69-1506.16	1000.77	234.04	705.81-1506.60	998.44	264.28	999.94	241.12
	Mean accuracy	65-72	68.45	2.11	63-71	68.67	2.14	68.52	2.09
								Group comparison	
Switch cost[2] (RT)		8.97-507.72	208.29	136.26	-460.84	122.35	148.15	t (32) =1.70, p =.09, d =.61	
Switch cost[2] (Mean accuracy)		-5 - 8	-0.18	3	-4 - 4	0.17	2.12	t (32) =-.35, p =.72, d =-.12	

[1]-Colour shape task [2]- Difference between switch trials and non-switch trials.

4.6.4 Findings of Correlation analyses

The correlation analyses of the executive function measures with measure of print exposure, age and years of education is presented in Table 4.5. There was no significant correlation of any of the EF variables with age. Only the auditory 2-back showed a significant positive correlation with measure of print exposure i.e., participants with higher print exposure had a higher d' score in the auditory -back condition (See figure 4.7). There was a significant positive correlation between years of education and Stroop effect (accuracy) i.e., participants with greater number of years of education had a larger Stroop effect (accuracy) (See figure 4.8). None of the other correlations of years of education with the EF measures were significant.

Table 4.5

Correlation of Executive function measures with measure of print exposure, age and years of education.

Executive function measures	Measure of print exposure (GJ-SV composite)		Age		Years of education	
	R-value	p-value	R-value	p-value	R-value	p-value
Stroop Effect (RT)	-0.004	0.981	0.286	0.106	-0.133	0.461
Stroop Effect (Accuracy)	-0.099	0.579	-0.023	0.897	.378*	0.028
Conflict effect (RT)	-0.137	0.440	0.035	0.844	0.059	0.738
Conflict effect (Accuracy)	0.132	0.457	-0.094	0.596	0.058	0.745
Visual 1-back	0.126	0.485	0.030	0.869	0.290	0.101
Visual 2-back	-0.071	0.694	-0.315	0.074	-0.048	0.791
Auditory 1-back	0.252	0.164	-0.036	0.844	0.326	0.069
Auditory 2-back	.408*	0.020	-0.115	0.530	0.165	0.367
Switch cost (RT)	0.091	0.611	-0.066	0.709	0.298	0.087
Switch cost (Accuracy)	0.101	0.568	0.112	0.528	0.041	0.819

***p<.001, **p<.01, *p<.05

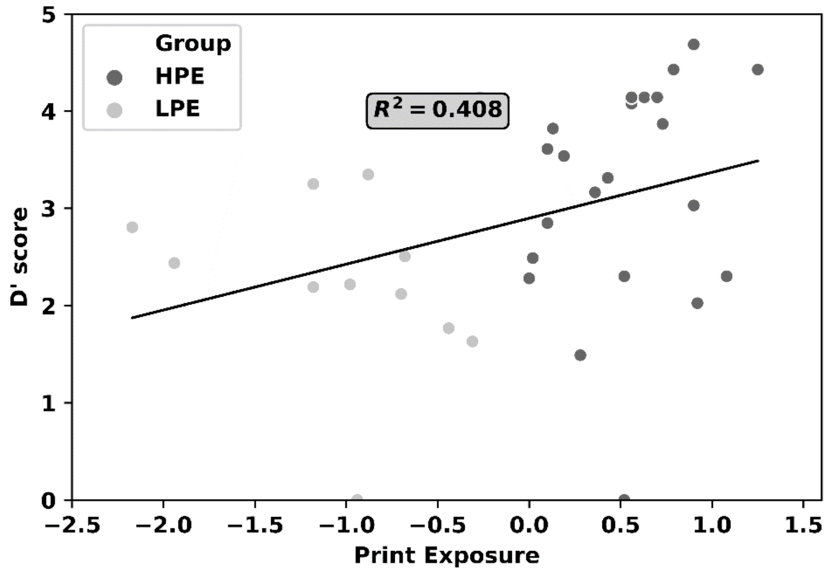


Figure 4.7 Significant correlations between print exposure and D' score of auditory 2-back task

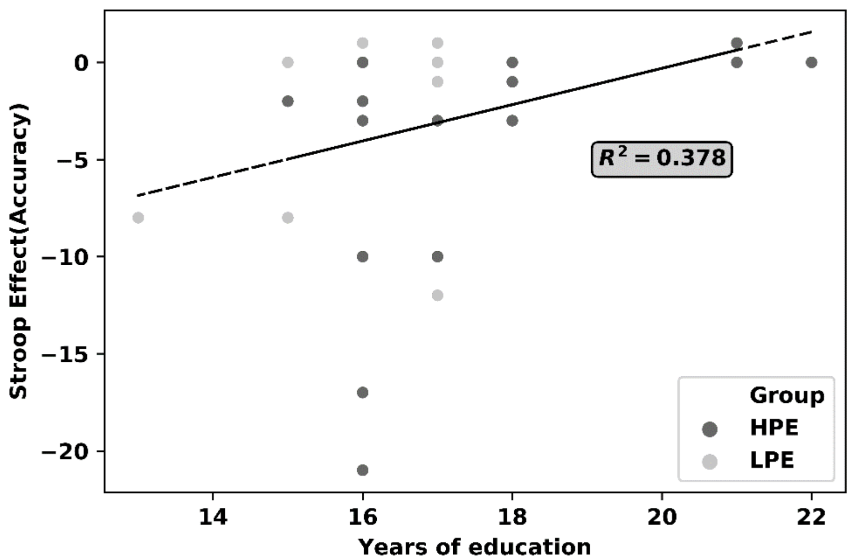


Figure 4.8 Significant correlations between years of education and Stroop effect (accuracy)

4.7 Discussion

4.7.1 Summary of findings

In this study, we aimed to investigate the impact of print exposure on non-verbal executive functions among bi-literate bilingual adults. Specifically, we examined the non-verbal executive function measures within the domains of inhibitory control, working memory and task switching. For the purpose of convergent validity, we included multiple tasks in each domain (Paap et al., 2015) except task-switching.

Table 4.6 summarises the findings of executive function measures. We hypothesised that print exposure would show a positive impact on each of the executive function measures that we examined. Contrary to our expectation, we did not find any statistical group difference or correlation with print exposure for any executive function measure except auditory N-back. Overall, on auditory N-back, the participants in HPE performed better (higher D prime) than participants in LPE. Additionally, the 2-back condition (which is a higher memory load condition) showed a significant positive correlation with print exposure i.e., participants with higher print exposure had higher D prime scores. This means that they had a higher hit rate and a lower false alarm rate. When compared with our results of comprehension measures in Chapter 2, we find a similar trend for the sentence comprehension task that was auditorily presented. Participants with higher print exposure were significantly more accurate than the LPE group on the sentence comprehension.

Although, most of the findings from our non-verbal executive function tasks showed no significant results, our findings from Chapter 2 on switches total in verbal fluency task showed a significant positive correlation with print exposure i.e., higher print exposure scores were associated with greater number of switches. Switching requires strategic search of subcategories and cognitive flexibility to shift efficiently between subcategories (Da Silva, 2004) and dependent on more controlled processing than those required for clustering (Troyer, 2000; Troyer et al.,1997). In the current study, participants with higher print exposure have produced a greater number of switches, which probably suggests that they have a better cognitive flexibility. This finding further strengthens the idea of using verbal/ linguistic stimuli along with non-verbal stimuli to measure impact of print exposure on executive functions in bi-literate bilingual individuals.

To summarise, the lack of group differences on both the inhibitory control tasks (Spatial Stroop and Flanker task) is in line with previous research by Kousaie & Phillips (2012) who studied a bilingual population and found no group differences on Flanker and Stroop tasks. Although, there seems to be a link of print exposure with working memory when testing using an auditory stimuli, this does not hold true for the visual N-back task. Additionally, there appears to be a relationship between print exposure and verbal switching ability (from verbal fluency task) which needs to be further investigated.

Table 4.6

Summary of findings of impact of print exposure on executive function measures

Executive function measures	**Group Comparison**					**Correlation with Years of education**		**Correlation with Print Exposure**	
	HPE (n =22)	LPE (n=12)	Statistically Significant Group Difference	Condition	Group * Condition	Direction of Correlation (+/-)	Statistically Significant Correlation	Direction of Correlation (+/-)	Statistically Significant Correlation
Inhibitory control									
Stroop Effect (RT)	Higher	Lower	No			-	No	-	No
Stroop Effect (Accuracy)	Lower	Higher	No			+	Yes	-	No
Conflict effect (RT)	Lower	Higher	No			+	No	-	No
Conflict effect (Accuracy)	Higher	Lower	No			+	No	+	No
Working memory									
Visual 1-back	Similar	Similar	No	1-back > 2-back	No	+	No	+	No
Visual 2-back	Similar	Similar				-	No	-	No
Auditory 1-back	Higher	Lower	Yes	1-back > 2-back	No	+	No	+	No
Auditory 2-back	Higher	Lower				+	No	+	Yes
Task switching									
Switch cost (RT)	Higher	Lower	No			+	No	+	No
Switch cost (Accuracy)	Lower	Higher	No			+	No	+	No

4.7.2 Limitations and future directions

Studies such as Coderre & Heuven (2014) and Paap et al (2015) have studied the impact of script similarity in executive function measures in bilinguals. However, this is the first time that a quantitative measure of print exposure has been used as a predictor of executive function measures in bi-literate bilingual individuals. As a next step, we could examine whether script differences and print exposure would impact executive functions. This could be done by replication of this study by comparing different groups of bi-literate bilinguals separated by script differences and print exposure and examine the effects for each group on executive function tasks.

In our study, we have manipulated the print exposure only in L2. Future studies could control for print exposure in both languages by creating a composite score for print exposure for L1 and L2, to study the impact of print exposure on executive function tasks.

As there is a known relationship between bilingualism and non-linguistic executive functioning (Bialystok et al., 2008; Bialystok et al., 2009; Bialystok, 2011; Kroll & Bialystok, 2013), we chose non-linguistic/minimally linguistic executive function tasks to test impact of print exposure on non-linguistic executive functions in bi-literate bilingual adults. By using non-linguistic or minimally linguistic measures, we expected to eliminate/minimise the effect of language variables manipulating only print exposure when measuring executive functions.

Literature has shown that print exposure has an association to some verbal executive function tasks in monolinguals (Barnes et al, 2003; Silva et al., 2012). Also, our findings from Chapter 2 on switches total in verbal fluency showed positive correlation with print exposure, suggesting a relationship between print exposure and cognitive flexibility in bi-literate bilingual adults. Since, the tasks that were chosen to measure executive functions were non-linguistic, there is a possibility they were not sensitive enough to tap into the relationship between print exposure and executive functions in bi-literate bilinguals. In future bi-literate bilingual studies, one may have to look at tasks that have both linguistic and non-linguistic aspects of executive functioning to check if there are differences in executive function measures when manipulating print exposure.

Recruiting more participants would have produced more reliable results. The unequal size of the two groups (HPE: 22; LPE: 12) may have resulted in non-significant results of Group comparisons.

Interim Summary for Phase I

In Phase I we sought to investigate the impact of bi-literacy on oral language production (at word and connected speech level), comprehension and executive functions in bilingual healthy adults. We examined this by devising a measure of literacy which we termed as print exposure and analysed its impact on oral language production and comprehension (Chapter 2), narrative production (Chapter 3) and executive functions (Chapter 4). We recruited thirty-four bi-literate bilinguals belonging to the South Indian diaspora (speaking Tamil, Telugu, Kannada and Malayalam in addition to English) residing in the UK.

In this sample we quantified print exposure both subjectively (self-report of reading and writing usage from participants in different contexts such as at work, home, formal and informal) and objectively (using a composite numeric score based on performance of these participants on grammaticality judgement and sentence verification tasks. The sample was divided based on their exposure to print into a group of high PE (HPE, 22 participants) and low PE (LPE, 12 participants). In addition to this we profiled the bilingualism variables such as proficiency, usage and dominance in both languages. The participants performed oral language production tasks (verbal fluency, word and non- word production), comprehension tasks (synonymy triplets and sentence comprehension), narrative production task and executive function tasks or measures (spatial Stroop, Flanker, N–back and colour-shape tasks).

We found that print exposure in L2 has some association with oral language production tasks both at the word level and connected speech level. On the other hand, a strong relation seems to exist between comprehension measures and print exposure (in L2) in our study. With regard to the non-verbal executive functions, we conclude that no direct link between print exposure (in L2) and non-verbal executive function measures in bi-literate bilinguals is discernible excepting working memory.

Additionally, there seems to be a strong link between print exposure and semantic processing in our research. The findings on the semantic tasks have been consistent across comprehension (synonymy triplets task and sentence comprehension task) and production (semantic fluency) favouring HPE. Higher print exposure was also associated with better narrative characteristics in terms of utterance level measures, more diversity of noun usage, higher percentage of adverbs, verbs per utterance and fewer repair measures.

In the subsequent phase (phase II- Chapter 5), we investigated the consequences of bi-literacy on a neurologically impaired population and specifically characterized the manifestation of reading difficulties at single word level in both languages of a bilingual person with aphasia.

Chapter 5 Reading difficulties in bi-literate bilingual persons with aphasia

5.1 Abstract

Background: A major proportion of the world's population is bilingual/multilingual. For those who have language impairments in one or more languages due to brain damage, the severity of impairment maybe different in both languages, also the modalities of language may be differentially affected. In particular, reading and writing maybe impaired differently in the different languages spoken by a bi/multilingual. It is important to understand how the reading impairments are manifested in the two languages to provide appropriate assessment and intervention. Manifestation of reading impairments are also dependent on the nature of the script of the language being read. The number of studies examining reading impairments in the bi-scriptal bilinguals speaking the Indian languages are limited and those which have attempted to profile and characterise the dyslexia in each language were based on models of reading aloud which are mostly based on alphabetic languages (English).

Aim: The current study aims to profile and characterise the reading difficulties in bi-scriptal BPWA speaking a combination of syllabic and alphabetic Kannada-English and Hindi-English.

Methods: We recruited seven BPWA, out of which we could extract usable data only for 4 BPWA (AP02, AP03, AP05 and AP07) with respect to their reading abilities. The participants spoke one of the Dravidian languages (Kannada, Tamil, Telugu) as their native language which are alpha-syllabic and English as their second language which is alphabetic in nature. A detailed questionnaire was administered to quantify the bilingual characteristics- proficiency, reading and writing characteristics and dominance. Language assessment was carried out using WAB-R in English and its adapted version in Kannada or Hindi to assess the type and severity of aphasia in both languages. Subtests from Psycholinguistic Assessment of Language Processing in Aphasia (PALPA; Kay, Lesser & Coltheart, 1992) were used to document the reading profile of BPWA in English which included letter discrimination, legality decision and lexical decision, spoken and written word matching and reading aloud. Reading subtests from Reading

Acquisition Profile (RAP-K; Rao, 1997) and words from Bilingual Aphasia test -Hindi (BAT; Paradis & Libben, 1987) were used to document the reading profile of BPWA in Kannada and Hindi respectively.

Results and outcomes: The results reveal differences of reading characteristics in the two languages of the four BPWA. In general, semantic processing in English as measured by both spoken and written word picture matching were affected in all the four participants. We have tried to map our findings to the Dual Route Cascaded (DRC) reading aloud model developed for alphabetic languages to explain the dyslexia in bi-scriptal bilingual persons with aphasia. While AP03 and AP05 were able to read at word level in both languages and were diagnosed with phonological dyslexia in English and alexia in Kannada, AP02's reading was severely affected and exhibited alexia in both Kannada and English Similarly, AP07 was able to read some familiar words in English, but had severe difficulty reading aloud in both Kannada and English characterising the reading impairment as alexia in both languages. This research provides preliminary evidence that a script related difference exists in the manifestation of dyslexia in bi-scriptal BPWA speaking a combination of alphabetic and alpha-syllabic languages.

5.1 Introduction

5.1.1 General introduction on bilingual aphasia

Majority of the world's population is bi/multilingual (Grosjean 1982; Kiran & Gray, 2018). Bilingual aphasia can be defined as an impairment in one or more languages in bilingual individuals following a brain damage (Kiran & Gray, 2018). In individuals with bilingual aphasia, one or both languages may be affected and the severity of impairment maybe different in both languages (Fabbro & Paradis, 1995; Fabbro, 2001). Similarly, different modalities such as reading and writing maybe impaired differently in the different languages spoken by a bi/multilingual (Wilson, Kahlaoui & Weekes, 2012). Reading and writing disorders in individuals with aphasia are relatively under reported (Lorenzen & Murray,2008). Reading and writing impairments in individuals, as a result of brain injury or neurologic condition, is referred to as acquired dyslexia and dysgraphia respectively (Coltheart, 1981). Acquired dyslexia is further classified into deep, surface, phonological; this classification is based on models of reading aloud developed based on studies on monolingual individuals with aphasia (Coltheart,1981; Siendenberg & McClelland, 1989) (See section 5.2.2 for a detailed description).

Manifestation of reading impairments are also dependent on the nature of the script of the language being read (See Weekes, 2012 for a review). In bilinguals, this is further complicated by the language combination (e.g. orthography-to-phonology transparency vs opaqueness or morphological complexity) and the existence of multiple scripts (alphabetic, syllabic/alphasyllabic and idiographic) (Eng & Obler, 2002; Weekes,2012; Weekes & Raman 2008; Law, Wong, Yeung & Weekes, 2008; Kambanaros & Weekes, 2013), therefore individuals with bilingual aphasia can have different combinations of scripts. Studies such as Raman & Weekes (2005) have documented differential dyslexia in bi-scriptal bilinguals. They have documented a Turkish-English speaker who exhibited surface dyslexia in English and deep dysgraphia in Turkish. Weekes et al (2007) report a Mongolian-Chinese bilingual speaker who exhibits different reading errors in both the scripts. For instance, Mongolian has an alphabetic script while Chinese has an ideographic script. The errors produced were typically semantic oral reading errors in Mongolian (within language errors) and semantically related translation errors in Chinese (between language errors) i.e., reading aloud a Chinese word with a Mongolian syllable.

All of these studies have used models of oral reading of alphabetic languages to characterize dyslexia. Consequently, there is not enough evidence to suggest that characterizations of dyslexia apply to a unique combination of languages with an alphabetic and syllabic script such as alphabetic English and alphasyllabic Indian languages namely Kannada and Hindi except for a few case studies (Ratnavalli, 2000; Karanth, 1981,2002). Therefore, the current study aims to profile and characterise the reading difficulties in bi-scriptal BPWA speaking a combination of syllabic and alphabetic Kannada-English and Hindi-English.

5.1.2 Characterisation of acquired dyslexia in persons with aphasia based on models of reading

Acquired dyslexias can be classified as peripheral (neglect, attentional & pure) and central (deep, surface & phonological) dyslexias. Central dyslexias such as surface dyslexia, deep dyslexia and phonological dyslexia is typically observed in individuals with left hemisphere brain damage and neglect dyslexia is commonly associated with right hemisphere damage. (See table 5.1 for the different error characteristics of types of central dyslexia). Characteristics of surface dyslexia are selective impairment to the reading aloud of irregularly spelled words particularly low frequency (like *yacht*) (Funnell ,2000) and have an abstract meaning with a preserved ability to read regular words and non-words and a tendency to regularize irregular words. Phonological dyslexia is characterized by an impairment in reading of non-words with a preserved ability in reading of regular and irregular words. Deep dyslexia is similar to phonological dyslexia except that the errors in reading are characterised as semantic (arm read as finger, visual (bus read as brush) and morphological errors (chairs read as chair). The errors in deep dyslexia are supposed to be due to the reliance of the reader on the semantic pathway for reading (Colheart et al. 2001).

Table 5.1

Error types in central dyslexias with examples.

Surface dyslexia	**Deep dyslexia**	**Phonological dyslexia**
Regularisation errors (YATCH as /jætʃt/)	Semantic errors (ARM as finger)	Lexicalisation errors (KLACK as slack)
Visual errors (SUBTLE as 'sublet')	Visual errors (BUS as brush)	Visual errors (BUS as brush)
Misapplication of letter-to-sound rules (RAGE as 'rag')	Morphological errors (TABLES as table)	Morphological errors (TABLES as table)

Several models and theories of reading such as connectionist model (Siendenberg & McClelland, 1989), dual route cascaded model (Coltheart, 1981) have attempted to explain the components in reading aloud different types of words such as regular words, irregular words and non-words. The dual-route cascaded model (DRC) developed by Coltheart et al. (2001) was originally developed to explain English reading but has since proven useful in other languages as well (Weekes, 2005) (See Figure 5.1). This model assumes three fundamental routes of reading, a sublexical route used for reading new words and non-words that could be used for reading regular words as well, a lexical pathway that reads known words without access to their meaning and a lexical semantic pathway that contacts the meaning of the words.

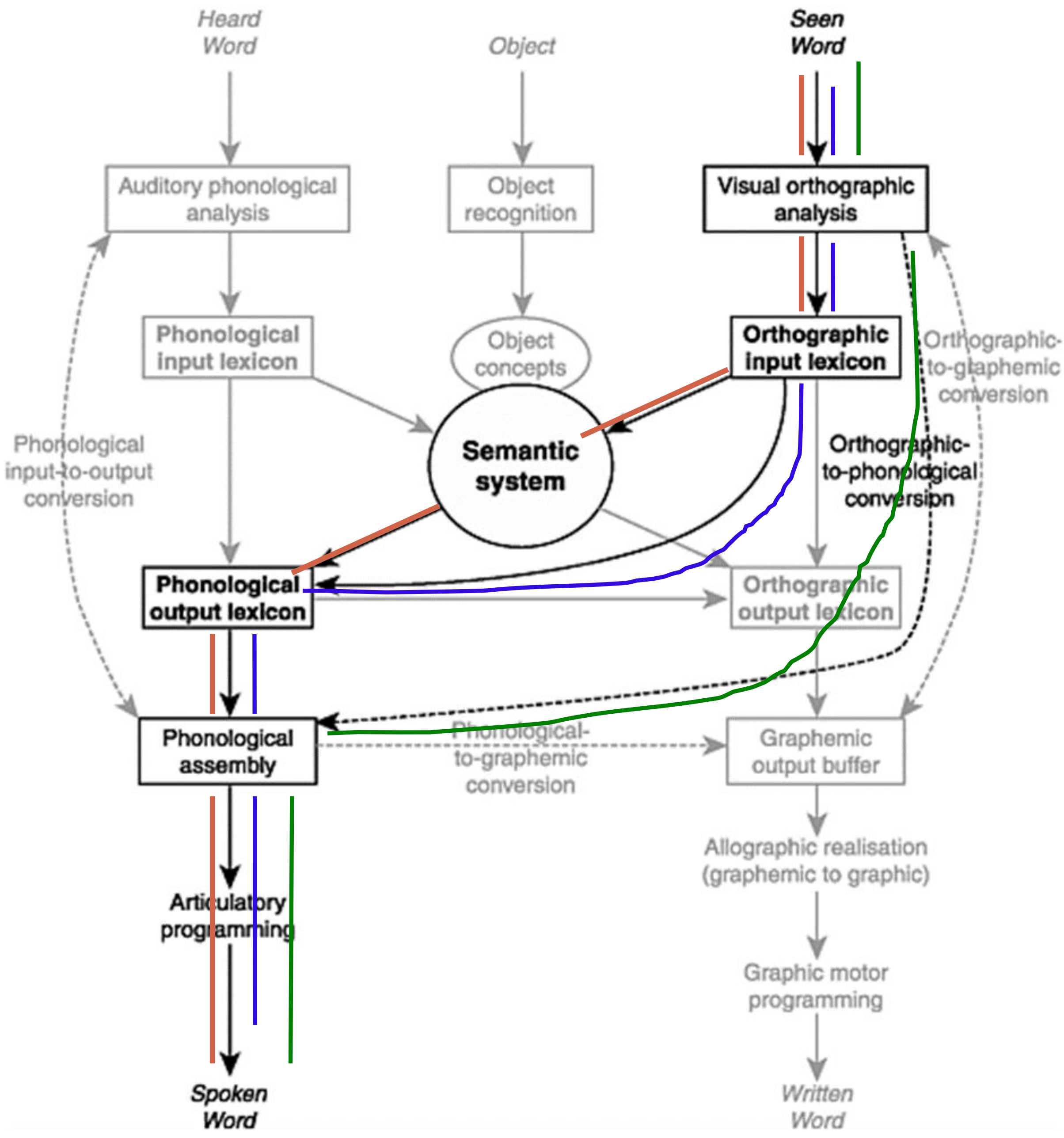


Figure 5.1 Architecture of the Dual-route cascaded model (Coltheart et al, 2001). The red markings indicate the indirect lexical route/ semantic route/indirect semantic route; The blue markings indicate the direct lexical route/direct non-semantic route and the green markings indicate the sub-lexical route/ orthography-phonology conversion route/non-lexical route.

Each level of dyslexia is explained by a disruption in each pathway; phonological dyslexia by the disruption of the sublexical grapheme-to-phoneme conversion route; surface dyslexia by the disruption of the direct and/or semantic pathways that leads to overreliance on the sublexical pathway; deep dyslexia by damage to both lexical and sublexical pathways, which leads reading to occur only through the semantic pathway.

An alternative neurological model to explain reading and consequently levels of dyslexia is the 'triangle model' (Harm & Seidenberg, 2004; Plaut *et al.*, 1996; Seidenberg & McClelland, 1989). This postulates the existence of triangle of units (phonology, semantics and orthography) that have bi-directional pathways between them. The model postulates that reading and writing occur not by whole-word representation but rather on sub-lexical mappings with different weights between the units (see Woollams *et al.*, 2007, for instance). This model describes phonological dyslexia and dysgraphia as due to damage to the phonological pathway. Surface dyslexia is explained as an impairment of the semantic units or to the semantics-phonology pathway (Plaut, 1997).

Similarly, surface dysgraphia could arise from the impairment of the semantic units or the semantics-orthography pathway. Finally, deep dyslexia results from the damage to the orthography-to-semantics and phonological pathways (Plaut & Shallice, 1993). The CDP+ model proposed by Perry, Ziegler and Zorzi (2007) assumes a direct lexical pathway (similar to DRC) and a connectionist sublexical pathway with units of graphemes and phonemes organized into onsets and codas. A limitation of all of these models is that they try to explain underlying oral reading mechanism through English orthography (see Perry et al. 2007). As these models are based on English orthographies/alphabetic languages, it is non-trivial to apply these models to other orthographies, in particular syllabic/alpha-syllabic languages such as Kannada and Hindi. This problem is further aggravated in bi-scriptal bilinguals speaking a combination of orthographies such as both alphabetic and alpha-syllabic (English and Kannada).

Within bilingual reading research, a model that has been used to explain reading aloud is the Bilingual Interactive Activation (BIA) (Dijkstra, Van Heuven & Grainger, 1998; Dijkstra and Van Heuven ,2002; see also Brysbaert & Dijkstra, 2006). Bilingual Interactive Activation (BIA) model of reading in biscriptal readers is a computational model of word identification that is based on the principles of statistical learning first proposed by McClelland and Rummelhart (1981). The BIA model and more recently the BIA (+) (Dijkstra and Van Heuven, 2002) assumes that the representations and mappings between orthography and phonology in both languages of a biscriptal reader are learned, represented and processed by a common system even if there are no similarities between features of the script in each language (e.g. Chinese and English). This would mean that both languages would have similar reading difficulties. Multiple studies [Kim et al 1997 (Korean-English); Dijkstra & Van Heuven, 2002 (Dutch-English)], [See Abutalebi et al (2000) for review] have supported the model that neural representations and mappings between orthography and phonology in both languages of a biscriptal reader are learned, represented and processed by a common neurological system. However, there are studies that do not support this based on the existence of differential dyslexia exhibited in the two languages of bi-scriptal bilinguals .For instance, Sasanuma (1980) reported a deep dyslexic YH, with difference in severity across the scripts within the same language(Kana the alpha-syllabic script being more severely affected than Kanji which is an ideographic script).

Likewise, Karanth (2002) reported an individual with differential dyslexia with alexia in Hindi (alpha-syllabic) and deep dyslexia in English (alphabetic). Consequently, there is no consensus on the type of model to be applied to explain reading difficulties in bi-scriptal bilinguals where the scripts have different orthographies such as both alphabetic and alpha-syllabic scripts (English and Kannada; English and Hindi). Therefore, there is an urgent need to not only profile but also observe persistent characteristics across bi-scriptal readers with similar language and orthographic combinations. This is an aspect which is being addressed in our study.

5.1.3 Characteristics of different writing systems and script differences

Scripts are typically classified as alphabetic, syllabic or ideographic (Coltheart, 1984). Alphabetic scripts have a limited number of symbols that when combined can generate an infinite number of words. Western Indo-European languages such as English, French, Spanish and German, and Semitic languages such as Hebrew and Arabic, all use alphabetical scripts. By contrast, for syllabic scripts the symbols represent not single sounds but the sound of a syllable. For example, Japanese Kana characters represent a syllable formed by a consonant and a vowel or a single vowel. Korean Hangul also represents syllables usually formed by an initial consonant, a vowel and a final consonant (Kim *et al.*,2007).

Writing systems of India have features of both alphabet and syllabary. The scripts of Indian languages originate from the Brahmi script used in Buddhist inscriptions of Indian emperor Ashoka (3rd BC). Basic linear unit in alphasyllabaries is the 'akshara graphic syllable' which is a consonant symbol with inherent vowel (ka) or attached diacritic vowel (ku) McCawley (1997). An example of the script and differences in diacritics of Kannada and Hindi languages are presented in Table 5.2. In European scripts, most diacritic symbols are written above or below basic letters (è, é etc.), but in south Asian scripts, depending on the vowel a diacritic may occur as a satellite above, below, leftward or rightward of a consonant (eg:- in Tamil க கா கே கோ). Spoken vowel short /a/ is considered 'inherent' in each consonant symbol. Eg:- க->|ka|. A syllable final consonant, a consonant symbol is either written in a 'conjunct' form (reduced in size) or else with a diacritic beneath it which 'kills' the inherent vowel 'a' eg:-ಠ - ಠೇಠ್, म् - अहम्

Table 5.2

Alphabets and words in Scripts of Kannada and English with different diacritics

Alphabets/Consonant-vowel combinations	**Kannada**	**Hindi**
/pa/	ಪ	प
/pɪ/	ಪಿ	पि
/po/	ಪೊ	पो
Words		
Hello	ನಮಸ್ಕಾರ /nəməskɑrɑ/	नमस्कार /nəməskɑr/
Grapes	ದ್ರಾಕ್ಷಿ /d̪rɑkʃɪ/	अंगूर /əŋuːr/

The languages used in our study English and Kannada are alphabetic and syllabic scripts respectively. However, Kannada graphemes are memorised as if each syllable was different from the others (Ratnavalli et al., 2000). Thus, syllabic scripts provide syllabically differentiable blocks, contrarily to alphabetic scripts where the unit is the grapheme. In Kannada, each separate written symbol corresponds to one vowel-consonant combination (or syllable) in which each consonant has a different grapheme shape depending on the vowel with which it is combined, and each such grapheme is memorized as if each syllable is different from others (Ratnavalli, et al. 2000). Therefore, both from the perspective of neural representations and the scriptal similarity it is important to classify the orthography-phonology relationship.

Wyndell and Butterworth (1999) suggests two dimensions along which this relationship can be characterized. A 'granularity' dimension that would be fine grain for the phoneme in alphabetic scripts and coarse grain for an ideographic character. A 'transparency' dimension that measures the degree of correspondence between the script and the phonology of a language, irrespective of the type of script or its 'granularity'. On this scale, Spanish is classified as a highly transparent language (Cuetos & Barbón, 2006) and Kannada has transparent correspondence between symbols and pronunciation (Ratnavalli et al 2000). English on the other hand is considered non-transparent (Weekes, 2005). Therefore, when presented with scripts that have differential characterizations (say English and Kannada) it is expected to generate an asymmetric pattern in brain-damaged persons (Béland & Mimouni, 2001; Weekes, 2005). A key theoretical question is whether the pattern of errors observed in individuals with brain damage such as acquired dyslexia and dysgraphia are equivalent across different scripts.

5.1.4 Acquired dyslexia in non-alphabetic scripts

Currently, reading models developed using alphabetic scripts in monolinguals have been successfully applied to non-alphabetic scripts (ideographic and Semitic) in other monolinguals to characterise dyslexia. We summarise a few studies to illustrate this point.

A case study by Law & Or (2001) demonstrated that a brain-damaged patient (Cantonese speaker) had performed better in oral reading than oral naming owing to, the authors claim, use of non-semantic routes for the production of spoken words. Previous studies such as Hillis & Caramazza (1991,1995) have argued that this result can be explained by a summation hypothesis, i.e phonological representations can be achieved by a combination of the semantic system and the conversion mechanism. Therefore, studying a brain-damaged person can answer whether the semantic system can be bypassed to achieve better oral reading. In this regard they tested a 42- year old Cantonese speaking Hong Kong female resident who had a cerebral contusion resulting in cerebral oedema. Administration of the Cantonese Aphasia Battery (CAB) (Yiu, 1992), a year after the accident, revealed that she failed to repeat single words and short phrases no longer than four syllables on a few occasions making phonologically similar errors. Comprehension of spoken and written words was diagnosed as impaired (17/20 on written word-picture matching and 15/20 on spoken word-picture matching). She was diagnosed with anomic aphasia.

For their study, the brain damaged participant was tested for spoken word-picture matching tasks using a series of 67 pictures as stimuli. In addition, a reading aloud task (consisting of words and non-words) and an orthographic lexical decision task (consisting of real and fake characters) were administered. Results from these tasks showed that the errors were unlikely to be caused by an impaired orthographic analysis system or a disrupted orthographic lexicon. Another interesting finding was the increased frequency of tonal errors (59%) in oral reading as opposed to oral naming (4%). The authors have adopted an auto-segmented phonology framework (Goldsmith, 1976; Leben, 1973; Yip, 1980) in which segmental features are represented in a separate tier from suprasegmental features such as tone. Consequently, for her the phonological representation in the brain may be damaged to just retain segmental features alone. The significantly better oral reading as compared to oral naming shows the bypassing of semantic pathways.

Studies on dyslexic patients in the Chinese languages (Cantonese, Mandarin) have shown selective impairment in reading irregular characters (Yin, 1991; Yin & Butterworth, 1992). Specifically, Yin & Butterworth (1992) have studied surface dyslexia in a cohort of 11 brain damaged patients and reported that there is a clear association between surface dyslexia and lexical semantic impairment in Chinese languages. Weekes & Chen (1999) studied a Chinese patient with anomic aphasia who had reduced confrontation naming and impaired spoken word naming. When examining the effects of oral reading of one-character monosyllabic Chinese words, they found that the patient displayed particularly severe impairments in reading irregular, low-frequency items. This they argue is because such items require support of semantic memory and resulting in Legitimate Alternate Reading of Components (LARC) errors. LARC errors are due to a loss of semantic support from lexical-semantic pathway necessary for reading in Chinese (Weekes, 2000).

A recent study by Bakthiar et al (2017) has studied the hypothesis that oral reading requires a semantic reading pathway. The standard dual route computational (DRC) model makes this assumption that skilled oral reading is supported by three pathways: semantic, lexical, and sublexical routes (Coltheart, Curtis, Atkins, &Haller, 1993; Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001). Evidence from Weekes (2005, 2012) shows that oral reading in different language families requires a lexical and sub-lexical pathway. Bakhtiar et al (2017) conducted a study of 21 brain injured Persian speakers with age ranges of 18 to 77 to study the use of semantic pathways in reading Persian.

Participants were assessed using a reduced form (Bedside) version of the Persian (P-WAB-1) adapted from the Western Aphasia Battery and then classified into two groups of fluent (16) and non-fluent cases (5) based on an overall score including the fluency score of the Persian WAB (Nilipour, Pourshahbaz, & Ghoreyshi, 2014). The stimuli consisted of 200 coloured pictures of objects and their transcriptions from the Snodgrass and Vandewart (1980) set. The word and picture naming tasks were presented in two different sessions, while task order was counterbalanced across the patients. A non-word reading task was administered to assess the integrity of the non-lexical pathway consisting of 30 non-words varying in letter length from 2 to 8 letters created by changing consonants and vowels of words to create meaningless stimuli. Non-words cannot rely on lexico-semantic information for correct pronunciation and therefore reflect operation of the non-lexical grapheme to phoneme pathway.

The results showed that oral reading scores were significantly better than picture naming and word naming scores. Left hemisphere damaged individuals showed higher disassociation between naming and reading tasks than right hemisphere damaged individuals. Further, the authors observed that there was a greater impairment when reading words with opaque spelling and overall oral reading is preserved better than picture naming. The authors note that prevalence of formal errors belies a reliance on direct non-semantic routes due to some deficit in the semantic route. An absence of effect of word length (i.e., number of letters) on oral reading accuracy cannot be explained clearly. However, since word length effects in oral reading are considered an index for non-lexical reading a plausible explanation is that impaired reading in Persian is less dependent on the non-lexical reading route than other Indo-European languages. This could be due to Persian having a relatively opaque orthography.

Significant effects of different lexico-semantic variables on oral reading accuracy confirm the assumption that semantic and non-semantic routes are typically employed during the oral reading. This suggests, according to the authors that, opaque words (irregular words) derive a benefit from semantic input and pattern of surface dyslexia in Persian.

In summary, from the above literature it is clear that reading aloud models developed to explain dyslexia in alphabetic languages [such as Spanish or English Coltheart (1984)] in monolinguals can also be applied to monolinguals speaking non-alphabetic languages such as Chinese (Sino-Tibetan), Persian (Semitic) as well. However, it is not clear that the same models can be applied to a bi-scriptal BPWA population. The next section will review work that has been carried out in explaining dyslexia in bi-scriptal BPWA which will then form the basis for our research objectives.

5.1.5 Reading impairments (dyslexia) in BPWA

Few studies (for a review see Lorenzen & Murray, 2008) have addressed the issue of reading and writing disorders in bilingual populations even though evidence from studies such as Weekes (2005) show that such studies of disorders contribute substantially to the models of reading and writing in English and other languages. Processing of reading and writing is driven by both neural mechanisms in the brain and the script similarity between languages themselves (Abutalebi *et al.*, 2001; Kim *et al.*, 1997, Brysbaert & Dijkstra, 2006; Weekes, 2005; Weekes *et al.*, 2007). Evidence exists that languages that have similar orthographies (such as Dutch and English) have few effects of differences in script on word recognition (Brysbaert & Dijkstra, 2006; Weekes, 2005; Weekes, Yin & Zhang 2007). Disassociations between orthographies of bilingual or bi-literate acquired dyslexia have been documented since the late 1970's and early 1980s (Karanth, 2002).

Eng and Obler (2002) examined acquired dyslexia in a bi-scriptal bilingual reader with two different orthographic systems of logographic (Cantonese) and alphabetic (English). The subject was a 65-year old bilingual male who spoke Cantonese at home and completed elementary education in English. Reading abilities in English were assessed using word recognition stimuli from Francis & Kucera (1982) in accordance to the criterion set forth by Coltheart (1984). Similarly, for Chinese, words were chosen from Yee (1986). These were controlled for frequency and number of letters in each word. Complexity in Chinese was measured using number of strokes. Findings reveal that the word recognition abilities were similarly affected in both languages. Reading disruption to some extent reflect the nature of orthographies involved. For instance, there were errors in lexical stress in English (student read as stu-DENT) and errors in lexical tone in Chinese which are script specific. However, errors such as semantic and visual errors were found across scripts. This implies that models of reading used in alphabetic languages could be used to some extent to explain the reading abilities in non-alphabetic languages, but errors arising out of script differences need to be explained with an expansion of the two-route model.

Raman & Weekes (2005) observed the pattern of reading impairment in a transparent orthography in Turkish language. This is the first study of acquired dyslexia in Turkish. The patient was a 67-year-old male, a native speaker of Turkish and had secondary and tertiary education in English. Following a severe CVA in 1999, Raman and Weekes (2003) reported deep dysphasia accompanied with acquired dyslexia in both languages. The question probed in the study was whether acquired dyslexia with a common locus for both English and Turkish can manifest differently due to differences in script and type of task. The authors identify an effect of imageability on reading in Turkish, which is typically thought of as being due to a semantic deficit and a characteristic of deep dyslexia, however the patient is diagnosed with surface dyslexia as the pattern of dyslexia was similar to the surface dyslexia pattern of Italian and Spanish.

Dissociations could also be due to extraneous factors including age of acquisition, pre-morbid proficiency and familiarity with each language could constrain the possibility of manifestation of aphasia in different languages (Paradis, 2001; Nilipour & Paradis, 1995; Yiu & Worrall, 1996). Weekes et al (2007) compared the performance of bi-literate bilingual persons whose two languages have different orthographies but controlled for age of acquisition and pre-morbid proficiency. The authors report 8 patients within the age range of 38- 58 years, all of whom were native speakers of Mongolian and learnt to speak Chinese at an early age (elementary school). They were administered four lexical tasks – oral reading, lexical decision, written word picture matching and spoken word matching. They found no effect of script differences and no interaction between script and task. They examined the effect of script on performance on a case-by case basis as the group testing may mask out individual variability (Caramazza, 1984). They generally found stronger evidence of dissociations on Chinese rather than Mongolian. Consequently, the authors have recommended controlling for age of acquisition and proficiency while interpreting the effect of script on word processing in bilingual individuals with acquired dyslexia.

Senaha & Parente (2012) studied acquired dyslexia in a bilingual individual with three different writing systems – alphabetic Portuguese, syllabic Kana and logographic Kanji of Japanese. The participant was a 48-year old male who suffered a traumatic brain injury at the age of 39. He was a native Brazilian whose parents emigrated from Japan. Japanese was acquired during childhood at home and Portuguese in school. He was administered a reading aloud, lexical decision task, reading and written comprehension of irregular and foreign words, written word comprehension common for all the three writing systems. An additional Kanji-katakana matching, and an analogous homophonic non-word and irregular word-matching was administered for Portuguese.

The authors found irregular word reading produced mainly regularization errors suggesting impairment to the lexical route with preserved use of non-lexical route in Portuguese. In the Japanese logographic reading, the authors found a reading impairment and no reading impairment when reading the syllabic script. In the Japanese reading there were no regularization errors. This dissociation is explained by the presence of different neural networks in the brain for each writing system. Presumably, impairment is due to some of the networks being affected. The authors adopt a multi-route model to explain the reading impairment across the writing systems. This is supported by the correlated reading impairments when reading in the logographic script and reading of irregular words in the alphabetic Portuguese script.

Among the Indian languages, an early study by Karanth (1981) documented reading difficulties in a 57-year-old Kannada-English bilingual with aphasia. The study identified that one of the major problems was combining letters to form words, word to form sentences causing reading difficulties. The author termed these characteristics as 'pure alexia' and asserts that these reading characteristics also correspond to 'verbal alexia' as defined by Hecaen & Kremin (1976). The study observed that the participant found it easier to read in English than Kannada which the author explains could be due to higher exposure to English reading and writing than Kannada. Even in this initial study, the author highlights the difficulty in reading Kannada as opposed to English due to script differences between the languages. There are intrinsic script differences between Kannada and English in the way the consonants are represented as graphemes. Unlike in English, where there are individual graphemes which represent pure consonants (e.g., /k/), Kannada contains no such pure consonants. Instead, one needs to visually perceive the base consonant, the vowel that is attached to the consonant in order to read the alphabet (e.g., k+a = ka).

Ratnavalli et al (2000) studied the degree and type of reading impairment in two Kannada-English bilingual persons with aphasia (BPWA). A detailed language and reading assessment were carried out using Western Aphasia battery in both languages. Case 1 was a 68 -year old male, who was fluent but had word finding difficulties. His auditory comprehension, repetition and written word recognition abilities were relatively intact. He had a severe naming and reading impairment in both languages and had a tendency to read letter-by-letter. His errors in reading English were real-words and in Kannada mostly non-words. They categorised his reading impairment as pure alexia associated with colour anomia and a right hemianopia.

Case 2 was a 60-year old multilingual (Telugu, Kannada, English and Hindi) with a sudden onset aphasia with difficulty in speaking, reading and writing. Language assessment was carried out in Kannada and English. He was fluent with a moderate word finding difficulty, with occurrence of phonemic and semantic paraphasias. Auditory comprehension was intact while repetition was affected. He was able to read single words and sentences in both languages. On reading at word and sentence level in English, the most common errors were context-based substitutions (return/retires) and visual errors whereas in Kannada the errors were non-words. He was diagnosed with angular gyrus syndrome with alexia, anomic aphasia and components of Gerstmann syndrome namely agraphia, right-left disorientation, acalculia and finger agnosia. The authors comment that although the reading scores were good on WAB, it did not actually reflect the actual reading abilities of the participant.

The authors attribute the differences in script between English and Kannada to the different reading strategies used by the participants. Consequently, they emphasise that orthography is important and further evaluation is necessary to establish reading aloud models in Indian languages. There is no agreed model on different types of scripts and how that could impact reading impairments in Indian languages. A limitation of the study is the lack of sensitivity of the stimuli to tap into effects of imageability, frequency, word length or regularity which would have facilitated differential diagnosis of the type of dyslexia.

Karanth (2002) examined the reading deficits of a bi-literate bilingual patient speaking Hindi and English. Hindi is considered phonologically transparent and English is considered as an irregular alphabetic writing system. There have been questions (Ardila, 1991; Karanth, 1985) on generalisation of models of reading aloud developed on alphabetic scripts to other types of scripts (for instance orthographic transparency). For a bi-literate bilingual person, speaking Hindi and English, reading in Hindi can be attained using the sub-lexical route due to its high grapheme phoneme correspondence. Conversely, the same bilingual may use the lexical route for reading in English.

The paper reports the reading abilities of a 30-year old businessman with a severe head injury. Patient was a multilingual able to speak, read and write Tamil, Bengali and Kannada in addition to Hindi and English. Language assessment was carried out using WAB (33 months post onset) in English. He was diagnosed with Broca's aphasia with favourable evolution. In English, his performance was characterised by poor recognition and reading of function words, reading of concrete words better than abstract and reading regular and exceptional words equally well. He was unable to read non-words. The errors in reading aloud words were semantic, formal and morphological in nature. These fit into the classic description of deep dyslexia. In Hindi, his reading difficulty was severely impaired and was labelled as pure alexic. The author suggests that the dissociation in reading performance between the two languages in a bilingual person is primarily driven by the difference in scripts suggesting differential cerebral representation of language. However, in order to confirm this hypothesis a large sample of similarly profiled (bi-literate bilinguals) have to be tested.

To sum up, there are only a few studies on reading impairment in bi-literate bilinguals PWA in languages with two different writing systems [for instance, Japanese (Kanji & Kana) (Sasanuma, 1980), Cantonese- English (Eng & Obler, 2002), Turkish- English (Raman and Weekes, 2005), Portuguese-Japanese (Senaha & Parente, 2012)]. In the Indian context, the bi-scriptal bilinguals not only read and write Indian languages that are typically alpha-syllabic (Kannada, Hindi), but also read and write English which is alphabetic. There is scant evidence of reading impairment among BPWA in India, speaking the Indian languages [e.g., Kannada-English (Karanth, 1981); Kannada – English bilinguals (Ratnavalli et al., 2000); Hindi- English (Karanth, 2002). These are all individual case studies and therefore study unique features for every participant.

There is therefore a need to characterise the variability of reading impairment across multiple bi-scriptal bilingual individuals which can become a basis to adapt the existing reading models to characterise reading impairments in bi-scriptal bilingual individuals. Our study will contribute significantly to the literature because, we are not studying bi-scriptal bilingual PWA merely as case studies, instead are considering them as a case series. This will help us understand the pattern of dyslexia in specific combinations of scripts in bilinguals. This is extremely important as this informs assessment and intervention for such individuals (with different scripts and extent of reading impairment in each script).

5.2 The current investigation, research questions and predictions

The aim of the present study was to profile and characterise the reading difficulties exhibited in bi-scriptal BPWA. We recruited seven BPWA, out of which we could extract usable data only for 4 BPWA (AP02, AP03, AP05 and AP07) with respect to their reading abilities. We collected and collated information on the following variables: language history, education details, occupational status, language usage (pre and post stroke), language proficiency (pre and post stroke) (which includes reading and writing), dominance and a detailed language assessment to document the language impairment in both the languages. Out of the four participants three participants were bi-scriptal BPWA from South India and one participant although originally a person of south Indian descent spent majority of his life in a Hindi speaking environment as he was a resident of North India. The participants spoke one of the Dravidian languages (Kannada, Tamil, Telugu) as their native language and English as their second language. These Dravidian languages are alpha-syllabic in nature and more transparent as compared to English which is alphabetic. Based on the Dual route cascaded model (Coltheart et al., 2001) (see figure 5.2), we aimed to characterise the type of dyslexia exhibited by these BPWA. We attempted to profile and characterise the reading impairments of these participants in English using PALPA (Kay, Lesser & Coltheart, 1992) set of letter discrimination, visual (lexical decision and legality decision) tasks tapping into the phonological processing, spoken word to picture matching and written word to picture matching measuring semantic processing and a set of reading aloud tasks to capture the effects of word length, spelling-sound regularity, imageability and frequency, grammatical class and lexicality effect in non-word reading. Similarly, for profiling the reading impairments in Kannada, word and non-word stimuli varying in syllable length, regularity and geminates were used.

The tasks chosen to characterise the type of dyslexia were mapped onto the different levels of the DRC model. Letter discrimination, visual (lexical decision and legality decision) tasks, word and syllable lengths map onto the visual orthographic analysis and orthographic input lexicon. An effect of spelling sound regularity can be mapped onto the lexical route.

Imageability effects implicate the semantic system and frequency effects could be attributed to the use of lexical route. The orthography to phonology conversion is responsible for non-word reading.

5.2.1 Research question and aims.

How are reading difficulties manifested in bi-scriptal bilingual persons with aphasia (BPWA**)?**

To address this, we documented and profiled the reading abilities in both the languages of BPWA, subsequently classifying the type of dyslexia based on the DRC model. Characterising the reading impairments in both languages allowed us to examine whether the extent of reading impairment/ type dyslexia is same or different in both the languages.

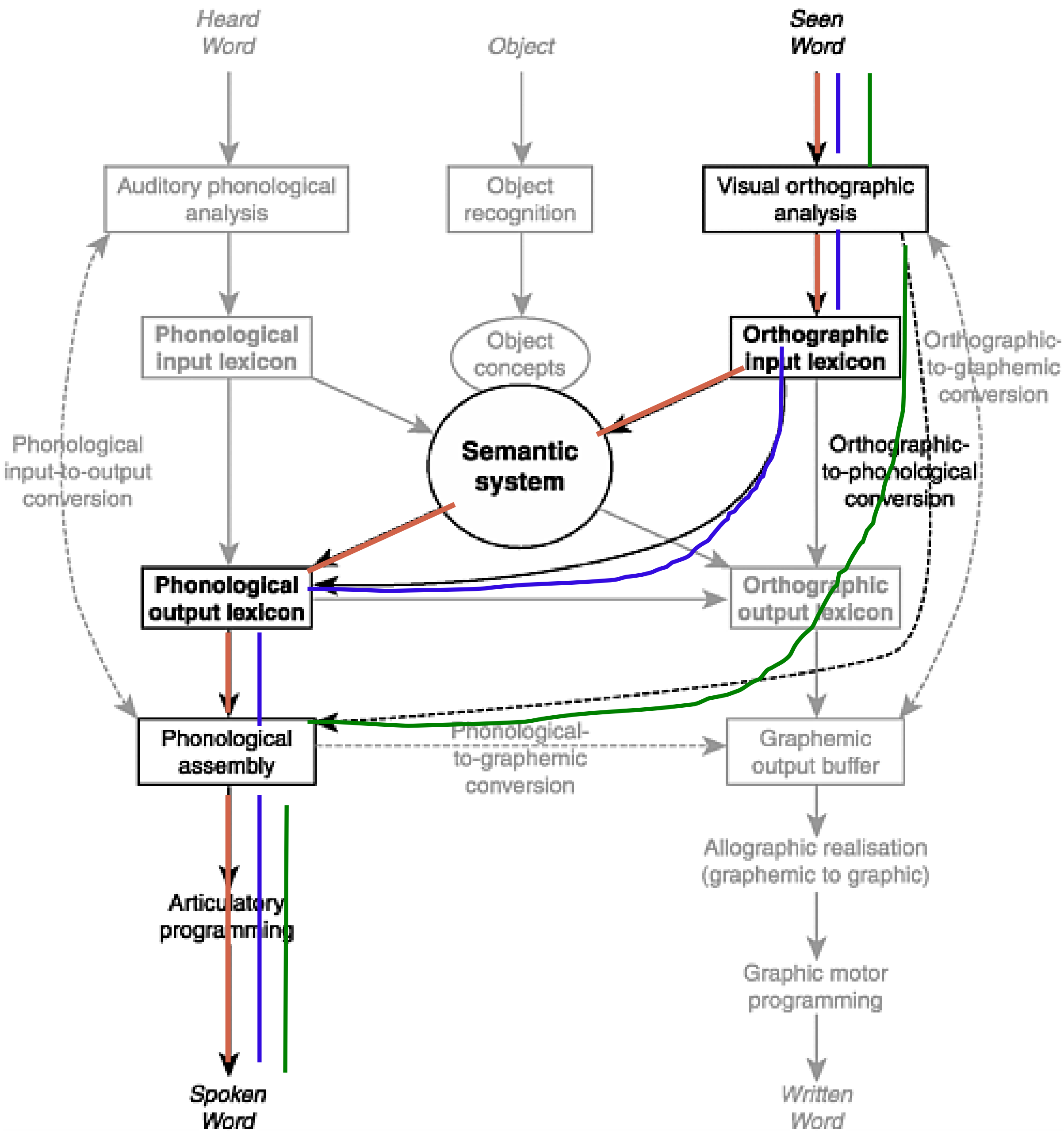


Figure 5.2 Architecture of the Dual-route cascaded model (Coltheart et al, 2001). The red markings indicate the indirect lexical route/ semantic route/indirect semantic route; the blue markings indicate the direct lexical route/direct non-semantic route and the green markings indicate the sub-lexical route/ orthography-phonology conversion route/non-lexical route.

Based on the literature summarised above, the types dyslexia could be classified as presented in Table 5.3.

Table 5.3

Performance pattern for profiling the types of dyslexia

Performance	Alexia	Deep Dyslexia	Surface Dyslexia	Phonological Dyslexia
Nonword reading	Impaired	Impaired	Unimpaired	Impaired
Regularity effects in reading aloud	Impaired	Present	Absent	Present
Imageability effects in reading aloud	Impaired	Yes	No	Yes (possibly)
Grammatical class effects in reading aloud	Impaired	Yes	No	Yes (possibly)
Semantic errors in reading aloud	Impaired	Yes	No	No

5.3 Methods

In this section, first, we will describe the subjective measures used for characterising our BPWA followed by the test batteries to characterise the severity and type of aphasia in both languages, and the extent of language impairment at the single word level in both languages. Second, we describe the experimental tasks used to profile and characterise reading abilities in both languages of BPWA.

5.3.1 Participants profile

A total of seven bilingual persons with aphasia (BPWA) (AP01, AP02, AP03, AP04, AP05, AP06, AP07) were recruited for the study. To be included in the study the participants had to have been pre-morbidly bi/multilingual, should have had a language impairment (aphasia) and should have had reading difficulties in either languages. All the participants were administered a detailed questionnaire to collect information with respect to their demographic details (age, gender, educational qualification, years of education, occupation, handedness). All BPWA (6) had sustained a single left hemisphere CVA resulting in aphasia at least four months prior to participation except AP06 who suffered a traumatic brain injury 5 years prior to testing. Medical and neurological reports were reviewed to establish medical history. All the participants were righthanded (pre-stroke) and had at least ten years of education. There was no history of other neurological conditions, alcohol or drug abuse, neuropsychiatric conditions or dementia. All the participants belonged to a cohort of bi/multilinguals speaking one of the south Indian languages (either Kannada/Coorgi/Tamil/ Telugu) as their native language and English as their second language except one participant (AP06) whose native language was Hindi, and the second language was English. The map of India with the languages spoken in each region is illustrated in Figure 5.3. In Karnataka, data collection was primarily done in Bengaluru and suburbs around Bengaluru and Mysuru. Table 5.4 presents the demographic details (age, sex, years of education, educational qualification, previous occupation, languages known, period post stroke, aetiology, type of aphasia and severity of aphasia) of all participants. Out of which we could extract usable data only from 4 BPWA. We had to exclude the 3 BPWA as the two BPWA (AP01, AP04) had a severe global aphasia, were unable to recognise alphabets and unable to read aloud at word level in either language; AP06 had a moderate broca's aphasia but was unable to read aloud at word level in either language. Therefore, we discuss the bilingual language profile and language assessment in detail only of the following participants- AP02, AP03, AP05 and AP07. Participation in this study was voluntary and participants provided written consent prior to participation (See Appendix 5.1 for an example of information sheet and consent form). All the procedures in this study were approved by the University of Reading Research Ethics Committee (Ethical approval code: 2017/038/AB).

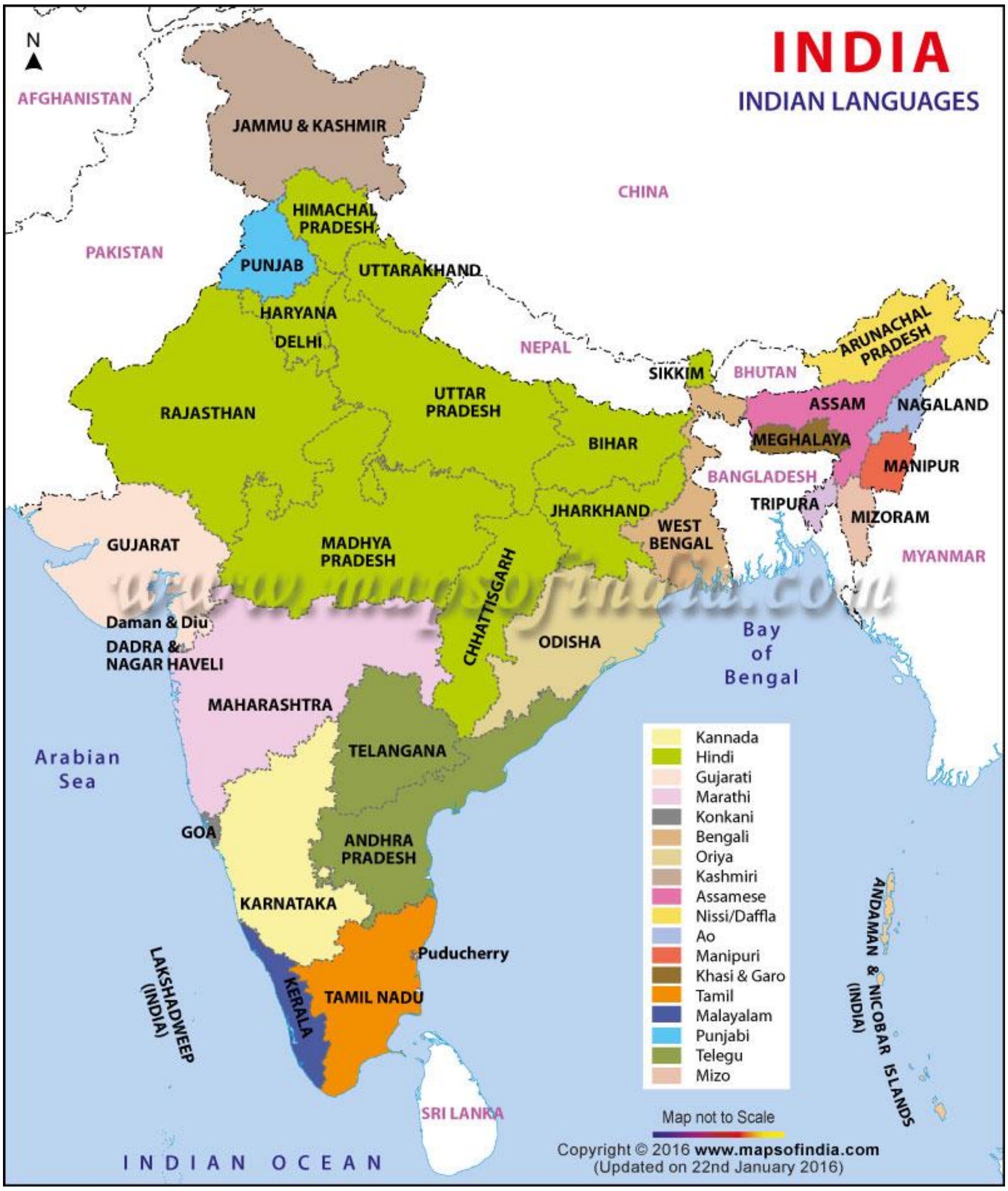


Figure 5.3 Map of India depicting the languages spoken across the country. The states in green speak Hindi (Indo-Aryan language); the state in ivory speaks Kannada; The states in darker green speak Telugu and the state in brown speaks Tamil; The state in blue speaks Malayalam. These four together constitute the Dravidian languages spoken in the Southern part of India.

Table 5.4

Demographic details of participants recruited.

Participant ID	Age/Sex	Years of Education	Educational qualification	Previous occupation	Languages known	Period post Stroke (in months)	Aetiology	Type of aphasia[1]	Severity of aphasia (based on AQ)[2,3]
APO1	31/Male	18	M. Pharm	Pharmacist	Coorgi, Kannada, Hindi, English	12	-	Global Aphasia	Severe
APO2	68/Male	16	B.E(Civil)	Civil Engineer	Kannada, English, Tamil	21	CVA with right hemiparesis	Broca's Aphasia	Severe
APO3	41/Male	15	B.Sc	Businessman	Telugu, Kannada, English, Hindi	6	CVA	Broca's Aphasia	Severe
APO4	42/Male	17	B.A		Kannada, English	4	CVA	Global Aphasia	Severe
APO5	75/Male	10	Class 10	Worker in Ordinance factory	Hindi, English, Tamil	24	CVA with left hemiplegia,	Anomic Aphasia	Moderate
APO6	32/Male	16	B.E(Mechanical)	Engineer	Hindi, English	60	Traumatic brain injury with right hemiplegia	Broca's Aphasia	Moderate
APO7	45/Male	10	Class 10	Sports coach	Kannada, English, Hindi	83	CVA with right hemiplegia	Broca's Aphasia	Severe

[1]- Type of aphasia were classified based on WAB-R (Kertesz, 2006) in English , in Kannada (Chengappa & Ravikumar, 2008) and WAB-Hindi (Karanth,1980); [2]-Aphasia quotient (AQ) was calculated by using the following formula [AQ= (SS score+ AVC score+ Repetition score+ Naming score)*2]; [3]-Severity rating scale: Mild (76 and above), Moderate(51-75), Severe(26-50), Very severe(0-25); [4]-Cells in grey indicate participants excluded from the study.

5.4.2. Bilingualism profile. We used various measures to characterise and profile bilingualism of the BPWA. We adapted a questionnaire developed by Muñoz, Marquardt & Copeland (1999). This questionnaire assessed language acquisition history, language of instruction during education, self-rated language proficiency (speaking, comprehension, reading and writing), and the current language usage patterns which is same as the one we have used in Chapter 2 (See appendix 2.2). Language dominance was measured using the language dominance questionnaire (Dunn & Tree, 2009). All the participants filled the language proficiency and usage part of the questionnaire twice to separately report pre-stroke and post-stroke language proficiency and language usage, with the support from caregiver or family members, as needed.

5.3.2.1 Results of Language profile of BPWA. All four participants were bi/multilinguals with different native languages but had English as their second language. AP02 and AP07 had Kannada as their native language. AP03 reported Telugu as his native language but had knowledge of Kannada as he moved to the state of Karnataka (where Kannada is the predominantly spoken language) at the age of 18 and used Kannada and Hindi on a day to day basis as a result of his job. He was more exposed to Telugu/Kannada; therefore, we have profiled his Telugu/Kannada and English. On the other hand, AP05 reported his native language to be Tamil, but he grew up in a city where Hindi was the predominantly spoken language. His schooling was also in Hindi and English and he preferred using Hindi at home as well as at school. Therefore, we have characterised his bilingual profile with respect to Hindi and English.

On a scale of 1 to seven (1 = very poor, 7 = native like proficiency), all four participants completed self-rated proficiency questionnaires both pre and post stroke. Proficiency scores were averaged across speaking, comprehension, reading and writing domains. All BPWA reported proficiency level of 5.25 or more in their respective native languages and English prior to stroke (except AP03 in English pre= 4.12). Post stroke the language proficiency level was reduced, with all participants having a score below 4 for their native languages and English. The reading and writing abilities were most affected for all participants post-stroke. All the participants acquired reading and writing of both their languages between 5-6 years of age except AP02 and AP03 who were introduced reading in L1 at about 4 years of age. All the participants reported their respective native languages (Kannada, Telugu, Hindi, Kannada) as their most frequently used language both pre-and -post stroke. On a scale of one to four (1- daily; 4- monthly), AP02 and AP03 reported their frequency of reading print prior to stroke (books, newspapers, magazines) to be daily in English, while AP05 and AP07's frequency of reading print in English was restricted to few times a week. However, all the participants were daily readers of print in their native language excepting AP02 who read few times a week in Kannada. The reading of print post stroke was severely affected for all participants (nil) except for AP02 and AP03 who continued reading in English for few times a week. The current language dominance score suggested that all the participants were dominant in their respective native languages. The bilingual profile of BPWA with the scores obtained from the language background questionnaire are presented in Table 5.5.

Table 5.5

Bilingual language profile of BPWA.

Bilingual profile	***AP02[8]***		***AP03***		***AP05***		***AP07***	
	Kannada	*English*	*Kannada/Telugu*	*English*	*Hindi*	*English*	*Kannada*	*English*
Language Acquisition history[5]	8[1]	6[1]	17[1]	2[1]	16[1]	0	16[1]	0
Reading and writing acquisition (in years)	4	5-6	3-4	5-6	5-6	5-6	5-6	5-6
Frequency of reading print[7] (prior to stroke)	2	1	1	1	1	2	1	2
Frequency of reading print[7] (post-stroke)	-	2	1	2	-	-	-	-
Language proficiency prior to stroke[5]	5.25	5.75	5.62	4.12	7	6.5	7	6
Listening	7[2]	6[2]	5	5	7	7	7	6.5
Speaking	6[2]	6[2]	5.5	3.5	7	6	7	5.5
Reading	5[2]	5.5[2]	6	5	7	7	7	6
Writing	3[2]	5.5[2]	6	3	7	6	7	6
Current language proficiency[5]	2.62	2.12	2.87	2.75	3.87	3.75	3.25	1.75
Listening	4[2]	4[2]	4	3	4	4.5	7	3
Speaking	3[2]	2.5[2]	3.5	2	4.5	3	2	1
Reading	2.5[2]	1[2]	2	4	3	4	3	2
Writing	1[2]	1[2]	2	2	4	3.5	1	1

Bilingual Profile	AP02		AP03		AP05		AP07	
	Kannada	English	Kannada/Telugu	English	Hindi	English	Kannada	English
Language and frequency usage prior to stroke[5]	4.5	2.5	2.6	2.3	4.83	2.83	4.83	2
At home	5[3]	1[3]	5	2	5	3	5	1
At community gatherings	4[3]	2[3]	3	3	5	3	5	2
At social gatherings (with work colleagues)	4[3]	4[3]	2	2	5	4	5	3
At work (with colleagues)	4[3]	4[3]	1	1	5	3	5	3
With friends	5[3]	2[3]	2	2	5	2	5	1
Telecommunication (phone, skype, chatting etc)	5[3]	2[3]	3	4	4	2	4	2
Current language and frequency usage[5]	4	1.75	2.6	2.6	3.6	1.6	5	1.5
At home	4[3]	1[3]	5	2	4	2	5	2
At community gatherings	4[3]	2[3]	4	2	-	-	5	2
At social gatherings (with work colleagues)	-	-	1	3	-	-	-	-
At work (with colleagues)	-	-	1	3	-	-	-	-
With friends	4[3]	2[3]	2	3	3	1	5	1
Telecommunication (phone, skype, chatting etc)	4[3]	2[3]	3	3	4	2	5	1
Current language dominance score[6]	21[4]	10[4]	19	6	22	7	26	3

[1]-maximum possible score was 20, greater score in one language means greater immersion into that language during childhood; [2]- on a scale of one to seven (1= very poor; 7= native like), greater score in one language means greater proficiency in that language;[3]-on a scale of one to five (1= not at all; 5= very often), greater score in one language means greater frequency of usage of that language; [4]-maximum possible score was 31, dominant language is the language which obtains a greater score than the other language;[5]-adapted from Munoz, Marquardt & Copeland (1999); [6]- adapted from Dunn & Fox Tree, 2009.[7]- Frequency of reading print (books, newspapers, magazines)on a scale of one to four (1= daily; 2= few times a week ; 3 = weekly; 4=monthly) [8]—AP06 reports that he was also exposed to both Kannada and English in a single context during language acquisition (which gets a score of 6).

5.3.3 Language assessment.

We administered WAB-R in English (Kertesz, 2006) and its adapted version in Kannada (Chengappa & Ravikumar, 2008) or Hindi (Karanth, 1980) to assess the type and severity of aphasia in both languages. WAB-R assesses four language areas: spoken language, auditory comprehension, repetition and naming. Severity of language deficits (Aphasia Quotient; AQ) and aphasia type were determined based on the performance on these subtests.

5.4.3.1 Results of WAB assessment. Only participant AP07 could not be tested on the English version of the test as he was unavailable for testing. Details of participants' performance on the individual subtests are provided in Table 5.6. All BPWA showed variable level of difficulty in auditory comprehension, spoken language production, naming, and repetition (see Table 5.6). Based on the test results, two BPWA (AP02, AP03) were non-fluent and presented with severe Broca's aphasia in both languages, while AP07 had severe Broca's aphasia in Kannada and could not be tested in English. AP05 was relatively fluent and presented with a moderate Anomic aphasia. The connected speech sample elicited through picture description in the two languages of each BPWA is presented in Table 5.7.

Table 5.6

Language scores on Western Aphasia battery in Kannada, Hindi (Karanth, 1980) and English (Kertesz, 2006).

Subtests of WAB	**AP02**		**AP03**		**AP05**		**AP07**	
	Kannada	*English*	*Hindi*	*English*	*Hindi*	*English*	*Kannada*	*English*
Spontaneous Speech (SS)[3]								
Information Content[1]	5	4	5	4	7	7	5	
Fluency[2]	2	1	5	4	6	6	2	
Score[3]	7	5	10	8	13	13	7	
Auditory Verbal Comprehension (AVC)								
Yes/No questions[4]	45	45	51	60	60	60	45	
Auditory word recognition [5]	47	54	51	59	59	57	47	
Sequential commands[6]	46	36	42	61	59	60	26	
Total[7]	138	135	144	180	178	177	118	
Score[8]	6.9	6.75	7.2	9	8.9	8.85	5.9	
Repetition								CNT[20]
Repetition[9]	28	34	39	58	82	74	11	
Score[10]	2.8	3.4	3.9	5.8	8.2	7.4	1.1	
Naming								
Object naming[11]	31	30	11	7	45	33	20	
Fluency[12]	1	4	0	0	9	11	3	
Sentence completion[13]	2	2	0	0	4	6	0	
Responsive speech[14]	3	8	4	2	10	10	4	
Total[15]	37	44	14	9	68	60	27	
Score[16]	3.7	4.4	1.5	0.9	6.8	6	2.7	
Aphasia quotient (AQ)[17]	40.8	39.1	45.2	47.4	73.8	70.5	33.4	
Aphasia severity [18]	Severe	Severe	Severe	Severe	Moderate	Moderate	Severe	
Aphasia type[19]	Broca's	Broca's	Broca's	Broca's	Anomic	Anomic	Broca's	

[1]-maximum possible score 10; [2]-maximum possible score 10; [3]-sum of information content and fluency score; [4]-maximum possible score 60; [5]-maximum possible score 80; [6]-maximum possible score 80; [7]-sum of all auditory verbal comprehension subtest scores; [8]-total score divided by 20; [9]-maximum possible score 100; [10]-repetition score divided by 10; [11]-maximum possible score 60; [12]-maximum possible score 20; [13]-maximum possible score 10; [14]-maximum possible score 10; [15]-sum of all the naming subtests scores; [16]- total divided by 10; [17]-AQ was calculated by using the following formula [AQ=(SS score+AVC score+Repetition score+Naming score)*2]; [18]-Severity rating scale: Mild (76 and above), Moderate(51-75), Severe(26-50), Very severe(0-25);[19]- Type of aphasia were classified based on WAB-R (Kertesz, 2006) in English and WAB-Hindi (Karanth,1980). [20]-CNT- Could not be tested due to unavailability.

Table 5.7

Connected speech elicited through picture description for each BPWA in Kannada/Hindi and English[1]

Participant Code	Kannada/Hindi	English
AP02	**cookie ko ko jump[2]**	CNP[3]
Translation tier	*/cookie to to jump/*	
AP03	**/iss me ek do teen aadmi hai/**	CNP[4]
Translation tier	*/in this one, two, three person there/*	
	/woh bada amma/	
Translation tier	*/that elder mother/*	
	/ek uska beta aur ek chota udar/	
Translation tier	*/one his son and one small there/*	
	/rooken chair naar/	
Translation tier	*/jargon (NW) chair jargon (NW)/*	
	/wo chair hum aatha iska/	
Translation tier	*/that chair we come his/*	
	/phir baad me iska chal raha hoon/	
Translation tier	*/then after his walk-ing (I am) (implied)/*	
	/yeh bhi nikal gaya/	
Translation tier	*/this also came off/*	
	/neeche poora andhar paani chala gaya/	
Translation tier	*/down full inside water go (past)/*	
	/aur uske baad ek fry ek pry aur do yeh one two iske sath mil raha/	
Translation tier	*/and after that one fry one pry (NW) and two this one two with this meet-ing/*	
	/aur kya bhi nahi/	
Translation tier	*/and what also no/* *'and nothing at all'*	
	/utna hi chal raha bas/	
Translation tier	*/that is all is happen-ing enough/* 'that is all what is happening'	
	/yeh toh/	
Translation tier	*/this is/*	
	/aur kya bhi nahi/	
Translation tier	*/and what also no/* *'and nothing at all'*	
	/teen aadmi hai/	
Translation tier	*/three persons there/* *'three persons are there'*	

Participant code	Kannada/Hindi	English
AP05	**/ek ladka stool par chadkar cooking jar ko khol raha tha/**	/standing and giving getting fall/ /boy and some work is going here/ /he is getting fell down/ /The stool is slipped/ /Ladies vanda cleaning gas/
Translation tier	*/one boy stool on climb-ed cooking jar to open-ing/* *'one boy climbed on the stool and (implied) was opening the cooking jar'*	
	/one boy stool/	
Translation tier	*'one boy stool'*	
	/stool slip ho raha tha/	
Translation tier	*/stool slip happen -ing (was)-past continuous tense/* *'stool was slipping'*	
	/ladki gas saaf kar rahi hai/	
Translation tier	*/girl gas clean do-ing/* *'Girl is cleaning the gas'*	
	/toh paani leakage ho raha hai/	
Translation tier	*/then water leakage happen -ing -presentcontinuous tense/* *'then water leakage is happening'*	
	/ghar me/	
Translation tier	*/house in/* *'in the house'*	
	/makaan me/	
Translation tier	*/house in/* *'in the house'*	
	/kitchen me/	
Translation tier	*/kitchen in/* *'in the kitchen'*	
AP07	**/nayi/**	CNP[3]
Translation tier	/dog/	
	/pata/	
Translation tier	/kite/	
	/mane/	
Translation tier	/house/	
	/tree/	
	/bavuta/	
Translation tier	/flag/	
	/nayi/[5]	
Translation tier	/dog/	

1-Two pictures were used to elicit responses, first the picnic picture from WAB was presented and in case of non-response the Boston cookie theft picture was considered. [2] -Needs lot of prompting, still finds it difficult to come up with responses to prompt questions.[3] -Couldn't describe picture in English.[4] -Responses only in Hindi, no verbal responses in English at the sentence level.[5]-Response to picnic picture was considered. CNP- Could not perform. NW-nonword

5.3.4 Experimental tasks used to profile and characterise the reading abilities of BPWA.

Subtests from Psycholinguistic Assessment of Language Processing in Aphasia (PALPA; Kay, Lesser & Coltheart, 1992) were used to document the reading profile of BPWA in English. For ease of understanding, the subtests were grouped as assessing phonological processing, semantic processing and reading aloud. The details of the experimental tasks used to profile and characterise acquired dyslexia in English are presented in Table 5.8.

Table 5.8

Experimental tasks used for profiling and characterizing acquired dyslexia in English

Experimental tasks	Stimuli used with examples	Response type	Total no. of items	Level of processing
		Phonology		
Letter discrimination	PALPA 21 1. TOWER tower 2. Bwonr BWONR	Tick response Same or different (Words & non-words)	Word pairs & non-word pairs (30 each) Total=60	Multi-letter strings discrimination with upper and lower case.
Legality decision	PALPA 24 1. Fresh 2. Long 3. Tsnao 4. Rsene	Tick whether a word or not	Words & non-words (30 each) Total=60	Rudimentary word processing
Lexical decision	PALPA 27 1. Need 2. Have 3. Swet 4. Fute	Tick whether a word or not	Exception words; regular words; pseudo-homophones; non-homophonic non-words (15 each) Total= 60	Word processing with spelling-sound regularity
Non-word repetition	PALPA 8 1.drange 2.truggle 3.adio 4.egular	Repetition	1-Syllable;2 -Syllable & 3-Syllable (10 each) Total= 30	Phonology Phoneme length is constant and syllable length is manipulated.

		Semantics		
Spoken word-picture matching	PALPA 47 Target item- Axe Close semantic distractor- Hammer Distant semantic distractor-Scissors Visually related distractor- Flag Unrelated distractor-Kite	Matching spoken word to picture	Total = 40	Semantic comprehension (auditory/spoken word)
Written word-picture matching	PALPA 48 Target item- Dog Close semantic distractor- Cat Distant semantic distractor-Kangaroo Visually related distractor- beetle Unrelated distractor-butterfly	Matching written word to picture	Total= 40	Semantic comprehension (visual/written)

Experimental tasks	Stimuli used with examples	Response type	Total no. of items	Level of processing
		Reading aloud		
Regularity effect	PALPA 35 1. Effort (R) 2. Take (R) 3. Ceiling (E) 4. Bouquet (E)	Reading aloud	Regular words & exception words (30 each) Total=60	Effects of spelling-sound regularity in reading aloud.
Imageability and frequency effect	PALPA 31 1. Night (HIHF) 2. Funnel (HILF) 3. Attitude (LIHF) 4. Tribute (LILF)	Reading aloud	High imageability, high frequency; high imageability low frequency; low imageability high frequency; low imageability low frequency (20 each) Total= 80	Effects of imageability and frequency and their effects in reading aloud. Imageability-semantic system Frequency- lexical system
Grammatical class effect	PALPA 32 1. Welfare (N) 2. Appear (V) 3. Happy (Adj) 4. Meanwhile (F)	Reading aloud	Nouns; adjectives; verbs & functors (20 each) Total= 80	Effect of grammatical word class in reading aloud
Word length effect	PALPA 29 1. key 2. ship 3. knife 4. bridge	Reading aloud	3 letter;4 letter;5 letter;6 letter (6 each) Total= 24	Effects of letter length in reading aloud.
Non-word reading	PALPA 36 1. ked 2. shid 3. snite 4. dringe	Reading aloud	3 letter;4 letter;5 letter;6 letter (6 each) Total= 24	Phonology

R- Regular; E-Exceptional; HIHF- High imageability- high frequency; HILF- high imageability low frequency; LIHF- low imageability high frequency; LILF- low imageability low frequency; N-Noun; V-Verb; Adj- Adjective; F-Functor.

5.3.4.1 Phonological processing. To assess the phonological processing abilities of the participants, stimuli from the following subtests were used- Letter discrimination (PALPA 21), Legality decision (PALPA 24), Visual lexical decision (with spelling sound regularity) (PALPA 27) and non-word repetition (PALPA 8). For the letter discrimination, the participants were presented with word/non-word pairs and they had to decide if the pairs were same or different. The legality decision task was a rudimentary word processing task where the non-word stimuli used did not have any resemblance to the real words and the non-words were almost impossible to pronounce (eg., *Tsnao*). The visual lexical decision task (with spelling sound regularity) examines the importance of spelling sound regularity in deciding whether a string of letters is a word or not. In the word stimuli list, half of the words were regular words (eg., *need, same)* and the other half were irregular words (e.g., *have, bind*). Similarly, 50% of non-words were pseudohomophones (they are pronounced in the same manner as existing words but spelt differently) (e.g., *wich, gote*) and the other half were non-homophonic non-words (which are not pronounced like real words) (e.g., *dort, fute*). For both the legality decision and lexical decision, the participants were visually presented with either a word or a non-word and they had to decide if the presented stimuli was a word or not. For the non-word repetition task, the participants were presented auditorily with either a word or a non-word and the they were expected to repeat what they heard clearly. Responses were recorded using a voice recorder. Responses were marked as correct or incorrect.

5.3.4.2 Semantic processing. Auditory and visual semantic comprehension were assessed using spoken word to picture matching (PALPA 47) and written word picture matching (PALPA 48) respectively. In this task, participants were presented with an A4 sheet which consisted of a target picture along with four distractors- close semantic distractor, distant semantic distractor, visually related distractor and an unrelated distractor. For example, if the target picture/word is '*axe'*, the four distractors presented along with it were a close semantic distractor (*'hammer'*), distant semantic distractor (*'scissors'*), a visually related distractor (*'flag'*) and an unrelated distractor (*'kite'*) (See Figure 5.4 for an example). Stimuli were black and white line drawings. For the spoken word picture matching task, participants were asked to listen to the spoken word said by the experimenter and point to the target picture and for the written word picture matching task, the target written word presented on the sheet had to be matched to the target picture. Participant's responses were recorded.

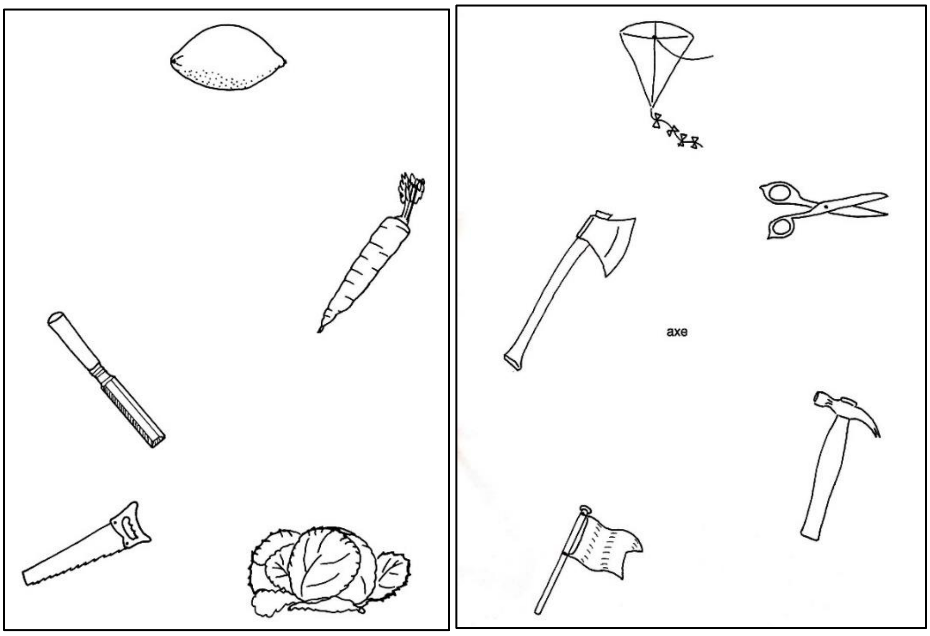


Figure 5.4 Sample stimuli used for spoken word panel (a –left) and written word picture matching task panel (b –right). For spoken word picture matching (panel a)-The target picture is 'carrot', the close semantic distractor is ('cabbage'), distant semantic distractor ('lemon'), a visually related distractor ('saw') and an unrelated distractor ('chisel'). For written word picture matching (panel b) The target word is 'axe', the close semantic distractor is ('hammer'), distant semantic distractor ('scissors'), a visually related distractor ('flag') and an unrelated distractor ('kite').

5.3.4.3 Reading aloud. Considering the characteristics of the different types of acquired dyslexia, the participants were tested on the following subtests of PALPA- spelling sound regularity reading (PALPA 35)(measuring spelling sound regularity), imageability and frequency reading (PALPA 31)(measuring imageability and frequency), grammatical class reading(PALPA 32)(measuring grammatical class effect), word length reading (PALPA 29) (measuring word length effect) and non-word reading (PALPA 36) [assesses the integrity of the non-lexical pathway (Bakthiar, Jafary & Weekes, 2017)]. For each of these sub-tests, participants were shown one written word at a time on a sheet of paper and were instructed to read the word aloud. Responses were recorded using a voice recorder. Responses were marked as correct or incorrect. Incorrect responses were classified into different error types. The description of errors with examples is presented in table 5.9.

Table 5.9

Description of types of errors in reading aloud with examples.

Error types	Description	Example
Semantic	Response with an associative or categorical relationship to the target	/smoke/ as /cigarette/
Letter by letter reading	Responses where participant reads the word letter-by-letter instead of the whole word.	/cheese/ as c-h-e-e-s-e
Visually related non-word	Non-word responses visually related to the target which is a real word	/tongue/ as /nongue/
visually related real word	Real word responses visually related to the target	/effort/ as /effect/
Unrelated real word	Real-word responses with no obvious relationship to the target.	/ignore/ as /know/
visually unrelated non-word	Non-word responses with no obvious relationship to the target.	/theory/ as /riri/
Lexicalisation	Substitution of non-words with real word responses.	/doot/ as /dot/
Regularisation	Substitution of irregular words with regular words.	/pint/ as /pɪnt/
Cross-linguistic	Incorrect substitution in non-target language	/cigarette/ as /t̪əmbɑkʊ/
Cross-linguistic translational equivalent	Correct substitutions in non-target language	/house/ as /mənɛ/
No response	Omissions, I don't know (IDK), or participant indicating they cannot read the stimuli.	

5.3.5 Characterising and profiling reading difficulties in Kannada and Hindi.

The participants were informally screened for letter recognition by presenting the written alphabets of Kannada. AP02, AP03 and AP07 were tested for reading abilities in Kannada as post-stroke they had some preserved reading of Kannada. AP05 was tested for reading abilities in Hindi as he had some preserved reading in Hindi.

5.3.5.1 Reading Acquisition profile in Kannada (RAP-K, Rao, 1997). Participants who were able to recognise alphabets of Kannada language on informal screening were then presented with word stimuli from the reading section of RAP-K for a detailed reading assessment. Although, RAP-K was originally designed for use with studying reading acquisition in children and identifying developmental dyslexia, this material was constructed by adapting several existing test materials in Kannada language (Ramaa, 1985; Karanth & Prakash, 1996) and incorporating new stimuli based on the structure of Kannada language. The test material encompasses words and non-words under the categories of simple CVCVCV combinations, geminates, polysyllabic (blends and clusters), special (arka and anuswara; showing orthographic irregularity). The details of RAP-K material used to profile and characterise acquired dyslexia in Kannada are presented in Table 5.10. The participants were shown one written word at a time on a sheet of paper and were instructed to read the word aloud. Responses were recorded using a voice recorder. Responses were marked as correct or incorrect and error responses were documented.

5.3.5.2. Word list from Bilingual aphasia test -Hindi (BAT-Hindi; Paradis & Libben, 1987). Due to unavailability of word stimuli in Hindi mirroring the PALPA, word stimuli from the BAT-Hindi were used; the stimuli could be categorised based on the number of syllables. The details of the BAT-stimuli used to profile and characterise acquired dyslexia in Hindi are presented in Table 5.10. Only AP05 was tested using the stimuli. The participant was shown one written word at a time on a sheet of paper and was instructed to read the word aloud. Responses were recorded using a voice recorder. Responses were marked as correct or incorrect.

Table 5.10

Stimuli used to profile and characterise acquired dyslexia in Kannada and Hindi

Sub-tests of RAP-K	Example stimuli	Response type	Number of items	Level of processing
Simple words (CVCVCV)	/mələjɑ/ /kərəgɑ/ /jət̪ənɑ/ /ləbət̪ɑ/	Reading aloud	Words and non-words (20 each) Total = 40	Consonant vowel combinations
Geminates	/əbbərɑ/ /kət̪t̪əlʊ/ /hʊnəbbɪ/ /nɛt̪t̪əkkʊ/	Reading aloud	Words and non-words (10 each) Total = 20	Consonants longer than singleton consonants
Polysyllabic words	/halluʤ͡ʤ͡ʊt̪t̪ɑ/ /rɛkkɛpʊkkɑ/ /nɑkeːrɪl̥ɑ/ /sʊt̪t̪ərɪkɑ/	Reading aloud	Words and non-words (10 each) Total = 20	Syllable length
Special words (measuring irregularity)	/kɑrmɪkɑ/ /bʰəɲɑ/ /pərt̪vənərɪ/ /ɑrələ̃kɑ/	Reading aloud	Words and non-words (10 each) Total = 20	Orthographic irregularity
Words from Bilingual aphasia test-Hindi (BAT-Hindi)	/pɛd̥/ /kəmi:ʒ/ /ʊd̪ɑsɪ/	Reading aloud	1 syllable X6; 2 syllable X 12; 3 syllable X 6 Total =24	Syllable length

5.4 Statistical Analyses

The correct responses from each of the tasks were averaged to obtain a mean score. This mean score was converted into percent correct score. A case series approach was employed to profile the reading impairments of the participants. A within-subject design was used to compare the performance of each participants on the sub-tests of PALPA for the reading aloud tasks. Chi-square tests were used to determine the effects of word length, imageability, frequency, regularity, grammatical class and lexicality effects in word and non-word reading aloud tasks. An Alpha level of 0.05 was used to determine the level of significance.

The incorrect responses in reading aloud were classified into different types of errors and an error distribution pattern for each BPWA was documented to further facilitate the classification of dyslexia based on proportion and type of errors.

5.5 Results

The results will be presented as performance of individual BPWA (AP02, AP03, AP05 and AP07) with reference to their performance on their language background measures and on tasks of phonological processing, semantic processing and reading aloud tested using PALPA in English and performance of participants in Kannada reading aloud using RAP-K. The performance of the BPWA on phonological processing, semantic processing and reading aloud tasks in English are presented in Table 5.11. The performance of BPWA (AP03) on reading aloud tasks of Kannada are presented in Table 5.12. The error profile of BPWA on non-word repetition and reading aloud subtests of PALPA are presented in Table 5.13.

Table 5.11

Performance of participants on tasks of semantic processing, phonology processing and reading aloud tasks in English.

	Stimuli, number correct and % correct	**AP02**	**AP03**	**AP05**	**AP07**
Semantic	PALPA 47: Spoken word -picture matching (N=40)				
	# correct, % correct	32(80)	34(85)	31(77.5)	23(57.5)
	PALPA 48: Written word -picture matching (N=40)				
	# correct, % correct	0(0)	34(85)	29(72.5)	26(65)
Phonology	PALPA 21: Letter discrimination (N=63)				
	# correct, % correct	41(65.08)	57(90.48)	61(96.83)	57(90.48)
	PALPA 24: Legality decision task (N=60)				
	# correct, % correct	40(63.49)	59(93.65)	52(82.54)	0(0)
	Words (n=30)	25(83.33)	29(96.67)	28(93.33)	0(0)
	Non-words (n=30)	15(50)	30(100)	24(80)	0(0)
		χ^2= 7.5, p = 0.006	χ^2= 0, p =1	χ^2= 1.29, p = 0.25	
	PALPA 27: Visual lexical decision task (N=60)				
	# correct, % correct	0(0)	40(63.49)	43(68.25)	0(0)
	Words (n=30)		25(83.33)	18(60)	
	Non-words (n=30)		15(50)	25(83.33)	
			χ^2= 7.5, p= 0.006	χ^2= 4.02, p = 0.04	
	PALPA 8: Non-word repetition (N=30)				
	# correct, % correct	22(73.33)	1(3.33)	18(60)	4(13.33)
	1- syllable (n=10)	4(40)	0(0)	2(20)	2(20)
	2-syllable (n=10)	8(80)	0(0)	7(70)	0(0)
	3-syllable (n=10)	10(100)	1(10)	9(90)	2(20)
		χ^2= 6.5, p = 0.03		χ^2= 10.83, p = 0.02	
Reading aloud	PALPA 29: Word length reading (N=24)				
	# correct, % correct		15(62.5)	24(100)	4(16.67)
	3-letter (n=6)		6(100)	6(100)	3(50)
	4-letter (n=6)		5(83.33)	6(100)	0(0)
	5-letter (n=6)		3(50)	6(100)	1(16.67)
	6-letter (n=6)		1(16.67)	6(100)	0(0)
			χ^2= 6.22, p = 0.10	χ^2= 0, p = 1	
	PALPA 35: Spelling sound regularity reading (N= 60)				

# correct, % correct	18(30)	47(78.33)	1(1.67)
Regular (n=30)	11(36.67)	28(93.33)	0(0)
Exception (n=30)	7(23.33)	19(63.33)	1(3.33)
	χ^2= 2.98, p =0.08	χ^2= 7.95, p =0.04	
PALPA 31: Imageability reading (N=80)			
# correct, % correct	24(30)	74(92.5)	4(5)
High imageability (n= 40)	18(45)	39(97.5)	3(7.5)
Low imageability (n= 40)	6(15)	35(87.5)	1(2.5)
	χ^2= 8.57, p =0.003	χ^2= 1.62, p =0.20	

Reading aloud

Stimuli, number correct and % correct	AP02	AP03	AP05	AP07
PALPA 31: Frequency reading (N=80)				
# correct, % correct		24(30)	74(92.5)	4(5)
High frequency (n = 40)		11(27.5)	38(95)	4(10)
Low frequency (n = 40)		13(32.5)	36(90)	0(0)
		χ^2= 0.23, p =0.62	χ^2= 0.18, p =0.67	
PALPA 32: Grammatical class reading (N =80)				
# correct, % correct		39(48.75)	72(90)	
Nouns (n =20)		7(34)	18(90)	
Adjectives (n=20)		9(45)	18(90)	
Verbs (n =20)		13(65)	20(100)	
Functors (n=20)		10(50)	16(80)	
		χ^2= 6.92, p=0.07	χ^2= 0.28, p =0.96	
PALPA 36: Non-word reading (N=24)				
# correct, % correct		14(58.33)	18(75)	
3-letter (n=6)		5(83.33)	5(83.33)	
4-letter (n=6)		4(66.67)	5(83.33)	
5-letter (n=6)		4(66.67)	5(83.33)	
6-letter (n=6)		1(16.67)	3(50)	
		χ^2= 3.42, p =0.33	χ^2= 0.31, p =0.95	

Table 5.12

Performance of participants on reading aloud tasks in Kannada.

Stimuli (#correct, % correct)	AP03
RAP-K (N= 120)	**# correct (% correct)**
Words (60)	17(28.33)
Non-words (60)	19(31.67)
	χ^2= 0.15, p=0.69
Simple words (CVCVCV) (N=40)	**# correct (% correct)**
Words (20)	10(50)
non-words (20)	9(45)
	χ^2= 0.1, p =0.75
Geminates (N=20)	**# correct (% correct)**
Words (20)	3(15)
non-words (20)	2(10)
Polysyllabic (N=20)	**# correct (% correct)**
Words (10)	1(10)
non-words (10)	3(30)
Arka (N=20)	**# correct (% correct)**
Words (10)	0
non-words (10)	0
Anuswara (N=20)	**# correct (% correct)**
Words (10)	3(30)
non-words (10)	5(50)

Table 5.13

Error profile of BPWA on non-word repetition and reading aloud tasks from subtests of PALPA

Error distribution by subtests of PALPA (#, proportion of errors)	AP02	AP03	AP05	AP07
PALPA 8: Non-word repetition (N=30)				
Total errors (#, proportion of errors)	8(0.26)	29(0.96)	12(0.40)	26(0.86)
Semantic	0	0	0	0
Letter by letter reading	0	0	0	0
visually related non-word	3(0.37)	23(0.79)	9(0.75)	13(0.50)
visually related real word	0	0	0	0
Unrelated real word	0	1(0.03)	0	0
visually unrelated non-word	0	0	0	8(0.30)
Lexicalisation	5(0.62)	5(0.17)	3(0.25)	0
Regularisation	0	0	0	0
Cross-linguitic translational equivalent	0	0	0	0
Cross-linguistic	0	0	0	0
No response	0	0	0	5(0.19)
PALPA 29: Word length reading (N=24)				
Total errors (#, proportion of errors)		9 (0.37)	0	20(0.83)
Semantic		0	0	1(0.05)
Letter by letter reading		2(0.22)	0	0
visually related non-word		6(0.66)	0	0
visually related real word		1(0.11)	0	1(0.05)
Unrelated real word		0	0	0
visually unrelated non-word		0	0	0
Lexicalisation		0	0	0
Regularisation		0	0	0
Cross-linguistic translational equivalent		0	0	1(0.05)
Cross-linguistic		0	0	0
No response		0	0	17(0.85)
PALPA 35: Spelling sound regularity reading (N= 60)				
Total errors (#, proportion of errors)		42(0.70)	13(0.21)	59(0.98)
Semantic		0	0	0
Letter by letter reading		6(0.14)	0	0
visually related non-word		18(0.42)	4(0.30)	0
visually related real word		9(0.21)	2(0.15)	1(0.01)
Unrelated real word		2(0.04)	0	0
visually unrelated non-word		0	0	0
Lexicalisation		0	0	0
Regularisation		7(0.16)	7(0.53)	1(0.01)
Cross-linguistic translational equivalent		0	0	0
Cross-linguistic		0	0	0
No response		0	0	57(0.96)

Error distribution by subtests of PALPA (#, proportion of errors)	AP02	AP03	AP05	AP07
PALPA 31: Imageability and frequency reading (N=120)				
Total errors (#, proportion of errors)		56(0.46)	6(0.05)	76(0.63)
Semantic		1(0.017)	0	4(0.05)
Letter by letter reading		9(0.16)	0	0
visually related non-word		34(0.60)	5(0.83)	0
visually related real word		6(0.10)	1(0.16)	1(0.013)
Unrelated real word		2(0.03)	0	0
visually unrelated non-word		4(0.07)	0	0
Lexicalisation		0	0	0
Regularisation		0	0	0
Cross-linguistic translational equivalent		0	0	2(0.02)
Cross-linguistic		0	0	2(0.02)
No response		0	0	67(0.88)
PALPA 32: Grammatical class reading (N =80)				
Total errors (#, proportion of errors)		**41(0.51)**	**7(0.08)**	
Semantic		0	0	
Letter by letter reading		6(0.14)	0	
visually related non-word		22(0.53)	3(0.42)	
visually related real word		9(0.21)	3(0.42)	
Unrelated real word		1(0.02)	1(0.14)	
visually unrelated non-word		3(0.07)	0	
Lexicalisation		0	0	
Regularisation		0	0	
Cross-linguistic translational equivalent		0	0	
Cross-linguistic		0	0	
No response		0	0	
PALPA 36: Non-word reading (N=24)				
Total errors (#, proportion of errors)		**10(0.41)**	**6(0.25)**	
Semantic		0	0	
Letter by letter reading		0	0	
visually related non-word		6(0.60)	3(0.50)	
visually related real word		0	0	
Unrelated real word		0	0	
visually unrelated non-word		0	0	
Lexicalisation		4(0.40)	3(0.50)	
Regularisation		0	0	
Cross-linguistic translational equivalent		0	0	
Cross-linguistic		0	0	
No response		0	0	

*Shaded region indicates tasks participants were unable to perform.

5.5.1 Performance of AP02 on experimental tasks

AP02 was a BPWA with Kannada as his native language and English as his second language. Pre-stroke, he had a greater proficiency in English compared to Kannada, but used Kannada more frequently compared to English. Post-stroke this changed, with a higher proficiency in Kannada compared to English and usage of both the languages were limited owing to his language impairment. The reading proficiency was similar in both the languages (Kannada: 4, English: 5.5) prior to the stroke, whereas post-stroke reading was the most affected (Kannada: 1.75; English: 1). He was diagnosed with Broca's aphasia in both the languages.

On the spoken word picture matching task, AP02 produced 80% correct responses. He was unable to perform the written word picture matching task. AP02's performance on all of the phonological processing tasks were considerably impaired. He was able to discriminate letters in English with 65% accuracy and was 64% accurate on legality decision task with a higher percentage of words correctly identified compared to non-words (words: 83%; non-words: 50%). He was unable to perform the visual lexical decision task in English. However, he was 73% accurate on the non-word repetition task and there was a significant difference in performance based on syllable length (χ^2= 6.5, p = 0.03) with higher accuracy on 3-syllable non-words (100%) compared to 1-syllable non-words (40%). He made 8 errors on non-word repetition, out of which 0.65 proportion of errors were lexicalisation errors and 0.37 proportion were visually related non-word errors (See table 5.13).

AP02 was unable to perform any of the reading aloud tasks in English or Kannada. It was observed on informal screening that he was unable to identify the alphabets of Kannada language.

5.5.2 Performance of AP03 on experimental tasks

AP03 was a multilingual pre-stroke, whose native language was Telugu and second language were English; apart from that he was able to communicate in both Kannada and Hindi on a regular basis. Prior to the stroke he had a higher proficiency in Kannada and Telugu compared to English. Post-stroke, his language proficiency declined across all the languages and modalities with the reading and writing proficiency being most affected (Kannada/Telugu:2; English:3). Additionally, AP03 preferred using Hindi for communication and therefore, the WAB assessment was carried out in Hindi. He was diagnosed with Broca's aphasia in both Hindi and English. He was unable to read in Hindi, and still had some preserved reading abilities in Kannada and English, therefore profiling of his reading abilities were carried out in Kannada and English.

AP03 performed similarly on both the spoken word picture matching and written word picture matching tasks with 85% correct responses. AP03 performed the letter discrimination task in English with 90% accuracy. On the legality decision task, he was 93% accurate with higher accuracy on non-words (100%) than words (97%). On the visual lexical decision task, he performed poorly with 64% correct responses. There was also a significant effect of lexicality (χ^2= 7.5, p = 0.006) with higher number of correct responses on words than non-words. He performed very poorly on non-word repetition task (3%). He produced 29 errors on non-word repetition, with the proportion of errors being visually related non-words (0.79), lexicalisation (0.17) and unrelated real word errors (0.03).

On word length reading, AP03 read aloud 63% correctly and there was no significant effect of word length (χ^2= 6.22, p = 0.10). He made 9 errors on word length reading, out of which 0.66 proportion were visually related non-word errors ,0.22 proportion of errors were letter by letter reading errors, and 0.11 proportion were visually related real word errors. (See table 5.13). On spelling sound regularity reading, he read aloud with 30% accuracy and there was no significant effect of regularity (χ^2= 2.98, p = 0.08). The error profile indicates that out of the 42 errors made, 0.42 proportion of errors were visually related non-words, 0.21 were visually related real words, 0.16 were regularisation errors, 0.14 of letter by letter reading, 0.04 of unrelated real words.

On imageability and frequency reading aloud, AP03 was able to read aloud with 30% accuracy and there was a significant effect of imageability (χ^2= 8.57, p = 0.003) with greater accuracy on high imageable words compared to low imageable words. The proportion of errors were visually related non-words (0.60), letter by letter reading (0.16), visually related real words (0.10), visually unrelated non-words (0.07), unrelated real words (0.03) and semantic (0.02).

On grammatical class reading, he read aloud 49% correctly, but there was no significant effect of grammaticality (χ^2= 6.92, p = 0.07). The proportion of errors were distributed across visually related non-words (0.53), visually related real words (0.21), letter by letter reading (0.14), visually unrelated non-words (0.07) and unrelated real words (0.02).

On non-word reading, he read aloud with 58% accuracy with no significant effect of letter length (χ^2= 3.42, p = 0.33). Out of 10 errors, major proportion of errors were visually related non-words (0.60) followed by lexicalisation errors (0.40).

AP03 performed poorly on the reading aloud task in Kannada. Overall, AP03 was able to read aloud non-words with a higher accuracy compared to words (non-words: 32%; words: 28%), but the difference in performance did not reach a statistical significance. On simple words (CVCVCV), he was able to read aloud words with greater accuracy compared to non-words (words: 50%; non-words: 45%). On geminates, the performance was considerably affected with AP03 being able to read aloud correctly only 15% of the words and 10% of non-words. The performance on polysyllabic words was also considerably reduced with 10% accuracy on words and 30% accuracy on non-words. On measure of regularity (arka and anuswara), he was unable to read aloud words from the arka category and read aloud words in anuswara category with 30% accuracy and non-words with 50% accuracy.

5.5.3 Performance of AP05 on experimental tasks

AP05 was a multilingual pre-stroke, whose native language was Tamil and second language was English; he was raised in a Hindi speaking environment. His schooling was also in Hindi and English. Prior to the stroke he was a balanced bilingual with similar proficiency in both languages (Hindi: 7; English:6.5). Post-stroke, his language proficiency was largely affected across both languages and modalities with limited reading and writing proficiency (Hindi: 3.5; English:3.75). He was diagnosed with Anomic aphasia in both Hindi and English.

AP05 performed similarly on both the spoken word picture matching and written word picture matching tasks with 77.5% and 72.5% correct responses respectively. On letter discrimination task, AP05 performed with 97% accuracy. On the legality decision task, he was 82.54% accurate with higher accuracy on words (93%) than non-words (80%). On the visual lexical decision task, he performed poorly with 68% correct responses. There was a significant effect of lexicality (χ^2= 4.02, p = 0.04) with higher number of correct responses on non-words compared to words. On the non-word repetition task, he was able to perform with 60% accuracy and there was a significant effect of syllable length (χ^2= 10.83, p = 0.02) with higher accuracy on longer syllable non-words compared to shorter syllable non-words. He produced 12 errors on non-word repetition, with a major proportion of errors being visually related non-words (0.75) followed by lexicalisation errors (0.25).

On word length reading, AP05 was able to read aloud with 100% accuracy.
On spelling sound regularity reading, he read aloud with 78% accuracy and there was a significant effect of regularity (χ^2= 7.95, p = 0.04). He produced 13 errors, majority of it being regularisation errors (0.5) followed by visually related non-words (0.30) and visually related real words (0.15). On imageability and frequency reading, AP05 was able to read aloud with 92% accuracy and there was no significant effect of imageability or frequency. He produced only 6 errors, a large proportion of which were visually related non-words (0.83) followed by visually related real words (0.16).

On grammatical class reading, he read aloud 90% of the words correctly and there was no significant effect of grammaticality (χ^2= 0.28, p = 0.95). Out of the 7 errors, the proportion of visually related non-words and visually related real words were 0.42, followed by unrelated real words (0.14). On non-word reading, he read aloud with 75% accuracy with no significant effect of letter length (χ^2= 0.31, p = 0.95). He produced 6 errors half of which were visually related non-words (0.50) and half of which were lexicalisation errors (0.50).
He was 100% accurate in reading aloud word stimuli in Hindi.

5.5.4 Performance of AP07 on experimental tasks

AP07 was a BPWA, whose native language was Kannada and second language was English. Prior to the stroke he was a balanced bilingual with similar proficiency in both languages (Kannada: 7; English:6). Post-stroke, his language proficiency was largely affected in both languages with the highest impact on reading and writing (Kannada: 2; English:1.5). He was diagnosed with Broca's aphasia in Kannada and could not be tested in English.

On spoken word picture matching, AP07 performed with 57% accuracy and on written word picture matching tasks with 65% accuracy. On letter discrimination task, AP07 performed with 90% accuracy. He was unable to perform the legality decision and visual decision task. On the non-word repetition task, he was able to perform with 13% accuracy. He produced 26 errors on non-word repetition, with the proportion of errors being visually related non-words (0.50), visually unrelated non-words (0.30) and no responses (0.19).

On word length reading, AP07 was able to read aloud with 17% accuracy. He produced 20 errors, a large proportion of which were no responses (0.85) followed by semantic (0.05), visually related real word (0.05) and cross-linguistic translational equivalent (0.05).

On spelling sound regularity reading, he performed poorly and read aloud with 2% accuracy. He produced 59 errors, a significant proportion of the errors were no responses (0.96) followed by visually related real word (0.01) and regularisation errors (0.01). On imageability and frequency reading, AP07 was able to read aloud with 5% accuracy. Out of the 76 errors, 0.88 proportion of the errors were no responses, followed by semantic (0.05), cross-linguistic (0.02) and cross-linguistic translational equivalent (0.02) and visually related real word (0.01). He was unable to read aloud the words in grammatical class reading and non-word reading. On informal screening, AP07 was able to identify some alphabets of Kannada, but was unable to read aloud at word level in Kannada.

5.6 Discussion

5.6.1 Summary of findings

In this study we report the reading difficulties exhibited by 4 bi-literate bilingual persons with aphasia. We aimed to profile and characterise the reading abilities in both languages –English (alphabetic script) and Kannada/Hindi (syllabic script). We investigated whether script differences would impact the manifestation of acquired dyslexia in the two languages. The results reveal unique differences of reading characteristics in the two languages of the four BPWA. Semantic processing in English as measured by both spoken and written word picture matching were affected in all the four participants. While AP03 and AP05 were able to read at word level in both languages, AP02's reading was severely affected and exhibited alexia in both Kannada and English Similarly, AP07 was able to read some familiar words in English, but had severe difficulty reading aloud in both Kannada and English characterising the reading impairment as alexia in both languages. Alexia has been referred to as a total loss of reading abilities (Karanth, 1981). We have made an attempt to classify and draw conclusions from the reading characteristics exhibited based on the dual-route cascaded model of reading aloud (Cotheart, 2001). We have used the pattern of performance mentioned in section 5.3.1 to profile and characterise the type of dyslexia (See Table 5.14). The details of the findings from the case series on the experimental reading tasks in English and Kannada/Hindi is presented in Table 5.15.

Table 5.14

Pattern of performance for profiling the type of dyslexia

Performance	Alexia	Deep Dyslexia	Surface Dyslexia	Phonological Dyslexia
Nonword reading	Impaired	Impaired	Unimpaired	Impaired
Regularity effects in reading aloud	Impaired	Present	Absent	Present
Imageability effects in reading aloud	Impaired	Yes	No	Yes (possibly)
Grammatical class effects in reading aloud	Impaired	Yes	No	Yes (possibly)
Semantic errors in reading aloud	Impaired	Yes	No	No

Table 5.15

Summary of findings from reading tasks in English and Kannada/Hindi

English Reading	AP02	AP03	AP05	AP07
Letter discrimination	Affected	Unaffected	Unaffected	Unaffected
% Accuracy	65	90	96	90
Legality decision (word vs. non-word)	Affected (non-words>words)	Unaffected	Affected (non-words>words)	CNP
% Accuracy	63.5	93.6	82.5	
Visual lexical decision (word vs. non-word)	CNP	Affected (non-words>words)	Affected (non-words>words)	CNP
% Accuracy		63.5	68.25	
Spoken word-picture matching	Affected	Affected	Affected	Affected
% Accuracy	80	85	77	57.5
Written word-picture matching	CNP	Affected	Affected	Affected
% Accuracy		85	72.5	65
Non-word repetition	Affected	Severely Affected	Affected	Severely Affected
% Accuracy	73	3.3	60	13
Effect of imageability	CNP	Present (HI>LI)	Absent	Very poor performance
Effect of frequency		Absent	Absent	Very poor performance
Effect of regularity		Absent	Present (Regular>irregular)	Very poor performance
Effect of word length		Absent	Absent	Very poor performance
Effect of grammatical class		Absent	Absent	CNP
Non-word reading (varying in letter length)		Poor performance	Poor performance	CNP
Kannada Reading aloud	Unable to identify letters		No reading difficulty in Hindi at word-level.	Unable to read aloud
Simple words (words vs. non-words)		Affected (non-words>words)		
Geminates (words vs. non-words)		Severely Affected		
Polysyllabic (words vs. non-words)		Severely Affected		
Regularity				
Arka		Severely Affected		
Anuswara		Severely Affected		
Type of dyslexia	Alexia in both languages	English: Phonological dyslexia Kannada: Alexia	English: Phonological dyslexia	Alexia in both languages.

5.6.1 Profiling and Characterisation of Acquired dyslexia

The current case series addresses the issue of manifestation and classification of acquired dyslexia in bi-literate bilinguals with aphasia in languages having an alphabetic script (English) and syllabic script (Kannada/Hindi).

5.6.1.1 Reading characteristics of AP02. AP02 was pre-morbidly a Kannada-English bi-literate bilingual, who exhibited broca's aphasia in both languages. In English, his letter discrimination, legality decision task and lexical decision task were affected, suggesting that rudimentary word processing abilities are impaired or impairment at the level of orthographic analyses or orthographic input lexicon. He showed poor performance on spoken word-picture matching task and was unable to perform the written word-picture matching task which is reflective of a semantic deficit. The performance on non-word repetition was affected with a significant proportion of lexicalisation errors and visually related non-words. However, he was unable to read aloud in both English and Kannada, which means that there was a severe impairment in reading abilities in both languages. Based on the pattern of performance in Table 5.14, all of the parameters listed are impaired in AP02. Therefore, we can classify the total loss of reading abilities in both languages as alexia.

5.6.1.2 Reading characteristics of AP03. AP03 was a multilingual speaking Telugu, Kannada, Hindi and English prior to stroke. He was diagnosed with Broca's aphasia in Hindi and English. However, he was unable to read in Hindi, Telugu and Kannada share some script similarities and he had some preserved reading abilities in Kannada and English. His letter discrimination and legality decision task abilities were unaffected, suggesting a relatively intact rudimentary word processing ability. However, he exhibited poor performance on visual lexical decision task (with spelling-sound regularity). His performance on spoken word picture matching and written word picture matching were considerably affected implying a damage to the semantic system. His performance on non-word repetition was impaired to a large extent with predominantly visually related non-word errors and lexicalisation errors. On reading aloud in English, there was an effect of imageability and there was a trend towards regularity effect. There were no effects of word length or grammatical class. He performed very poorly on non-word repetition. A majority of errors in reading were visual errors (visually related non-words, visually related real words, visually unrelated real words and lexicalization errors. The pattern of performance for AP03 seems to indicate an impairment of the orthography-phoneme conversion (sub-lexical route) and can be characterised as phonological dyslexia in English (See Table 5.16).

AP03 had some preserved reading abilities in Kannada, he was able to recognise alphabets and read simple words, however performance on geminates and polysyllabic words were severely affected. Reading of arka and anuswara (which is a measure of regularity in Kannada) were also severely affected. The errors in reading were mostly script related non-words (Ratnavalli, 2002) which were visual in nature. Since, his reading in Kannada was severely impaired we categorise the reading impairment exhibited by AP03 as alexia.

Table 5.16

Pattern of performance exhibited by AP03

Performance	Alexia	Deep Dyslexia	Surface Dyslexia	Phonological Dyslexia
Nonword reading	Impaired	Impaired	Unimpaired	**Impaired**
Regularity effects in reading aloud	Impaired	Present	Absent	**Present (Marginal)**
Imageability effects in reading aloud	Impaired	Yes	No	**Yes**
Grammatical class effects in reading aloud	Impaired	Yes	No	**Yes (Marginal)**
Semantic errors in reading aloud	Impaired	Yes	No	**No**

5.6.1.3 Reading characteristics of AP05. AP05 was pre-morbidly a multilingual who was fluent in Tamil, Hindi and English. He was diagnosed with Anomic aphasia in Hindi and English. In English, his letter discrimination ability was relatively intact. However, his performance on legality decision and lexical decision was affected with the performance being better on words compared to non-words. His performance on spoken word picture matching and written word picture matching was notably affected. This poor performance on legality decision, lexical decision, spoken word and written word picture matching task implies damage to the orthographic input lexicon. He also performed poorly on non-word repetition with a significant proportion of the errors being visually related non-words and lexicalisation errors.

Table 5.17

Pattern of performance exhibited by AP05.

Performance	Alexia	Deep Dyslexia	Surface Dyslexia	Phonological Dyslexia
Nonword reading	Impaired	Impaired	Unimpaired	**Impaired**
Regularity effects in reading aloud	Impaired	Present	Absent	**Present**
Imageability effects in reading aloud	Impaired	Yes	No	**Absent**
Grammatical class effects in reading aloud	Impaired	Yes	No	**Absent**
Semantic errors in reading aloud	Impaired	Yes	No	**No**

On oral reading tasks in English, there was no effect of imageability, frequency, grammatical class or word length, but there was a significant effect of regularity, with relatively preserved reading of regular words and impaired irregular words with a major portion of errors being regularisation errors followed by visually related non-words and real words. There was a considerable impairment in reading non-words with lexicalization errors. Based on the above features of reading errors and the pattern of performance of AP05 (See Table 5.17), we can classify the reading impairment exhibited by AP05 in English as phonological dyslexia. He had no difficulty in reading aloud in Hindi at word level as tested using stimuli from Bilingual aphasia test (BAT), but the absence of a comprehensive reading test battery in Hindi does not allow us to come to any conclusions regarding his reading abilities in Hindi.

5.6.1.4 Reading characteristics of AP07 AP07 was a Kannada-English bilingual pre-stroke who was diagnosed with Broca's aphasia in Kannada. He was unable to perform WAB in English. His reading abilities in both English and Kannada were severely affected. His letter discrimination ability is English was unaffected, however he was unable to perform the legality decision and lexical decision task in English which suggests that access to orthographic input lexicon is severely affected. He performed poorly on both spoken word picture matching and written word picture matching which indicates an impairment of the semantic system. His non-word repetition ability was severely affected, and errors were mostly visually related non-words and real words. On reading aloud tasks in English, his performance was severely affected with absence of responses for grammatical class reading and non-word reading. A significant proportion of his errors were no responses and very few semantic and cross-linguistic errors. He was able to identify very few letters in Kannada and had a total loss of reading ability in Kannada. Based on the pattern of performance in Table 5.14, all of the parameters listed are impaired in AP07, therefore, we can classify the total loss of reading abilities in both languages as alexia.

5.6.3 Conclusions

It is a one of a kind study that attempts to profile reading impairments in bi-scriptal bilinguals in specific Indian language groups. This study contributes to the current body of research that facilitates better assessment and intervention of bi-scriptal bilingual BPWA. Overall, our results suggest that there is a script related difference in the manifestation of dyslexia in line with previous work on bi-scriptal BPWA (Sasanuma, 1980; Eng & Obler, 2002; Raman & Weekes, 2003,2005; Weekes et al., 2007; Senaha & Parente, 2012; Karanth, 1981; Ratnavalli et al, 2000).

5.6.4 Limitations of our study

In general, as two of our BPWA (AP02 and AP07) had severe reading impairments in English and Kannada, we diagnosed them with alexia (Ratnavalli et al, 2000; Karanth, 1981; 2002) in both languages. Two other BPWA (AP03 and AP05) exhibited features of phonological dyslexia in the alphabetic English. AP03's reading Kannada was significantly poor therefore, he was diagnosed with alexia in Kannada. On the other hand, AP05 was able to read aloud accurately in Hindi at the word level, but the stimuli were not sensitive enough to tap into variables such as syllable length, imageability, frequency and regularity. Therefore, it is difficult to draw conclusions regarding reading impairment in Hindi.

Although we attempted to classify the reading abilities in both the alphabetic and syllabic languages based on the dual route cascaded model, none of our BPWA, had enough reading abilities in the syllabic languages (near total loss of reading ability) except AP05 making it difficult to adapt the model of reading aloud to Kannada/Hindi.

5.6.4.1 Recruitment problems Recruitment of BPWA was aggravated by the need to have a homogenous group (same two language bilinguals) and the lack of institutional support in identifying such BPWA. This further amplified the time constraint on me owing to which only a few participants could be recruited (7 BPWA). Within these, we had to exclude three because of the severity of aphasia (global aphasia). Consonant to the problem of homogeneity was the multilingual nature of participants having different L1 (Telugu, Tamil, Hindi, Kannada) and variance in reading proficiency.

5.6.4.2 Lack of parallel material in Indian languages for testing The study was impacted by the lack of a parallel test stimuli that mirrors PALPA in Indian languages. PALPA in English accounts for effects of imageability, frequency, regularity, word length and non-word reading. The lack of reliable published and consequently usable materials significantly limited the scope of our study. Access to institutionally authorised material that could be regarded as an alternative in Indian languages was also denied.

5.6.5 Future directions

India is a predominantly multilingual country. The major language families in India include Indo – Aryan (74.3%), Dravidian (23.9%), Austro – Asiatic (1.2%) and Tibeto – Burman (0.6%). Some languages have scripts while many do not have. As per the 2001 census of India, approximately 25% of the total population are bilinguals in India which is growing even further. There is an urgent need to develop and disseminate test materials to tap into the reading impairments in Indian languages. Consequent to such development and dissemination, we also need to have large scale studies that profile and characterise the reading impairments in bi-scriptal bilingual Indian population. This will in-turn facilitate the characterisation of specific script to language combinations among bilinguals (Kannada-English; Tamil-English) which can then be used to derive/adapt models of reading among bilinguals.

All of these Indian languages have scripts that have varying scriptal differences with English. Some languages such as Tamil have less transparent orthographies as compared to Kannada which has a very transparent orthography. In this sense, Kannada is further away from English (in terms of script) than Tamil. Consequently, bilinguals speaking unique combinations of these languages need to be assessed to understand how reading difficulties manifest in both language combinations (Kannada-English, Tamil-English). This would immensely benefit assessment and treatment of bilinguals with neurological impairment.

Chapter 6 Summary and Conclusions

6.1 Overall summary

The overarching goal of our research was to characterize the effect of bi-literacy on bilingual healthy adults and bilingual neurologically impaired adults (BPWA). The current research was divided into Phase I (Chapters 2-4) and Phase II (Chapter 5). In Phase I, we examined the effect of PE on oral language production and comprehension (Chapter 2), narrative production (Chapter 3) and executive functions (Chapter 4). We recruited bi-literate bilinguals belonging to the South Indian diaspora (speaking Tamil, Telugu, Kannada and Malayalam in addition to English) residing in the UK. Within this sample we measured bi-literacy both subjectively (self-report of reading and writing usage from participants in different contexts such as at work, home, formal and informal), frequency of reading and objectively (using a composite numeric score based on performance of these participants on grammaticality judgement and sentence verification tasks, we have called the measure print exposure (PE). The sample (34 participants) were matched for years of education, age and gender and divided based on their exposure to print into a group of high PE (HPE, 22 participants) and low PE (LPE, 12 participants). In addition to this we profiled the bilingualism variables such as proficiency, usage and dominance in both languages. The participants performed oral language production tasks (verbal fluency, word and non- word production), comprehension tasks (synonymy triplets and sentence comprehension), narrative production task and executive function tasks or measures (spatial Stroop, Flanker, N –back and colour-shape tasks).

In phase II, we investigated the consequences of bi-literacy on a neurologically impaired population and specifically characterized the manifestation of reading difficulties at single word level in both languages of a BPWA. We recruited BPWA in the South Indian state of Karnataka in India. Participants were bi-literate bilinguals on one alphabetic language (English) and one alpha-syllabic language (Kannada/Hindi) pre-stroke. Within this population, we profiled, characterized and diagnosed the reading difficulty for BPWA in both languages (Chapter 5). We documented the pre- and post-stroke bilingualism variables. We conducted a case series analysis where BPWA performed a series of oral reading tasks in English and Kannada/Hindi.

6.2 Review and contributions of this research.

In this section, we will summarize and discuss the results of the preceding chapters, and the implications of this study to the clinical and theoretical research on bi-literate bilinguals. We will end this chapter with a discussion of limitations of the current project and suggested future directions. Table 6.1 summarizes our findings from both Phase I and Phase II of our study.

Table 6.1

Summary of results from the experimental chapters

Chapter 2. Impact of print exposure on oral language production and comprehension in bi-literate bilingual healthy adults.		
Specific research questions	**Methods**	**Results**
• To determine the differences in oral language production tasks (verbal fluency and word and non-word repetition) and comprehension measures (synonymy triplets and sentence comprehension tasks) between HPE and LPE participants. • To investigate the relationship between print exposure in L2 and measures of oral language production and comprehension	*Participants*: A total of thirty-four neurologically healthy bi-literate bilingual adults in the age range of 25-55 years with varying levels of print exposure in their second language were recruited for the current study. *Objective measures of print exposure*: Grammaticality judgement and Sentence verification task *Language production tasks*: Verbal fluency tasks (semantic and letter); word & non-word repetition in English *Variables*: Quantitative: (number of correct responses, fluency difference score), Time-course (1st RT, sub-RT, initiation, slope), Qualitative (cluster size, number of switches); number of correct word and non-word repetition; Proportion of errors. *Comprehension measures:* Synonymy triplets and sentence comprehension in English *Variables:* % Accuracy. Error profile across various grammatical structures.	*Group Differences* *Language production tasks:* No significant impact of PE on language production but difference in pattern of error profile on word and non-word repetition with the LPE having higher percentage of errors on low imageability non-words. *Comprehension measures:* Individuals with HPE exhibited better comprehension as measured by the synonymy and sentence comprehension tasks than those with LPE. *Correlations* Significant positive correlation of semantic fluency (CR), switches total and non-word repetition with PE, Significant positive correlations of synonymy triplets and sentence comprehension tasks with PE.

Chapter 3. Impact of print exposure on narrative production in bi-literate bilingual healthy adults		
Specific research questions	**Methods**	**Results**
• To investigate the narrative characteristics in the L2 oral narratives of healthy bi-literate bilingual adults with HPE and LPE on the narrative production characteristics • To investigate correlations between print exposure in L2 with oral narrative production.	*Participants*: Same as Chapter 3 *Narrative task elicited using the Frog, where are you? picture book.* *Variables measured in the narrative task- utterance level measures, morpho-syntactic measures, lexical measures and repair measures*	*Group Differences* Utterance level: Total words uttered showed significant differences between HPE and LPE groups, with HPE uttering a greater number of total words *Morpho-syntactic:* Verbs per utterance were higher for the HPE group and group differences were also significant. *Lexical:* No significant differences were seen. *Repair:* Repair level measures showed fewer repetitions for the HPE group. *Correlations* Total words, verbs per utterance, TTR nouns, %adverbs showed a positive correlation with print exposure. %Grammatical errors, %present participle, % nouns and number of repetitions showed a negative correlation with PE.

Chapter 4. Impact of print exposure on executive functions in bi-literate bilingual healthy adults		
Specific research questions	**Methods**	**Results**
• To determine the differences in measures of inhibition (spatial Stroop and Flankers task), working memory (visual and auditory N-back) and task switching (colour-shape task), between HPE and LPE participants. • To determine the relationship between print exposure in L2, age and years of education with measures of inhibition, working memory and task switching.	*Participants*: Same as Chapter 2 *Executive function measures:* Spatial Stroop, Flanker, N-back (visual and auditory), and color-shape task *Variables*: Stroop effect (RT and accuracy), Conflict effect (RT and accuracy), D' score, and switch cost (RT and accuracy)	*Group Differences:* HPE showed significantly better working memory (higher d' scores) on auditory N-back task. *Correlations:* Significant positive correlation of N-back task (auditory 2-back) with print exposure, participant with higher print exposure had higher d' scores.

Chapter 5. Reading difficulties in bi-literate bilingual persons with aphasia (BPWA)		
Specific research questions	**Methods**	**Results**
To determine the type of dyslexia exhibited in both languages of BPWA and perform cross-linguistic comparison.	*Participants* A total of seven bi-scriptal bilingual persons with aphasia (BPWA) were recruited for the study, with the post- onset duration ranging from 4 months to 6 years 11 months. Four participants included for the study. *Variables* *English reading* Phonology: Letter discrimination, Legality decision, visual lexical decision and non-word repetition. Semantics: spoken word picture matching, written word picture matching. Reading aloud: effect of imageability, frequency, regularity, word length, grammatical class, and non-word reading. *Kannada reading* Simple words, geminates, polysyllabic words and special words (measuring regularity).	Out of the four BPWA, AP02 and AP07 had severe reading impairment in both languages and were characterized as having alexia in both languages. AP03 and AP05 exhibited characteristics of phonological dyslexia in English with individual differences. While AP03 exhibited alexia in Kannada, AP05 had no reading difficulty at word level in Hindi.

For Phase I, we performed two types of comparisons on our sample, first we divided the participants into two groups (HPE and LPE) based on the composite score (with z=0.0 as the cut-off) derived from our measure of PE. All participants with scores greater than the cut off were classified as HPE and the rest as LPE. The first comparison, therefore, was whether any group differences exist in any of the experimental tasks. The second comparison was whether there was a correlation between the composite score and the experimental tasks. Following are the key findings from this research:

1. **Impact of L2 print exposure on oral language production.**

We predicted that print exposure would have a positive impact on verbal fluency (direct impact on letter fluency and a relatively lesser impact on semantic fluency). We also predicted that HPE group would produce a greater number of correct words and non-words than LPE group on word and non-word repetition task. These predictions were not borne out; however, we found some subtle differences between the groups.

Based on the performance on verbal fluency, word and non-word repetition tasks, there was no obvious difference on the overall accuracy scores. However, contrary to expectation, semantic fluency (CR) showed a significant positive correlation with PE and this suggests that print exposure may be associated with improved semantics which is also evident from the findings of other semantic measures in our study namely synonymy triplets task and sentence comprehension task.

Switches total showed a significant positive correlation with print exposure. Switching requires strategic search of subcategories and cognitive flexibility to shift efficiently between subcategories (Da Silva, 2004) and dependent on more controlled processing than those required for clustering (Troyer, 2000; Troyer et al, 1997). It was also observed that, participants with HPE have produced a greater number of switches, which probably suggests that they have better cognitive flexibility.

The key findings of word and non-word repetition are that, there was a significant positive correlation between non-word repetition and PE but no significant group difference. This is in consonance with previous research by Petersson et al. (2000) and Kosmidis et al. (2006) on monolingual populations who have shown two groups with different literacy levels show significant differences in non-word repetition between the groups but not so in word repetition. Additionally, the error pattern on non-word repetition showed that LPE produced higher percentage of errors in comparison to HPE on low imageability non-words. Since the accuracy scores were at ceiling, perhaps probing into RT analyses would likely indicate differences in performance of word vs. non-word repetition.

2. Impact of L2 print exposure on semantic comprehension.

We expected no significant differences between the groups based on previous literature (Reis and Castro-Caldas,1997). However, the findings suggested otherwise. The findings showed significant group difference on the synonymy triplets task and sentence comprehension task (HPE more accurate than LPE). We draw support for these findings from children's literature and interpret this as a similar finding to Nation and Snowling (1998), where children with poor reading skills performed poorly on a synonymy judgement task. The sentence comprehension task used in our study is a listening task. Previous research (Hedrick & Cunningham, 1995; Proctor et al., 2005) have shown that bilingual children with higher reading scores performed better on listening comprehension tasks, and our results mirror these.

Our results showed that there was a positive correlation of print exposure with synonymy triplets and sentence comprehension and a significant difference between both groups. This suggests a strong link between print exposure and semantic processing. The findings on the semantic tasks have been consistent across comprehension (synonymy triplets task and sentence comprehension task) and production (semantic fluency) favouring HPE.

3. Impact of L2 print exposure on narrative production.

We hypothesised that HPE L2 oral narratives will have significantly greater number of utterances, more morpho-syntactically rich, more lexically diverse and have lesser repairs as compared to LPE L2 oral narratives and consequently significant positive correlations on all the narrative measures except % grammatical errors, number of repetitions and repairs (which will be negatively correlated).

On the Frog story narrative, there were significant group differences and significant correlations for all three variables (total words, verbs per utterance and the number of repetitions) which highlight that increased print exposure in L2 is associated with higher number of words in the narrative, higher verbs per utterance and fewer repetitions in L2 oral production.

The total words produced exhibit significant differences between the two groups and a significant positive correlation with PE. In theory, verbosity could behave as a richer utterance level measure. However, we have discussed why this is not so in section 3.7.1. The findings of higher verbs per utterance is in line with our finding of one of the tasks of comprehension (synonymy triplets task) where print exposure was associated with better verb comprehension compared to noun comprehension (Chapter 2). A sentence is considered grammatically incomplete without a verb; therefore, they are essential in sentence production and comprehension (Reyes & Thompson, 2012).

The findings of fewer repetitions with increased print exposure implies that the narratives were more fluent. This mirrors relationships known to exist between print exposure and verbal fluency with monolingual speakers (Cunningham & Stanovich, 1991) and provides evidence that print exposure impacts fluency in open utterance level tasks. Findings also suggest increase in L2 print exposure is associated with using- more words, fewer grammatical errors (in line with findings of Sparks in Dabrowska (2012), less present participle morphemes, more adverbs, fewer nouns, a more diverse range of nouns and fewer repetitions.

To sum, higher print exposure is associated with better narrative characteristics in terms of utterance level measures, more diversity of noun usage, higher percentage of adverbs, verbs per utterance and fewer repair measures.

4. Impact of L2 print exposure on non-verbal executive functions

Based on the literature we predicted that there will be a significant group differences between HPE and LPE; positive correlations between print exposure in L2 and performance measures of inhibition, working memory and task switching (i.e., Stroop effect, conflict effect, D-prime, switch cost).

Our findings suggest no significant group differences or correlations of print exposure in L2 with any of the executive function tasks, excepting auditory N-back which is a working memory measure. Higher print exposure was also associated with improved performance on the auditory 2-back condition. We could hypothesise that the better performance on this condition could be due to the task demanding higher working memory load. This is in line with our findings on the sentence comprehension task. This was an auditorily presented task where higher print exposure was associated with better accuracy score.

6.3 Conclusions

This study is a first-of-its-kind which investigated print exposure and various aspects of bi-literate bilingual adults on oral language production at word and sentence level (narrative production) and executive function measures in a holistic manner (integrating inhibitory control, working memory and task switching).

We conclude that print exposure in L2 has some association with oral language production tasks both at the word level and connected speech level. On the other hand, a strong relation seems to exist between comprehension measures and print exposure (in L2) in our study. With regard to the non-verbal executive functions, we conclude that no direct link between print exposure (in L2) and non-verbal executive function measures in bi-literate bilinguals is discernible excepting working memory.

Additionally, there seems to be a strong link between print exposure and semantic processing in our research. The findings on the semantic tasks have been consistent across comprehension (synonymy triplets task and sentence comprehension task) and production (semantic fluency) favouring HPE.

6.4 Significant contributions to literature of Phase I and future directions

This research contributes significantly to our understanding of oral language production (word and connected speech level), comprehension and executive functions in adult biliteracy. This study is a first of its kind in many respects and has some substantial limitations that are expected in its class of studies. It also has plenty of scope for exploratory next steps which can facilitate stronger affirmations of some of the findings. In this section, we will elaborate on the significant contributions that this research makes to the field of bi-literacy and bilingualism and we also elaborate on the limitations that pave the way for future studies.

1. Characterization of the populations

We have successfully measured language proficiency subjectively. The goal of such measurements was to tease apart the language proficiency in reading and writing. In order to achieve that, not only did we record (with self-assessment) language usage, dominance and proficiency with reading and writing separately but also documented the acquisition and frequency of reading and writing. This has resulted in a comprehensive questionnaire which catalogues and categorizes all these parameters for bi-literate bilingual healthy adults.

We also introduced print exposure (PE) as a measure of literacy combining scores of grammaticality judgment and sentence verification. This has proven to be a sensitive measure for evaluating the impact of print exposure on various tasks of oral language production (word and connected speech level), comprehension and executive functions.

Measurement of language proficiency and reading and writing skills in L1 has been done subjectively, since PE was objectively measured only in L2, the language proficiency and reading and writing skills in L1 was only matched (when selecting the two groups). This proficiency was based on self-report and hence has a tendency to be either over or underestimated. An objective measure of proficiency would allow for a more nuanced characterization of the sample. A future direction would be to make this an objective score based on an explicit test of performance. Following creation of such objective scores, an immediate next step would be to control for the bi-literacy, bilingual attributes measured by the questionnaire such as language proficiency and usage while grouping participants and perform similar analyses.

2. Type of populations

All the participants in our study are matched on education. Despite this, the impact of print exposure superseded the uniform impact of education. One of the limitations of this population was the non-uniformity in L1 (although the languages were from the same language family) leading to the probability of a bias in the data. To control for this bias, we suggest choosing participants with the same L1.

3. Exposure to L2.

All of the participants were Indian immigrants in the UK, hence their usage of English (L2) was very frequent and reportedly very proficient. However, in spite of this similarity the impact of print exposure superseded the effect of exposure to L2 which is evident from group differences in narratives and comprehension tasks.

4. Classification of groups

While print exposure in L2 is a robust measure to predict measures of oral language production and comprehension, it still has some intrinsic limitations. Firstly, composite score of PE only measures the print exposure in L2 and does not account for print exposure in L1 among participants. Secondly, division of the groups into HPE and LPE was based on an arbitrary cut-off. Since the cut-off was arbitrary, participants with scores very close to the cut-off were not accurately classified. A larger participant pool would allow us to classify them into larger number of groups. Participants who overlap between groups can be excluded thereby reducing the confusion of accurate grouping. In addition, a larger sample size with homogeneity in both L1 and L2 would also lend to more statistical measures such as regression and clustering.

5. Lack of parallel test material in L1 (the Indian native language of participants)

Phase I was significantly impaired by the absence of test material in L1 (the Indian native language of participants) for many of the tasks. In such absence it did not behove to measure PE in both L1 and L2, consequently only PE in L2 is considered, as test material was readily available in English. A possible next step in this direction would be a) To develop a composite PE score that combines PE in both L1 and L2, thus forming a holistic bilingual bi-literate PE score. b) Consequently, testing would have to be done separately in L1 and L2 to quantify the sensitivity of this composite PE in both L1 and L2. An unrelated, but strongly allied, development would be the development of test material for different L1-L2 combinations i.e Kannada-English, Tamil –English etc. which would develop complementary testing in both languages and hence accurately quantify the sensitivity of this composite PE.

6. Type of tasks

A specific limitation of the executive function measures reported in Chapter 4 were that they were all non-verbal measures of executive functions. Research on impact of PE in monolinguals have used verbal executive function measures. In our study, we have not included verbal executive function measures. An interesting study would be to repeat the same kind of experiment with both verbal and non-verbal executive function measures (See Calabria et al, 2011) which would inform whether there is a differential impact of PE on verbal and non-verbal executive function measures.

All of the tasks used in this research were behavioural tasks. Factors such as fatigue, practice trials, noise levels and distractions could have influenced the performance and testing. Perhaps, a more controlled and improvised method which could be used in the future could be to incorporate an eye tracking method or functional neuroimaging which could further help strengthen the findings.

6.5 Significant contributions to literature of Phase II and future directions

In phase II (Chapter 5), we aimed to profile and characterise the reading abilities in both languages – English (alphabetic script) and Kannada/Hindi (syllabic script) of 4 BPWA based on the dual-route cascaded model of reading aloud (Coltheart, 2001). We investigated whether script differences would impact the manifestation of acquired dyslexia in the two languages. The results reveal unique differences of reading characteristics in the two languages of the four BPWA. Key findings and contribution of this research to the literature are-

1. Type of dyslexia in two languages.

Our key findings suggest, two of our BPWA (AP02 and AP07) had severe reading impairments in English and Kannada, we diagnosed them with alexia (Ratnavalli et al, 2000; Karanth, 1981; 2002) in both languages. Two other BPWA (AP03 and AP05) exhibited features of phonological dyslexia in the alphabetic English. AP03's reading Kannada was significantly poor therefore, he was diagnosed with alexia in Kannada. On the other hand, AP05 was able to read aloud accurately in Hindi at the word level, but the stimuli was not sensitive enough to tap into variables such as syllable length, imageability, frequency and regularity. Therefore, it was difficult to draw conclusions regarding reading impairment in Hindi.

Previous research in Indian bilinguals has studied the neurologically impaired population as single case studies (Ratnavalli et al, 2000; Karanth, 1981; 2002) in the form of case reports on diagnostic language tests, not really delving into the different aspects of reading such as imageability, frequency and regularity in both languages. Our study is the first of its kind which studies neurologically impaired bilingual Indians (bi-literate pre-stroke) with languages employing two different scripts (alphabetic- English, alpha-syllabic- Hindi/Kannada) tapping into different aspects of reading profile in the two languages by borrowing from the literature such as Psycholinguistic Assessment of Language Processing in Aphasia (PALPA; Kay, Lesser & Coltheart, 1992) in English, reading subtests from Reading Acquisition Profile (RAP-K; Rao, 1997) in Kannada and words from Bilingual Aphasia test -Hindi (BAT; Paradis & Libben, 1987). This gives a much more comprehensive picture of the reading characteristics in both the languages.

2. Influence of various variables of bilingualism and usage

Profiling BPWA in Phase II involved adapting the language proficiency questionnaire developed in Phase I to profile both pre and post morbid language proficiency in BPWA. This showed both the strength and versatility of the questionnaire developed in Phase I. It also demonstrates the depth of probing of the questionnaire developed in Phase I.

6.6 Limitations and Future directions

1. **Unparallel tasks across the languages**

The study was impacted by the lack of a parallel test stimuli that mirrors PALPA in Indian languages. PALPA in English accounts for effects of imageability, frequency, regularity, word length and non-word reading. The lack of reliable published and consequently usable materials significantly limited the scope of our study. Access to institutionally authorised material that could be regarded as an alternative in Indian languages was also denied. Therefore, there is an urgent need to develop and disseminate test materials to tap into the reading impairments in Indian languages.

2. **Severity of impairment in participants recruited**

Although we attempted to classify the reading abilities in both the alphabetic and syllabic languages based on the dual route cascaded model, none of our BPWA, had enough reading abilities in the syllabic languages (near total loss of reading ability) except AP05 making it difficult to adapt the model of reading aloud to Kannada/Hindi. In future, studies could target at recruiting BPWA with graded severity levels, which in turn would help us make more nuanced classification of reading impairments in the two languages.

3. **Difficulty in recruitment**

Recruitment of BPWA was aggravated by the need to have a homogenous group (same two language bilinguals) and the lack of institutional support in identifying such BPWA. This further amplified the time constraint on me owing to which only a few participants could be recruited (7 BPWA). Within these, we had to exclude three because of the severity of aphasia (global aphasia). Consonant to the problem of homogeneity was the multilingual nature of participants having different L1 (Telugu, Tamil, Hindi, Kannada) and variance in reading proficiency.

4. **Reduced sample size and need for large-scale studies**

Firstly, the sample size was small owing to recruitment difficulties and scope of the PhD. We need to have large scale studies that profile and characterise the reading impairments in bi-scriptal bilingual Indian population. This will in-turn facilitate the characterisation of specific script to language combinations among bilinguals (Kannada-English; Tamil-English) which can then be used to derive/adapt models of reading aloud among bilinguals.

5. Varying script differences

All of these Indian languages have scripts that have varying scriptal differences with English. Some languages such as Tamil have less transparent orthographies as compared to Kannada which has a very transparent orthography. In this sense, Kannada is further away from English (in terms of script) than Tamil. Consequently, bilinguals speaking unique combinations of these languages need to be assessed to understand how reading difficulties manifest in both language combinations (Kannada-English, Tamil-English). This would immensely benefit assessment and treatment of bilinguals with neurological impairment.

In conclusion, our research has demonstrated that bi-literacy has some significant consequences for the healthy and the neurologically impaired population. Our research points to there being a cognitive-linguistic impact of bi-literacy where language seems to show a stronger impact than cognition for the healthy population. In the neurologically impaired population, our research provides a comprehensive profiling of reading abilities in BPWA in the Indian population. This research also provides plenty of scope for exploratory next steps which can facilitate stronger affirmations of some of the findings.

Appendices

Appendix 2.1: Raw values of participants on background measures (age, gender, years of education, occupation and L1)

Participant ID	Age	Gender	Years of education	Occupation	L1
High Print exposure					
PL0001	30	Male	22	Student	Kannada
PL0003	29	Female	21	Postdoctoral Researcher	Kannada
PL0008	34	Female	21	Postdoctoral Researcher	Malayalam
PL0009	33	Male	17	Student	Tamil
PL0010	35	Male	21	Lecturer	Tamil
PL0011	30	Female	16	Home maker	Tamil
PL0013	41	Male	17	Software Engineer	Tamil
PL0016	28	Male	16	construction manager	Tamil
PL0018	45	Female	16	Nurse	Malayalam
PL0020	25	Female	16	Software Engineer	Kannada
PL0021	28	Female	16	Student	Malayalam
PL0024	41	Female	18	Business Analyst	Malayalam
PL0025	38	Male	16	Regional Manager	Telugu
PL0026	31	Female	16	Nurse	Malayalam
PL0027	52	Male	21	Intellectual property Manager	Malayalam
PL0028	41	Female	15	Home maker	Malayalam
PL0029	27	Male	17	Web developer	Tamil
PL0030	29	Male	16	Student	Malayalam
PL0031	25	Male	17	Web Developer	Tamil
PL0034	41	Female	18	Tax Assistant	Tamil
PL0035	38	Female	18	Banking executive	Malayalam
PL0038	34	Female	18	Senior Insight Manager	Kannada
Low Print exposure					
PL0002	32	Female	17	Home maker	Kannada
PL0004	28	Male	16	Student	Kannada
PL0005	46	Male	17	Social Worker	Malayalam
PL0006	44	Female	15	Nurse	Malayalam
PL0007	24	Male	15	student	Telugu
PL0014	32	Female	17	Home maker	Tamil
PL0015	36	Female	17	saleswoman	Telugu
PL0017	46	Male	13	Pharmacy dispenser	Malayalam
PL0022	31	Female	16	Software Engineer	Kannada
PL0023	32	Female	16	Software Engineer	Kannada
PL0032	25	Male	17	Student	Tamil
PL0033	25	Male	17	Research Assistant	Tamil

Appendix 2.2: Language Background, Usage, Proficiency and Dominance Questionnaire

Demographic Data

1. Participant ID ___________
2. Age (in years): _________
3. Date of Birth: __________
4. Gender: Male/Female
5. Education (highest level attained): ___________
6. a) Country of Origin: ___________

   b) Country of Residence: __________
7. Hand preference: Left/Right
8. Occupation: ________

Language Background and History

9. How many languages do you understand and speak? List them below.

   ____

   ____

   ____

10. What is your native language (i.e., spoken at home from birth)?

    ____

11. At what **age** and how did you learn your L2, L3 and other languages?

	Age of L2	Age of L3	Age of L4
Formal (schooling, classroom instruction, work)	_____	_____	_____
Informal (interaction friends, neighbours, community gatherings)	_____	_____	_____
Both formal and informal	_____	_____	_____
Others (adult language classes, study in other states/cities)	_____	_____	_____

Educational History

12. We are interested to know your educational history and the language you learnt through education. This will help us to understand your reading and writing abilities. Please provide the following details (i.e., the age) when you learnt various languages, especially with regard to reading and writing.

Educational Details (Approximate Age)		Medium of instruction	When and how did you learn to **read**?			When and how did you learn to **write**?		
			L1	L2	L3	L1	L2	L3
Kindergarten (3-4years)								
Primary School	Class 1 (5-6years)	____	____	____	____	____	____	____
	Class 5 (9-10years)							
Secondary School	Class 8 (12-13years)	____	____	____	____	____	____	____
	Class 10 (14-15years)	____	____	____	____	____	____	____
	Class 12 (17-18years)							
Higher Education	Professional training (Diploma, IT, Skill training etc)	____	____	____	____	____	____	____
	Bachelors/equivalent	____	____	____	____	____	____	____
	Masters/equivalent	____	____	____	____	____	____	____
	PhD							

13. What is the educational qualification of your spouse/partner/someone you live with?

____

14. How often do you read books, newspapers, magazines etc in each of the languages?

L1: ☐ Daily ☐ Few times a week ☐ Weekly ☐ Monthly

L2: ☐ Daily ☐ Few times a week ☐ Weekly ☐ Monthly

L3: ☐ Daily ☐ Few times a week ☐ Weekly ☐ Monthly

Current Language Usage and Frequency of Usage

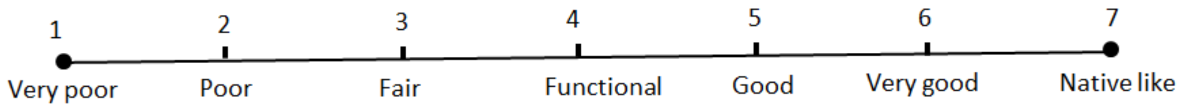
15. What languages and how frequently do you use these languages to communicate in the following situations?

1	2	3	4	5
Not at all	Rarely	Sometimes	Often	Very Often

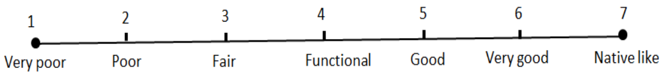
	L1 __________	L2 __________	L3 __________
a. At home (with family)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
b. At community gatherings	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
c. At social gatherings (with work colleagues)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
d. At work (with	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
e. With friends	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
f. Telecommunication (phone, Skype, chatting etc)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

Language Proficiency Rating

16. We are interested to know how comfortable you are in the languages that you know. Please circle the number which best represents your ability to communicate in each of the following situations.

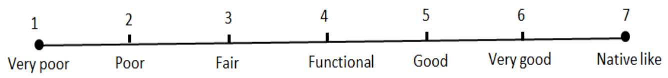


L1____________



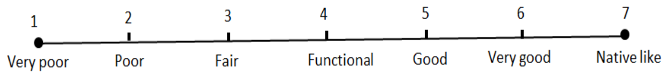
Speaking in casual conversations	1	2	3	4	5	6	7
Listening in casual conversation	1	2	3	4	5	6	7
Speaking in formal situations	1	2	3	4	5	6	7
Listening in formal situations	1	2	3	4	5	6	7
Reading formal texts (work papers, documents, newspapers, magazines etc)	1	2	3	4	5	6	7
Reading informal texts (text messages, letters, social media, emails etc)	1	2	3	4	5	6	7
Writing formal texts (articles, official letters/emails etc)	1	2	3	4	5	6	7
Writing informal texts (text messages, social media, emailing friends etc)	1	2	3	4	5	6	7

L2____________



Speaking in casual conversations	1	2	3	4	5	6	7
Listening in casual conversation	1	2	3	4	5	6	7
Speaking in formal situations	1	2	3	4	5	6	7
Listening in formal situations	1	2	3	4	5	6	7
Reading formal texts (work papers, documents, newspapers, magazines etc)	1	2	3	4	5	6	7
Reading informal texts (text messages, letters, social media, emails etc)	1	2	3	4	5	6	7
Writing formal texts (articles, official letters/emails etc)	1	2	3	4	5	6	7
Writing informal texts (text messages, social media, emailing friends etc)	1	2	3	4	5	6	7

L3______________



Speaking in casual conversations	1	2	3	4	5	6	7
Listening in casual conversation	1	2	3	4	5	6	7
Speaking in formal situations	1	2	3	4	5	6	7
Listening in formal situations	1	2	3	4	5	6	7
Reading formal texts (work papers, documents, newspapers, magazines etc)	1	2	3	4	5	6	7
Reading informal texts (text messages, letters, social media, emails etc)	1	2	3	4	5	6	7
Writing formal texts (articles, official letters/emails etc)	1	2	3	4	5	6	7
Writing informal texts (text messages, social media, emailing friends etc)	1	2	3	4	5	6	7

Bilingual Dominance Scale

- (Dunn & Fox Tree, 2009)

1 & 2. At what age did you first learn:-

L1 ______ L2 ______

Scoring:- 0-5 years= +5 ; 6-9years=+3 ; 10-15 years= +1; 16 and up= +0

3 & 4. At what age did you feel comfortable speaking this language? (If you still do not feel comfortable, please write 'not yet')

L1 _______ L2 _______

Scoring:- 0-5 years= +5 ; 6-9years=+3 ; 10-15 years= +1; 16 and up= +0; 'not yet'= +0

5. Which language do you predominantly use at home?

L1 ______ L2 ______ Both _____

Scoring:- a) If one language used at home= +5 for that language
b) If both the languages used at home= +3 for each language

6. When doing Math in your head (calculating such as multiplying 243x5), which language do you calculate the numbers in? _________

Scoring:- +3 for language used for Math ; +0 if both languages used.

7. If you have a foreign accent, which language(s) is it in? ___________________

Scoring:- a) If one language is listed, add +5 to the opposite language of the one listed.
b) If both languages are listed, add +3 to both languages.
c) If no language is listed, add nothing.

8. If you had to choose a language to use for the rest of your life, which language would it be? ____________

Scoring: - +2 for language chosen for retention.

9 & 10. How many years of schooling (primary school through University) did you have in:

L1 _____ L2 _____

Scoring: - 1-6 years= +1; 7 and more years= +2

11. Do you feel that you have lost any fluency in a particular language? _____
If yes, which one?_______
At what age? _________

Scoring: -3 in language with fluency loss; 0 if neither has lost fluency.

12. Which country/region do you currently live in? _________

Scoring: - +4 for predominant language of country/region of residence.

Appendix 2.3: Stimuli for grammaticality judgement task

Philadelphia Comprehension Battery (Saffran, Schwartz, Linebarger, Martin, & Bochetto, 1988)

Instructions: The participants were instructed to respond with a key press of letter 'm' if the sentence was grammatically correct or press 'z' when the sentence was grammatically incorrect.

Scoring: A score of one was given for accurate judgement of the task and a zero for an incorrect response. The maximum score that a participant could receive was 60.

Training set

1. Where did the woman faint?
2. The teacher was disliked the students
3. The man was helped by the clerk.
4. The man saw the letter his father.
5. The boy was believed to be a criminal.
6. The man lets his son help in the store.
7. Who was the man looking?
8. They had closed the windows.
9. The farmer should planting corn
10. They can suggested a restaurant
11. The children played baseball
12. The magazine published those articles

Block 1

1. Where did the woman faint?
2. The teacher was disliked the students
3. The man was helped by the clerk
4. He saw the letter his father
5. The boy was believed to be a criminal
6. The man lets his son help in the store
7. Who was the man looking?
8. I like that photograph my sister
9. The boy was carried by the man
10. That's who thought could win
11. The man was helped the clerk
12. What did the woman faint?
13. The car was followed by the truck
14. Why did the boy invite?
15. He saw the letter from his father

Block 2

16. I want you will go to the store now
17. Will you done the homework problem?
18. Where was the man looking?
19. Was the girl invited to the party?
20. Many was later her class
21. Why did the student argue?
22. Was the girl he invited to the party?
23. That's who I thought could win
24. Are the boys fixing the radio?
25. The boy was telephoned the girl
26. He forced the dog sit up
27. Frank thought was going to win
28. You promised to invite me to your party

29. The man allows his son fly the plane
30. I can smell the cookies baking

Block 3

31. The cupboard is full the groceries
32. Do you read the morning paper?
33. The teacher was disliked by the students
34. I like that photograph of my sister
35. Where did she put the book?
36. The boy was carried the man
37. Was the girl enjoying the show?
38. The cupboard is full of those groceries
39. He forced the dog to sit up
40. Why did she put the book?
41. We hope we can be finished by six o' clock.
42. The boy was telephoned by the girl
43. Who did the boy invite?
44. The child was angry his mother.
45. The man lets his son to help in the store

Block 4

46. I want you to go to the store now
47. Was the girl enjoy the show?
48. You promised would invite me to your party.
49. The car was followed the truck
50. Who did the student argue?
51. Will you do the homework problem?
52. I can smell the cookies to bake.
53. Do you reading the morning paper
54. Are the boys fix the radio?
55. The child was angry at his mother
56. We hope can be finished by six o' clock
57. Mary was late for her class
58. The boy was believed was a criminal.
59. The man allows his son to fly the plane.
60. Frank thought he was going to win.

Appendix 2.4: Sentence verification materials passages and sentences

(Adapted from Royer, Greene & Sinatra,1987)

Instructions: The participants were expected to read each passage and decide whether the information in the statements was already present in the passage they read (originals and paraphrases) or whether it was new information (meaning changes and distractors).

Scoring: A score of one was given if the correct option was chosen, the maximum score that could be obtained was 72.

Black Holes

You can see lots of things in the night sky with a telescope. But scientists believe there are some things in the sky that we will never see, even with the biggest telescope in the world.

That's because they're invisible. They're the mysterious dead stars called black holes. After billions of years stars burn out and die. As a star's gases burn, they give off light and heat. But when the gas runs out, the star stops burning and begins to die. As the star cools, the outer layers of the star pull in toward the center. The star squashes into a smaller and smaller ball. Imagine if the Earth were crushed until it was the size of a tiny marble. That's how tightly this dead star, a black hole, is packed.

A black hole is so tightly packed that its gravity sucks in everything — even light.

Sentence	Category	
	Old	New
You can see many objects in the sky at night with a telescope.		
But scientists believe there are some things in the sky that we will never see, even with the biggest telescope in the world.		
That's because they're invisible.		
After millions of years stars wear out and die.		
As a planet's gases freeze, they turn into water and ice.		
The satellite stops orbiting and begins to fall.		
Imagine if the Earth were flattened until it was the size of a large football pitch.		
That's how tightly this dead star, a black hole, is packed.		
A black hole is so dense that its gravity pulls in everything — even light.		
If the star was very small, the star ends up as a cold, dark ball called a black dwarf.		
If the star was very big, it keeps squashing inward until it's packed together tighter than anything in the universe.		

The light from a black hole can never come back to your eyes, so you see nothing but blackness.		

Pillows

One wonderful thing about grandparents, Tim decided, was the stories they could tell about his parents when they had been young. His favourite story about his mother was the famous pillow caper.

"Nowadays," Grandma said, "a feather pillow is something of a rarity or a luxury. Most people seem content with polyester fillings and such. When your mother was small, we had nothing but feather stuffed in our house. You don't know what comfort is until you've sunk your head into 3,000 bits of goose down."

"Once when your mother had nothing to do, she saw the point of one little feather sticking out of a tiny hole in the corner of her pillow. She pulled it out and another came right along to take its place. You can imagine the rest of this story!" "Yes," laughed Tim, "she pulled out all the feathers." "I went to her room," said Grandma, "and there I found 3,000 feathers flying around. All your mother could say was: 'I didn't know there would be so many of them!'"

Sentence	**Category**	
	Old	**New**
Most people seem content with polyester fillings and such		
You don't know what comfort is until you've sunk your head into 3,000 bits of polyester.		
It is always fun visiting grandparents because they take you someplace exciting, like the zoo or the circus.		
Being able to hear stories of when his mum and dad were kids was one of the great things about having grandparents around, Tim concluded.		
His favourite grandparent was his mother's mother.		
In our home, we only had pillows filled with feathers when your mum was a child.		
"Nowadays," Grandma said, "feather pillows are very common and not considered a luxury."		
His favourite story about his father was the famous pillow caper.		
Once when your mother had nothing to do, she saw the point of one little feather sticking out of a tiny hole in the corner of her pillow.		
"I never guessed there would be this many feathers," was the only thing she could say.		
"Yes," laughed Tim, "she pulled out all the feathers."		
"I wish," said Tim, "that I could get a goose down pillow."		

Televisions

Many people worked to create television. In 1862, Abbe Giovanna Caselli invented a machine called the Pantelograph. Caselli was the first person to send a picture over wires. By the 1880s, Alexander Graham Bell invented a machine that transmitted pictures and sound over wires. His machine was called the Photophone.

The World's Fair was held in Paris, France, in the year 1900. The first International Congress of Electricity was held at the World's Fair. That was when the word *television* was first used – by a Russian named Constantin Perskyi. That name stuck, and is now shortened to "TV."

Philo Taylor Farnsworth showed an electronic system in San Francisco in 1927. His TV was the forerunner of today's TV, which is an electronic system based on his ideas. Before 1947, there were only a few thousand televisions in the U.S. By the 1990s, there were televisions in 98% of American homes.

Sentence	**Category**	
	Old	**New**
Several people helped to invent television.		
In 1862, Abbe Giovanna Caselli invented a machine called the Pantelograph.		
In 1906, Boris Rosing built the first working mechanical TV in Russia.		
By the 1880s, Alexander Graham Bell had developed a machine that transferred images and sound over wires.		
His machine was called the Photophone.		
That was when the word *mobile phone* was first used – by a German named Mikael Grass.		
Philo Taylor Farnsworth showed an electronic system in San Francisco in 1927.		
His TV was the predecessor of modern TV, which is an electronic machine based on his designs.		
Before 1947, there were only a few hundred cars in the U.S.		
By the year 2000, there were dishwashers in 98% of American homes.		
One system was a mechanical model based on a rotating discs that spin like CDs.		
At the beginning of TV history, there were several types of TV technology.		

Europe

European historical architecture are among the most well–known in the world. One example of a famous architectural structure is called “Stonehenge,” in England. Stonehenge has many, very large stones set up in circles. No one knows why the stones were set up that way, because it was at a time before history was recorded.

In addition to Stonehenge, The “Acropolis” in Athens, Greece is also very famous for its architectural structures. The Acropolis is a flat–topped hill, which lies about 150 meters above sea level. Many historical temples and other buildings were built on the Acropolis. The Acropolis is a huge tourist site. About 14 million people visit this location each year.

Europe is also famous for its food. The oldest cookbook in Europe was called *De Re Coquinaria,* or “The Art of Cooking”*.* The book does not tell how to prepare the dishes, but it does tell what to put in each dish.

Sentence	**Category**	
	Old	**New**
European historic architecture is some of the most famous in the world.		
One example of a famous geological site is “The Giant’s Causeway,” in Ireland.		
Stonehenge has several, very big stones arranged in circles.		
In addition to Stonehenge, The “Acropolis” in Athens, Greece is also very famous for its architectural structures.		
The geology of Europe is varied and complex, giving rise to the wide variety of landscapes found in the continent		
Many historical temples and other buildings were built on the Acropolis.		
The Acropolis is an important tourist attraction.		
The oldest religious texts are the Pyramid Texts of Ancient Egypt.		
The book does not tell how to prepare the dishes, but it does tell what to put in each dish.		
You can see examples of European buildings all around the world.		
Of course, the Champagne region in France is famous for its wine.		
There is much controversy over the identity of the book’s author.		

Voyager 1 and 2

The Voyager 1 and 2 spacecrafts left Earth in 1977 on a five-year mission. Their mission was to reach Jupiter and Saturn and send information back to earth about them. Jupiter and Saturn are the largest planets in the solar system. In 1981, they finished their mission. But, they kept going. Scientists decided to plan a longer trip for them: they would travel even further until they reached Uranus and Neptune.

Voyagers 1 and 2 are very efficient. They were built with no moving parts. They use the breakdown, or the decay, of the element plutonium to create fuel. They can each get the *equivalent* of 30,000 miles per gallon of gasoline! They were made to be able to work in radioactive environments. The gas giants – Jupiter, Saturn, Uranus, and Neptune – are very radioactive places.

Sentence	**Category**	
	Old	**New**
The Voyager 1 and 2 spacecrafts left Earth in 1977 on a five-year mission.		
Their mission was to travel to Jupiter and Saturn and transmit information about them back to earth.		
Jupiter and Saturn are the largest planets in the solar system.		
In 2013, they began their mission.		
Scientists agreed to plot a longer trip: they would travel onwards until they reached Uranus and Neptune.		
Voyagers 1 and 2 are very efficient.		
They were made with several delicate, moving parts.		
They use the burning of gasoline as their fuel.		
They were built to work in radioactive conditions. The gas giants – Jupiter, Saturn, Uranus, and Neptune – are very radioactive planets.		
Voyagers 1 and 2 have sent information back to Earth from farther away than any other spacecraft.		
Scientists think that they will keep getting information from Voyagers 1 and 2 until about 2020.		
Scientists have learned about the atmospheres, interiors, and rings of the gas giant stars.		

The Maya

The Mayan Indians lived in Mexico for thousands of years before the Spanish arrived in the 1500s. The Maya were an intelligent, culturally rich people whose achievements were many. They had farms, beautiful palaces, and cities with many buildings. The Mayan people knew a lot about nature and the world around them. This knowledge helped them to live a better life than most people of that time, knowledge about tools and farming, for instance, made their work easier and more productive.

The Maya built large temples to honor the Mayan gods. Skillful workers built cities around these temples. Workers had to carry all of the building materials themselves. Today, many of these ancient Mayan cities and temples are still standing.

Although the cities that the Maya built were beautiful, and the people worked hard to build them, very few of the people lived in them. Usually, only the priests lived in the cities. The other people lived in villages of small huts with no windows in the forests.

Sentence	**Category**	
	Old	**New**
The Mayan Indians lived in Mexico for thousands of years before the Spanish arrived in the 1500s.		
They had farms, beautiful palaces, and cities with many buildings.		
The Mayan people knew nothing about nature and the world around them.		
This understanding meant they lived a better life than most people of that time, useful knowledge about tools and farming, for example, made work easier and more productive.		
Workers used donkeys to carry the building materials.		
To this day, several of these old Mayan cities and temples remain standing.		
Although the cities that the Maya built were beautiful, and the people worked hard to build them, very few of the people lived in them.		
Typically, just the priests lived in the cities.		
The other people stayed together in large huts with windows open to the forest.		
Their houses were much simpler than the elaborate structures in the cities.		
The walls were made of poles covered with dried mud, and the roof was made of grass or leaves.		
Most Maya lived a simple life close to nature.		

Appendix 2.5: Sample consent form

University of Reading

Faculty of Life Sciences

School of Psychology and Clinical Language Sciences

Harry Pitt Building

University of Reading

Earley Gate

Reading RG6 6AL

Supervisor:

Dr. Arpita Bose

Email:

Phone:

PhD Student:

Anusha Balasubramanian

Email:

Research mobile:

Bi-literacy effects on language and cognition in bilingual healthy adults

Consent Form

I, ………………………………………………… agree to take part in this study. It is about how different levels of literacy affects the ability to repeat words/sentences and also the memory and attention in bilingual individuals. It is being carried out by Ms. Anusha Balasubramanian and Dr. Arpita Bose at The University of Reading.

- I have seen and read a copy of the Participant's Information Sheet.
- I was able to ask questions about the study. They have been answered.
- I understand that personal information is confidential and only a number will identify my data.
- I understand that the whole study will take two to three one-hour sessions to complete.
- I understand that I will get the honorarium for participation in the research only after completion of the study and not in between.
- I know the information will be stored in secure locked cabinets.
- I know the information will be kept for five years.
- I understand that taking part in this study is voluntary.
- I can withdraw at any time without having to give an explanation.
- I am happy to proceed with my participation.

Signature --

Name (in capitals) --

Information sheet

Supervisor:

Dr. Arpita Bose

Email:

Phone: +44(0)1183786105

PhD Student:

Anusha Balasubramanian

Email:

Research mobile:

Faculty of Life Sciences

School of Psychology and Clinical Language Sciences

Harry Pitt Building

University of Reading

Earley Gate

Reading RG6 6AL

INFORMATION SHEET

Title: Bi-literacy effects on language and cognition in bilingual healthy adults

This research aims at investigating how different levels of literacy (i.e., ability to read and write in two languages) might have an effect on language and cognitive abilities of bilingual individuals. This will ideally help us understand the influence of literacy in bilingual individuals and further if these literacy skills tend to have an impact on oral language and cognitive abilities.

We will be grateful if you will kindly consider participating in this research. This study will include a range of easy language tasks like naming pictures, reading words or repeating words presented on a laptop screen. The testing may take two to three one-hour sessions and will be scheduled on different days based on your convenience. Participants will be remunerated for their time and travel with an honorarium of £10/session at the end of the study. We will ensure that frequent breaks are provided during testing to avoid fatigue and frustration, and if needed a session can be stopped and resumed on a later date.

Participant's data will be kept confidential and securely stored, with only a number attached to each participant, and therefore it will not be possible to link any set of data with any individual. All information collected for the project will be destroyed after five years in accordance with the University's procedures.

Your participation in this experiment is completely voluntary. You may withdraw at any time without giving any reason. This application has been reviewed by the University Research Ethics Committee and has been given a favourable ethical opinion for conduct.

Thank you for your help.

Anusha Balasubramanian

PhD Student

Appendix 2.6: Clustering and switching categories

A. Animals

African: aardvark, antelope, buffalo, camel, chameleon, cheetah, chimpanzee, cobra, eland, elephant, gazelle, giraffe, gnu, gorilla, hippopotamus, hyena, impala, jackal, lemur, leopard, lion, manatee, mongoose, monkey, ostrich, panther, rhinoceros, tiger, wildebeest, warthog, zebra

Australian: emu, kangaroo, kiwi, opossum, platypus, Tasmanian devil, wallaby, wombat, koala bear

Beasts of burden: camel, donkey, horse, llama, ox, bull, alpaca, cow

Bird: budgie, condor, eagle, finch, kiwi, macaw, parrot, parakeet, pelican, penguin, robin, toucan, woodpecker, hawk

Canine: Wolf, Dog

Pet: budgie, canary, cat, dog, gerbil, golden retrieval, guinea pig, hamster, parrot, rabbit

Rodent: beaver, chinchilla, chipmunk, gerbil, gopher, ground hog, guinea pig, hedgehog, marmot, mole, mouse, muskrat, porcupine, rat, squirrel, woodchuck

Nocturnal: Owl, Bat

Aquatic animal: alligator, auk, beaver, crocodile, dolphin, fish, frog, lobster, manatee, muskrat, newt, octopus, otter, oyster, penguin, platypus, salamander, sea lion, seal, shark, toad, turtle, whale
Farm animals: chicken, cow, donkey, ferret, goat, horse, mule, pig, sheep, turkey
Reptile: alligator, chameleon, crocodile, gecko, iguana, lizard, newt, salamander, snake
Birds of prey: Eagle
Small birds: Sparrow, pigeon
Deer: antelope, caribou, eland, elk, gazelle, gnu, impala, moose, reindeer, wildebeest
Feline: bobcat, cat, cheetah, cougar, jaguar, leopard, lion, lynx, mountain lion, ocelot, panther, puma, tiger
Arboreal: panda, sloth, bear, red panda, monkey, koala bear
Fur: beaver, chinchilla, fox, mink, rabbit
Primate: Orangutan
Flightless birds: Ostrich, Penguin

B. Clothes

Upper body: shirt, tops, t-shirt, cardigan

Lower body: trouser, pant, shorts, slacks, jeans, skirts, leggings, pyjamas

Accessories: belt, towel, handkerchief, owel, handkerchief,
Traditional: shawl, saree, dhoti, salwar, Punjabi, quilt, kimono, dishdash

Women's clothing: Frock

Under garments: bra, boxers, underwear, lingerie, trunk, vest, blouse

Formal wear: shirt, pant, tie, coat, suit

C. Food items

Breakfast: Cereal

Curries: Tomato curry, Brinjal curry, vegetable curry, fish curry

Italian: Pasta, Pizza, Spaghetti Bolognese, Macaroni, Lasagne,

Non-vegetarian side dishes: Chicken jalfrezi, Chicken tikka masala, Chicken korma masala, Kebab, Pork, Turkey, Chicken Korma masala

Snacks: onion bajji, samosa, vegetarian roll, sausage roll.

Dessert: Chocolate cake, yogurt, Nutella

Fruits: Orange, blackberries, apple, banana, mango, strawberries

British food: Stick slice, Sherperd's pie, Burgers, Cereals, Baked beans, Hash browns, Flat bread

Rice: Fried rice, Kesari bath, Chilli fried rice, Paneer fried rice, Wheat, Pongal

South Indian: Dosa, Idly, Poori, Puttu, uthappam, ghee roast

Vegetarian side dishes: Paneer Manchurian, dal, sambar, raitha

Flat breads: Cauliflower parotha, potato parotha, Bread

Salad: Carrot, Broccoli, Caesar salad, Mexican bean salad

Appendix 2.7: Stimuli for Word and non-word repetition

High Imageability High Frequency (HIHF)	High Imageability Low Frequency (HILF)	Low Imageability High Frequency (LIHF)	Low Imageability Low Frequency (LIHF)
Radio	Cart	boncept	mercy
student	Spider	opunion	plen
letter	Funnel	prisciple	dend
hospital	alcohol	drister	clee
village	monkey	settion	voe
battle	Onion	sping	merly
marriage	Pill	mimber	prath
hand	drum	antitude	felly
coffee	elbow	prought	reash
fire	pupil	loment	apisade
window	gravy	minner	trabite
church	tractor	crasis	itony
school	pig	shality	sutire
mother	tobacco	affort	grivity
hotel	axe	baranter	trenson
summer	elephant	fict	minacle
night	potato	purpise	binus
plane	feather	pheory	dalour
audience	wheat	clenth	puct
picture	slope	idia	sogmy
biffle	weast	fact	tribute
cottee	trantor	crisis	folly
hetal	otion	attitude	valour
mirtage	calt	character	analogy
sammer	afe	member	bonus
pline	pupit	system	dogma
hend	pib	thing	episode
pisture	pell	idea	pact
wembow	dunkey	length	treason
ragio	slape	opinion	woe
nirth	eltow	moment	plea
slurch	gramy	effort	deed
sprool	halocle	concept	gravity
mither	epilent	theory	realm
hopsitle	pitaro	quality	irony
lutter	drim	purpose	wrath
fide	tanacco	thought	clue
vallige	fannel	principle	miracle
Student	spuder	manner	satire
Andience	foaster	session	atalogy

Appendix 2.8: Synonymy triplets score sheet

Name_____________________ Date_____________________

Age_____________________

Instructions: In this test which examines knowledge of word meanings, the subject is presented with three words and asked to choose the two words which he/she thinks are closest in meaning. Sample items include both pictorial and written stimuli.

Three words are displayed on each test page. Beginning with the word on top, name each word for the subject, pointing to each word as you name it. Ask the subject to read the words silently as well. Instruct the subject to think about what each word means and to choose the two words which are similar in meaning. You may repeat the names of each word as many times as the subject requests. Ask the subject to point to the two words which are closest in meaning.

On the response form, circle the words chosen by the subject. The correct pair is underlined. Record on the summary sheet (below) the number of correct pairs of nouns and verbs chosen by the subject. Use the examples below to familiarize the subject with the task.

Instructions to subject:

(Ex. 1) circle, triangle, circle

I want you to look at these three shapes. Which two look the same? *(Correct any errors)* That's right, the two circles are the same.

(Ex. 2) star, rectangle, square

In this example, none of the shapes are exactly the same, but two of them are very much alike. Which two are similar – almost alike? *(Correct errors)*

That's right, the rectangle and the square are the most similar in shape.

(Ex. 3) man, chair, boy

(Ex. 4) to run, to jog, to sit

I want you to look at these words. I will read them to you and I want you to read them to yourself and think about what they mean. I will repeat the words as many times as you wish. *(Name each word from top to bottom).* Which two words do you think have the most similar meanings? *(If necessary, correct errors, provide further explanation and review all examples).*

I am going to show you more sets of words like these examples and I want you to read them and think about what each word means. I will repeat their names as many times as you wish. You are to choose the two words which you think are most similar in meaning. *(Proceed to test items)*

Score Summary (number correct)

Synonymy Triplets: Response Form (Target Pair**)

Practice Items				Target	Response
1.	Circle *	Triangle	Circle*	13	
2.	Star	Rectangle*	Square*	23	
3.	Man*	Chair	Boy*	13	
4.	To run*	To jog*	To sit	12	
Trials				**Target**	**Response**
1.	To allow*	To encourage	To permit*	13	
2.	To lie	To rob*	To steal*	23	
3.	Violin*	Fiddle*	Clarinet	12	
4.	To scream*	To threaten	To shout*	13	
5.	Lake	Brook*	Stream*	23	
6.	Trailer	Trolley*	Streetcar*	23	
7.	To rip*	To tear*	To slice	12	
8.	To strangle*	To murder	To choke*	13	
9.	Automobile*	Train	Car*	13	
10.	To preach	To instruct*	To teach*	23	
11.	Thief*	Spy	Robber*	13	
12.	Shack*	Hut*	Tent	12	
13.	To repair*	To fix*	To design	12	
14.	To disapprove	To hate*	To detest*	23	
15.	Hydrant	Faucet*	Spigot*	23	
16.	To shine*	To scrub	To polish*	13	
17.	Bathtub	Pail*	Bucket*	23	
18.	To prepare	To construct*	To build*	23	
19.	Lawyer*	Policeman	Attorney*	13	
20.	Omelette*	Dosa*	Upma	12	
21.	To propose*	To suggest*	To insist	12	
22.	Dock*	Pier*	Shore	12	
23.	To brag*	To flatter	To boast*	13	
24.	Axe*	Hatchet*	Razor	12	
25.	Coat	Pants*	Slacks*	23	
26.	Briefcase	Wallet*	Billfold*	23	
27.	Couch*	Table	Sofa*	13	
28.	To remember*	To review	To recall*	13	
29.	To scare*	To frighten*	To annoy	12	
30.	To continue	To start*	To begin*	23	
				Nouns	/15
				Verbs	/15
				Total	/30

Appendix 2.9 Sentence comprehension (Test of Reception of Grammar (TROG -2))

Sr No.	Grammatical category	Item
A0a	Practise items	The girl is sitting
A0b		The cat is running
A1	Two elements	The sheep is running
A2		The scarf is yellow
A3		The lady/woman is pointing
A4		The comb is red
B1	Negative	The man is not sitting
B2		The star is not red
B3		The cow is not running
B4		The fork is not big
C1	Reversible in and on	The cup is in the box
C2		The duck is on the ball
C3		The pencil is on the scarf
C4		The star is in the ball
D1	Three elements	The girl pushes the box
D2		The dog stands on the table
D3		The cat touches the shoe
D4		The elephant chases the duck
E1	Reversible SVO	The cat is looking at the boy
E2		The boy is chasing the dog
E3		The elephant is pushing the girl
E4		The lady/woman is pushing the cow
F1	Four elements	The horse sees the cup and the book
F2		There is a long pencil and a red ball
F3		The boy looks at the chair and the knife
F4		There is a yellow star and a big flower
G1	Relative clause in subject	The man that is eating looks at the cat
G2		The book that is red is on the pencil
G3		The girl that is jumping points at the man
G4		The shoe that is red is in the box
H1	Not only X but also Y	The pencil is not only long but also red
H2		Not only the box but also the flower is yellow
H3		Not only the lady/woman but also the cat is running
H4		The man is not only running but also pointing
I1	Reversible above and below	The flower is above the duck
I2		The cup is below the star
I3		The knife is above the shoe
I4		The pencil is below the fork
J1	Comparative/absolute	The duck is bigger than the ball
J2		The tree is taller than the house
J3		The pencil is longer than the knife
J4		The flower is longer than the comb
K1	Reversible passive	The cow is chased by the girl
K2		The boy is pushed by the elephant
K3		The duck is chased by lady/woman
K4		The sheep is pushed by the boy

L1	Zero anaphor	The man is looking at the horse and running
L2		The book is on the scarf and is blue
L3		The boy is chasing the dog and is jumping
L4		The box is in the cup and is blue
M1	Pronoun/Gender/number	They are carrying him
M2		He is chasing them
M3		She is pointing at them
M4		They are pushing him
N1	Pronouns binding	The man sees that the boy is pointing at him
N2		The boy sees the elephant is touching him
N3		The girl sees the lady is pointing at her
N4		The lays sees the girl is touching her
O1	Neither nor	The girl is neither pointing nor running
O2		Neither scarf nor flower is long
O3		The box is neither big nor yellow
O4		Neither girl nor dog is sitting
P1	X but not Y	The cup but not the fork is red
P2		The comb is long but not blue
P3		The man but not the horse is jumping
P4		The girl is running but not pointing
Q1	Post modified subject	The elephant pushing the boy is big
Q2		The box in the cup is yellow
Q3		The horse chasing the girl is big
Q4		The scarf on the shoe is blue
R1	Singular/plural inflection	The cows are under the tree
R2		The boy picks flowers
R3		The girls stand on the chair
R4		The cat chases ducks
S1	Relative clause in subject	The girls chases the dog that is jumping
S2		The man pushes the cow that is standing
S3		The cup is in the box that is red
S4		The scarf is on the pencil that is blue
T1	Center-embedded sentence	The sheep the girl looks at is running
T2		The man the elephant sees is eating
T3		The duck the ball is on is yellow
T4		The scarf the book is on is yellow

Appendix 3.1: Example transcript: Transcription > Extraction of Narrative Words > Segmentation > Preparation for input to CLAN.

1. <u>Transcription (verbatim - from audio file to text file)</u>

One boy boy and his pet brings uh one frog and put it in the glass jar and they uh [dɒ] uh boy and dog go to sleep and that night frog jump from that glass jar and go away from window then boy wake up then he search in hi his shoes and dog searching his in glass jar and dog put uh his his head in glass jar it stuck then boy looks at window and jumps from window both boy and pet go to search that frog and go on searching and searching and boy uh uh see uh searching in one hole in mud uh when he mm he saw in mud one rat come outside boy gets scared uh then he uh boy some boy boy sitting one big tree in tree hole he's uh s searching for his frog from that uh big hole in that tree one owl come out and bu uh boy scared and jump uh jump from that mm jump from that uh tree then boy go to one hill in hill one deer with uh with uh standing but boy doesn't know it's a deer then boy hold that uh deer and deer scared and jump from that hill and boy and [pes] (pet) uh fell down in the river that river uh riverside one log log uh mm log is found there in front of that log lots of small small fish uh uh frogs are sitting in boy and pet search for his frog then he found his frog then boy say goodbye to old frog he take his take his pet dog and go away

2. <u>Extraction of narrative words (using guidelines from Quantitative Production Analysis: A training manual for the analysis of aphasic sentence production (Berndt, 2000))</u>

The following items were deleted:

- *non-linguistic fillers e.g. 'um' 'uh'*
- *comments made by participant e.g. 'oh what's that word?'*
- *habitually used phrases e.g. 'all of sudden' (phrases used more than 3 times across the narrative considered habitual)*
- *co-ordinating conjunctions that function to join to otherwise independent sentencesstereotyped phrases e.g. 'Once upon a time / they lived happily ever* after'.

One boy boy and his pet brings ~~uh~~ one frog and put it in the glass jar ~~and~~ they ~~uh [dɒ] uh~~ boy and dog go to sleep ~~and~~ that night frog jump from that glass jar and go away from window ~~then~~ boy wake up ~~then~~ he search in hi his shoes ~~and~~ dog searching his in glass jar ~~and~~ dog put ~~uh~~ his his head in glass jar it stuck ~~then~~ boy looks at window and jumps from window both boy and pet go to search that frog and go on searching and searching ~~and~~ boy ~~uh uh~~ see ~~uh~~ searching in one hole in mud ~~uh when~~ he ~~mm~~ he saw in mud one rat come outside boy gets scared ~~uh then~~ he ~~uh~~ boy some boy boy sitting one big tree in tree hole he's ~~uh~~ s searching for his frog from that ~~uh~~ big hole in that tree one owl come out and bu ~~uh~~ boy scared and jump ~~uh~~ jump from that ~~mm~~ jump from that ~~uh~~ tree ~~then~~ boy go to one hill in hill one deer with ~~uh~~ with ~~uh~~ standing ~~but~~ boy doesn't know it's a deer ~~then~~ boy hold that ~~uh~~ deer ~~and~~ deer scared and jump from that hill ~~and~~ boy and [pes] (pet) ~~uh~~ fell down in the river that river ~~uh~~ riverside one log log ~~uh mm~~ log is found there in front of that log lots of small small fish ~~uh uh~~ frogs are sitting in boy and pet search for his frog ~~then~~ he found his frog t~~hen~~ boy say goodbye to old frog he take his take his pet dog and go away

3. <u>Segmentation into utterances (using guidelines from Quantitative Production Analysis: A training manual for the analysis of aphasic sentence production (Berndt, 2000))</u>

Segmentation based on syntactic indicators, intonational indicators, pauses and semantic criteria.

One boy boy and his ~~pet~~ brings ~~uh~~ one frog and put it in the glass jar ~~and~~ they ~~uh [dɒ] uh~~ boy and dog go to sleep ~~and~~ t~~hat n~~ight frog jump from that glass jar and go away from window ~~then~~ boy wake up ~~then~~ he search in hi his shoes and dog searching his in glass jar and dog put ~~uh~~ his his head in glass jar it stuck ~~then~~ boy looks at window and jumps from window both boy and pet go to search that frog and go on searching and searching ~~and~~ boy ~~uh uh~~ see ~~uh~~ searching in one hole in mud ~~uh when~~ he ~~mm~~ he saw in mud one rat come outside boy gets scared ~~uh then~~ he ~~uh~~ boy some boy boy sitting one big tree in tree hole he's ~~uh~~ s searching for his frog from that ~~uh~~ big hole in that tree one owl come out ~~and~~ bu ~~uh~~ boy scared and jump ~~uh~~ jump from that ~~mm~~ jump from that ~~uh~~ tree ~~then~~ boy go to one hill in hill one deer with ~~uh~~ with ~~uh~~ standing ~~but~~ boy doesn't know it's a deer ~~then~~ boy hold that ~~uh~~ deer ~~and~~ deer scared and jump from that hill ~~and~~ boy and [pes] (pet) ~~uh~~ fell down in the riverthat river ~~uh~~ riverside one log log ~~uh mm~~ log is found there in front of that log lots of small small fish ~~uh uh~~ frogs are sitting in boy and pet search for his frog ~~then~~ he found his frog t~~hen~~ boy say goodbye to old froghe take his take his pet dog and go away

4. <u>Deletion of omitted words – ready for input into CLAN</u>

One boy boy and his pet brings one frog and put it in the glass jar they boy and dog go to sleep that night frog jump from that glass jar and go away from window boy wake up he search in hi his shoes dog searching his in glass jar dog put his his head in glass jar it stuck boy looks at window and jumps from window both boy and pet go to search that frog and go on searching and searching boy see searching in one hole in mud he he saw in mud one rat come outside boy gets scared he boy some boy boy sitting one big tree in tree hole he's s searching for his frog from that big hole in that tree one owl come out bu boy scared and jump jump from that jump from that tree boy go to one hill in hill one deer with with standing boy doesn't know it's a deer boy hold that deer deer scared and jump from the hill boy and pets fell down in the river that river riverside one log log log is found there in front of that log lots of small small fish frogs are sitting in boy and pet search for his frog he found his frog boy say goodbye to old frog he take his take his pet dog and go away

Appendix 3.2: Comparison of transcript coded independently by 2 Speech and Language Therapy students.

Key

Coder 1
Coder 2
Differences in coding

*MOT: that's a lot of coffee .
%mor: pro:dem|that~v|be-3S det|a |pro|lot prep|of n|coffee
%mor: pro|that v|be&3s det|a n|lot prep|of n|coffee

*MOT: you made a baby !
%mor: pro|you v|make-PAST det|a n|baby .
%mor: pro|you v|make&past det|a n|baby

*MOT: look at what you did .
%mor: v|look prep|at wh|what pro|you v|do-PAST
%mor: v|look prep|at wh|what pro|you v|do&past

*MOT: Eve # you drew a little baby # see .
%mor: n:prop|Eve pro|you v|draw-PAST det|a adj|little n|baby v|see .
%mor: n:prop|Eve pro|you v|draw&past det|a adj|little n|baby v|see

*MOT: here are the eyes and here's the nose .
%mor: adv:loc|here v|be-PL det|the n|eye-PL conj:coo|and adv:loc|here~v|be-3S det|the n|nose .
%mor: pro|here v|be det|the n|eyes conj|and pro|here v|be&3s det|the n|nose

*MOT: no # that's a tongue sticking [//] xxx his tongue out .
%mor: neg|no pro:dem|that~v|be-3S det|a n|tongue v|stick-PRESP pro:poss|his n|tongue prep|out .
%mor: neg|no qn|that v|be&3s det|a n|tongue v|stick-presp det|his n|tongue prep|out

*CHI: xxx hey # dat my xxx . [+ bch]
%mor: ?|hey pro|that pro:poss|my
%mor: fil|hey qn|dat det|my

*MOT: that's your card ?
%mor: pro:dem|that~v|be-3S pro:poss|your n|card
%mor: pro|that v|be&3s det|your n|card

*MOT: you going to put some xxx coffee .
%mor: pro|you v|go-PRESP inf|to v|put qn|some n|coffee .
%mor: pro|you v|going inf|to v|put qn|some n|coffee

*MOT: put some milk in your cup .
%mor: v|put qn|some n|milk prep|in pro:poss|your n|cup .
%mor: v|put qn|some n|milk prep|in det|your n|cup

*MOT: that's Eve's cup .
%mor: pro:dem|that~v|be-3S n:prop|Eve~poss|s n|cup .
%mor: qn|that v|be&3s n:prop|Eve-poss n|cup

*CHI: write Eve .
%mor: v|write n:prop|Eve .
%mor: v|write n:prop|Eve

*MOT: write Eve ?
%mor: v|write n:prop|Eve .
%mor: v|write n:prop|Eve

*MOT: e@l v@l e@l Eve .
%mor: n:prop|Eve .
*%mor: n:prop|Eve

*CHI: xxx w(r)ite her head <and then> [/] and then dat be Eve . [+ bch]
%mor: v|write pro:poss|her n|head conj:coo|and adv|then pro:dem|that v|be n:prop|Eve
%mor: v|write det|her n|head conj|and adv|then pro|dat v|be n:prop|Eve

*MOT: can you translate ?
%mor: aux|can pro|you v|translate .
%mor: v:aux|can pro|you v|translate
*FAT: write for her # write her instead of draw her # draw her head and
%mor: v|write prep|for pro|her v|write pro|her adv|instead prep|of v|draw
pro|her n|head conj:coo|and
*%mor: v|write prep|for pro|her v|write pro|her adv|instead prep|of v|draw
det|her n|head conj|and

*GLO: you want me to draw your head ?
%mor: pro|you v|want pro|me inf|to v|draw pro:poss|your n|head .
%mor: pro|you v|want pro|me inf|to v|draw det|your n|head

*CHI: yeah m:hm [?] .
%mor: ?|yeah
%mor: fil|yeah

*MOT: here's head .
%mor: adv:loc|here~av|be-3S n|head
%mor: pro|here v|be&3s n|head

*MOT: and here's an eyebrow and here's another eyebrow and here's an eye
%mor: conj:coo|and avd:loc|here~v|be-3S det|an n|eyebrow conj:coo|and
avd:loc|here~v|be- 3S det|another n|eyebrow conj:coo|and avd:loc|here~v|be-
3S det|an n|eye .
%mor: conj|and pro|here v|be&3s det|an n|eyebrow conj|and pro|here v|be&3s
adj|another n|eyebrow conj|and pro|here v|be&3s det|an n|eye

*MOT: and here's another eye .
%mor: conj:coo|and avd:loc|here~v|be-3S det|another n|eye
%mor: conj|and pro|here v|be&3s adj|another n|eye

*MOT: how many eyes do you have ?
%mor: wh|how qn|many n|eye-PL v|do pro|you v|have
%mor: wh|how qn|many n|eyes v|do pro|you v|have

*CHI: one # two # three # four # seven # eight # nine .
%mor: det:num|one det:num|two det:num|three det:num|four det:num|seven det:num|eight det:num|nine
%mor: n|one n|two n|three n|four n|seven n|eight n|nine

*MOT: that's a lot of eyes .
%mor: pro|that~v|be-3S det|a pro|lot prep|of n|eye-PL
%mor: pro|that v|be&3s det|a n|lot prep|of n|eyes

*MOT: I wouldn't put that +/.
%mor: pro|I aux|would~neg|not v|put pro:dem|that
%mor: pro|I v:aux|would neg|not v|put pro|that

*FAT: Eve # don't put the pencil in your eye # dear .
%mor: n:prop|Eve aux|do~neg|not v|put det|the n|pencil prep|in pro:poss|your n|eye .
%mor: n:prop|Eve v:aux|do neg|not v|put det|the n|pencil prep|in det|your n|eye

*GLO: you don't want red eyes do you ?
%mor: pro|you aux|do~neg|not v|want adj|red n|eye-PL v|do pro|you .
%mor: pro|you v:aux|do neg|not v|want adj|red n|eyes v:aux|do pro|you

*MOT: (be)cause you have pretty blue eyes .
%mor: conj:sub|because pro|you v|have adj|pretty adj|blue n|eye-PL
%mor: conj|because pro|you v|have adj|pretty adj|blue n|eyes

*MOT: and let's make a little tiny nose .
%mor: conj:coo|and v|let~pro|us v|make det|a adj|little adj|tiny n|nose
%mor: conj|and v:aux|let pro|us v|make det|a adj|little adj|tiny n|nose

*FAT: Eve # do not do it again .
%mor: n:prop|Eve v|do neg|not v|do pro|it adv|again .
%mor: n:prop|Eve v|do neg|not v|do pro|it adv|again

*MOT: here's a little tiny nose .
%mor: adv:loc|here~v|be-3S det|a adj|little adj|tiny n|nose .
%mor: pro|here v|be&3s det|a adj|little adj|tiny n|nose

*MOT: and here's a very pretty little mouth .
%mor: conj:coo|and adv:loc|here~v|be-3S det|a adv|very adj|pretty adj|little n|mouth
%mor: conj|and pro|here v|be&3s det|a adv|very adj|pretty adj|little n|mouth

*MOT: how's that ?
%mor: wh|how~v|be-3S pro|that .
%mor: wh|how v|be&3s pro|that

*CHI: then I put some milk in here in this cup .
%mor: adv|then pro|I v|put qn|some n|milk prep|in adv:loc|here prep|in pro:dem|this n|cup
%mor: adv|then pro|I v|put qn|some n|milk prep|in pro|here prep|in det|this n|cup

*MOT: ok # put some milk in there in this cup .
%mor: ?|ok v|put qn|some n|milk prep|in adv:loc|there prep|in pro:dem|this n|cup
%mor: fil|ok v|put qn|some n|milk prep|in pro|there prep|in det|this n|cup

*MOT: see # it even says Eve .
%mor: v|see pro|it adv|even v|say-3S n:prop|Eve
%mor: v|see pro|it adv|even
v|say&3S n:prop|Eve Summary

Discrepancies noted:

- 'your / her / my' consistently as 'pro' by coder 1, consistently coded as 'det' by coder 2
- 'here / there' consistently as 'adv:loc' by coder 1, consistently coded as 'pro' by coder 2
- Numbers e.g. 'one' consistently coded as 'det:num' by coder 1, consistently coded as 'n' by coder 2.
- A few discrepancies for 'aux' vs 'v'
- 'lot' consistently coded as 'pro' by coder 1, consistently coded as 'n' by coder 2
- 'another' consistently coded as 'det' by coder 1, consistently coded as 'adj' by coder 2
- 'that' consistently coded as 'pro:dem' by coder 1, coded as 'pro / qn' by coder 2
- Coder 1 consistently marked plurals, Coder 2 did not mark plurals

Calculation of Inter-coder reliability
Total Words coded = 209
Words where coders assigned different word classes = 33 Inter-coder reliability = 100 – ((33 / 209) x100)
= 84.211 %

Appendix 3.3: Dependent Variables & CLAN Commands

Variable **Utterance Level Measures**	CLAN Command
Total Number of Utterances	eval @ +t*SP01: +u
Total Number of Words	eval @ +t*SP01: +u
Percentage of Grammatical	(freq @ +t*SP01 +s"<+ gram>") / (Total
Morpho-syntactic Measures	
Verbs per Utterance	eval @ +t*SP01: +u
Percentage of Auxiliaries	eval @ +t*SP01: +u
Percentage of Third Person	eval @ +t*SP01: +u
Percentage of Past Tense	eval @ +t*SP01: +u
Percentage of Past Participle	eval @ +t*SP01: +u
Percentage of Present	eval @ +t*SP01: +u
Percentage of Plurals	eval @ +t*SP01: +u
Lexical Measures: Open Class Words	
Type Token Ratio (TTR)	eval @ +t*SP01: +u
Vocabulary Diversity (VocD)	vocd @ +t*SP01
Percentage of Nouns	eval @ +t*SP01: +u
TTR Nouns	freq @ +t%mor +s"@|-n"
Percentage of Verbs	eval @ +t*SP01: +u
TTR Verbs	freq @ +t%mor +s"@|-v"
Percentage of Adverbs	eval @ +t*SP01: +u
Percentage of Adjectives	eval @ +t*SP01: +u
Lexical Measures: Closed Class Words	
Percentage of Prepositions	eval @ +t*SP01: +u
Percentage of Conjunctions	eval @ +t*SP01: +u
Percentage of Pronouns	eval @ +t*SP01: +u
Percentage of Wh-Words	eval @ +t*SP01: +u
Percentage of Determiners	eval @ +t*SP01: +u
Measures of Repair	
Number of Retraces	eval @ +t*SP01: +u
Number of Repetitions	eval @ +t*SP01: +u

Appendix 3.4: Raw scores of narrative variables

Appendix 3.4.1: Discourse Level Measures - Individual Data

Participant ID	Print exposure Score	Grouping	Total Utterances	% of grammatical errors	Total Words
PL0001	0.63	HPE	41	31.70732	336
PL0002	-1.18	LPE	29	86.2069	214
PL0003	0.36	HPE	24	16.66667	194
PL0004	-0.94	LPE	44	11.36364	495
PL0005	-0.68	LPE	39	30.76923	424
PL0006	-1.94	LPE	47	29.78723	326
PL0007	-0.44	LPE	37	24.32432	266
PL0008	0.52	HPE	35	22.85714	496
PL0009	0.43	HPE	37	16.21622	385
PL0010	0.1	HPE	24	20.83333	248
PL0011	0.73	HPE	39	20.51282	311
PL0013	0.13	HPE	44	56.81818	406
PL0014	-0.98	LPE	28	17.85714	200
PL0015	-1.18	LPE	48	39.58333	274
PL0016	1.25	HPE	48	14.58333	560
PL0017	-0.88	LPE	43	20.93023	406
PL0018	0.28	HPE	50	18	424
PL0020	0.9	HPE	37	8.108108	395
PL0021	0.56	HPE	58	17.24138	495
PL0022	-0.7	LPE	32	53.125	263
PL0023	-0.31	LPE	32	18.75	319
PL0024	0.52	LPE	33	6.060606	345
PL0025	0.79	HPE	55	1.818182	604
PL0026	0	HPE	53	33.96226	447
PL0027	0.1	HPE	44	2.272727	520
PL0028	1.08	HPE	78	5.128205	890
PL0029	0.56	HPE	43	23.25581	418
PL0030	0.19	HPE	36	47.22222	261
PL0031	0.02	HPE	53	39.62264	596
PL0032	-2.17	HPE	33	21.21212	270
PL0033	-0.27	LPE	38	15.78947	389
PL0034	0.92	HPE	54	7.407407	601
PL0035	0.7	HPE	33	6.060606	365
PL0038	0.9	HPE	26	0	305

Appendix 3.4.2 Morpho-Syntactic Measures Individual Data

Participant ID	Print exposure Score	Grouping	% Plurals	% Auxiliaries	% Third person Singular	% Past tense	% Past participle	% Present participle	Verbs/Utt
PL0001	0.63	HPE	2.679	1.19	10.417	0.595	0.893	2.679	1.707
PL0002	-1.18	LPE	1.869	1.869	2.804	1.869	0.467	3.738	1.31
PL0003	0.36	HPE	4.639	1.546	0	16.495	0	3.093	1.583
PL0004	-0.94	LPE	2.02	2.222	7.273	0.202	0.808	3.232	2.409
PL0005	-0.68	LPE	3.066	1.887	0.236	10.142	0.708	3.066	1.949
PL0006	-1.94	LPE	6.748	9.202	5.828	5.521	1.84	7.669	1.277
PL0007	-0.44	LPE	3.008	2.632	0.752	13.91	0	3.008	1.378
PL0008	0.52	HPE	1.411	1.815	0.605	11.492	0.806	2.823	2.571
PL0009	0.43	HPE	4.416	4.156	0.26	13.766	0.519	4.156	1.757
PL0010	0.1	HPE	4.839	6.452	4.839	5.242	0	7.258	1.667
PL0011	0.73	HPE	2.894	3.859	1.929	10.932	0.643	3.537	1.359
PL0013	0.13	HPE	3.941	6.404	2.709	8.374	0.493	6.897	1.659
PL0014	-0.98	LPE	0.5	1.5	0	13.5	0	0.5	1.179
PL0015	-1.18	LPE	1.46	2.19	1.46	12.409	0.365	4.38	1.292
PL0016	1.25	HPE	2.143	3.571	10.893	2.679	0.714	3.571	2.354
PL0017	-0.88	LPE	2.709	6.404	0.493	13.054	0.493	6.897	1.791
PL0018	0.28	HPE	3.538	2.83	0	14.387	0.236	3.774	1.68
PL0020	0.9	HPE	2.532	4.557	9.873	1.519	0.253	4.051	2.108
PL0021	0.56	HPE	1.01	1.616	1.01	11.717	1.01	2.02	1.534
PL0022	-0.7	LPE	0.76	2.662	1.901	7.224	0	5.323	1.375
PL0023	-0.31	LPE	1.567	7.21	4.702	0.313	1.254	1.881	1.938
PL0024	0.52	LPE	2.899	3.188	10.145	0.29	0.29	4.058	1.636
PL0025	0.79	HPE	2.318	1.987	7.285	2.649	0.662	2.483	1.982
PL0026	0	HPE	2.013	6.935	1.79	8.949	1.566	3.132	1.585
PL0027	0.1	HPE	2.692	1.923	0	14.038	1.154	3.077	2.182
PL0028	1.08	HPE	2.36	2.809	1.685	10.449	0.562	3.146	2.295
PL0029	0.56	HPE	1.196	2.392	0.478	15.311	0.239	2.871	1.86
PL0030	0.19	HPE	1.533	3.065	0.766	14.176	0.766	6.513	1.556
PL0031	0.02	HPE	2.181	5.369	2.013	9.564	0.671	3.356	2
PL0032	-2.17	HPE	2.963	0.37	2.593	11.481	0.741	4.444	1.667
PL0033	-0.27	LPE	1.799	4.37	9.254	5.656	1.028	2.828	1.868
PL0034	0.92	HPE	1.331	3.661	0.666	13.311	0.666	1.997	2.333
PL0035	0.7	HPE	3.836	2.192	0	10.685	0.822	2.192	1.97
PL0038	0.9	HPE	1.639	0.984	0	12.787	0.328	1.639	2.154

Appendix 3.4.3: Lexical Diversity -Individual Data

Participant ID	Print exposure Score	Grouping	Type token ratio (TTR)	Vocabulary density (VocD)
PL0001	0.63	HPE	0.318	0.356
PL0002	-1.18	LPE	0.36	0.381
PL0003	0.36	HPE	0.459	0.479
PL0004	-0.94	LPE	0.295	0.332
PL0005	-0.68	LPE	0.321	0.336
PL0006	-1.94	LPE	0.313	0.344
PL0007	-0.44	LPE	0.387	0.413
PL0008	0.52	HPE	0.317	0.316
PL0009	0.43	HPE	0.301	0.331
PL0010	0.1	HPE	0.415	0.476
PL0011	0.73	HPE	0.325	0.365
PL0013	0.13	HPE	0.32	0.386
PL0014	-0.98	LPE	0.405	0.408
PL0015	-1.18	LPE	0.281	0.326
PL0016	1.25	HPE	0.305	0.377
PL0017	-0.88	LPE	0.305	0.323
PL0018	0.28	HPE	0.278	0.31
PL0020	0.9	HPE	0.306	0.366
PL0021	0.56	HPE	0.263	0.296
PL0022	-0.7	LPE	0.304	0.327
PL0023	-0.31	LPE	0.339	0.391
PL0024	0.52	LPE	0.339	0.405
PL0025	0.79	HPE	0.272	0.32
PL0026	0	HPE	0.273	0.334
PL0027	0.1	HPE	0.323	0.355
PL0028	1.08	HPE	0.302	0.355
PL0029	0.56	HPE	0.335	0.371
PL0030	0.19	HPE	0.379	0.413
PL0031	0.02	HPE	0.307	0.373
PL0032	-2.17	HPE	0.326	0.321
PL0033	-0.27	LPE	0.386	0.442
PL0034	0.92	HPE	0.318	0.359
PL0035	0.7	HPE	0.384	0.402
PL0038	0.9	HPE	0.351	0.384

Appendix 3.4.4: Lexical Measures: Open Class Words- Individual Data

Participant ID	Print exposure Score	Grouping	% Nouns	% Verbs	% adjectives	% adverbs	TTR Nouns	TTR Verbs
PL0001	0.63	HPE	25.595	20.833	2.679	3.869	0.337	0.657
PL0002	-1.18	LPE	31.776	17.757	5.607	3.738	0.368	0.605
PL0003	0.36	HPE	26.289	19.588	4.639	6.701	0.585	0.684
PL0004	-0.94	LPE	22.02	21.414	4.646	3.434	0.422	0.528
PL0005	-0.68	LPE	24.292	17.925	2.83	4.717	0.427	0.566
PL0006	-1.94	LPE	22.699	18.405	3.067	3.374	0.351	0.6
PL0007	-0.44	LPE	24.436	19.173	1.88	6.391	0.477	0.706
PL0008	0.52	HPE	21.371	18.145	1.815	7.661	0.396	0.578
PL0009	0.43	HPE	21.039	16.883	1.818	10.13	0.395	0.6
PL0010	0.1	HPE	22.581	16.129	4.032	6.855	0.589	0.775
PL0011	0.73	HPE	23.151	17.042	2.572	5.466	0.403	0.717
PL0013	0.13	HPE	20.443	17.98	2.463	8.128	0.494	0.644
PL0014	-0.98	LPE	21.5	16.5	2.5	10.5	0.439	0.636
PL0015	-1.18	LPE	19.343	22.628	1.825	8.759	0.321	0.5
PL0016	1.25	HPE	17.679	20.179	5.179	8.036	0.427	0.619
PL0017	-0.88	LPE	17.734	18.966	2.709	7.635	0.431	0.506
PL0018	0.28	HPE	25.236	19.811	1.415	4.953	0.262	0.583
PL0020	0.9	HPE	18.481	19.747	3.038	8.354	0.397	0.538
PL0021	0.56	HPE	24.646	17.98	2.828	6.667	0.303	0.528
PL0022	-0.7	LPE	25.856	16.73	1.521	7.605	0.294	0.636
PL0023	-0.31	LPE	20.376	19.436	1.881	6.897	0.444	0.645
PL0024	0.52	LPE	20	15.652	6.377	10.145	0.478	0.685
PL0025	0.79	HPE	21.026	18.046	5.298	9.272	0.378	0.569
PL0026	0	HPE	18.121	18.792	1.342	10.067	0.358	0.464
PL0027	0.1	HPE	21.538	18.462	4.808	8.269	0.411	0.563
PL0028	1.08	HPE	18.652	20.112	7.303	10	0.631	0.469
PL0029	0.56	HPE	19.139	19.139	4.306	8.612	0.475	0.538
PL0030	0.19	HPE	22.605	21.456	0	6.13	0.475	0.518
PL0031	0.02	HPE	19.295	17.785	3.02	5.537	0.383	0.689
PL0032	-2.17	HPE	25.926	20.37	1.481	5.185	0.343	0.564
PL0033	-0.27	LPE	20.823	18.252	3.856	8.74	0.432	0.831
PL0034	0.92	HPE	18.802	20.965	4.992	9.318	0.494	0.524
PL0035	0.7	HPE	23.288	17.808	3.836	9.041	0.552	0.646
PL0038	0.9	HPE	19.016	18.361	2.951	7.213	0.5	0.625

Appendix 3.4.5: Lexical Measures: Closed class words- Individual data

Participant ID	Print exposure	Groups	% preposition	% conjunctions	% determiners	% pronouns	% wh words
PL0001	0.63	HPE	9.524	3.869	20.2381	6.845	0
PL0002	-1.18	LPE	13.084	6.542	1.869159	11.682	0
PL0003	0.36	HPE	10.309	1.546	9.278351	17.526	0.015464
PL0004	-0.94	LPE	10.303	3.232	18.38384	5.859	0.018182
PL0005	-0.68	LPE	11.557	3.302	18.86792	8.962	0.016509
PL0006	-1.94	LPE	8.896	1.84	15.33742	10.429	0.01227
PL0007	-0.44	LPE	10.526	1.504	14.66165	13.158	0.007519
PL0008	0.52	HPE	11.29	6.452	16.73387	10.484	0.004032
PL0009	0.43	HPE	9.351	4.675	16.1039	9.87	0.012987
PL0010	0.1	HPE	8.065	5.242	17.74194	9.677	0.012097
PL0011	0.73	HPE	9.003	2.251	18.64952	12.862	0.009646
PL0013	0.13	HPE	10.099	3.448	13.30049	10.099	0.024631
PL0014	-0.98	LPE	10.5	5.5	16.5	12.5	0
PL0015	-1.18	LPE	8.759	1.825	11.31387	18.248	0
PL0016	1.25	HPE	11.429	5	11.78571	10.893	0.0125
PL0017	-0.88	LPE	9.113	4.926	11.33005	16.995	0.014778
PL0018	0.28	HPE	9.906	3.302	19.57547	8.491	0.011792
PL0020	0.9	HPE	10.38	4.81	14.17722	13.418	0.017722
PL0021	0.56	HPE	9.293	3.636	18.9899	10.505	0.008081
PL0022	-0.7	LPE	9.125	4.563	21.29278	6.084	0.015209
PL0023	-0.31	LPE	6.583	5.956	15.3605	10.972	0.00627
PL0024	0.52	LPE	11.884	4.058	16.52174	9.565	0.005797
PL0025	0.79	HPE	9.272	4.636	17.38411	7.119	0.006623
PL0026	0	HPE	7.606	2.461	15.21253	13.199	0.011186
PL0027	0.1	HPE	10.962	4.808	18.26923	6.923	0.013462
PL0028	1.08	HPE	9.213	4.045	7.41573	11.461	0.016854
PL0029	0.56	HPE	9.809	3.589	13.15789	13.397	0.009569
PL0030	0.19	HPE	12.644	2.682	11.49425	13.793	0.007663
PL0031	0.02	HPE	10.235	5.201	12.91946	14.765	0.015101
PL0032	-2.17	HPE	10.741	2.963	21.48148	7.407	0.003704
PL0033	-0.27	LPE	8.483	4.37	16.19537	10.797	0.017995
PL0034	0.92	HPE	7.155	5.491	9.317804	12.146	0.023295
PL0035	0.7	HPE	10.411	3.836	12.32877	11.233	0.010959
PL0038	0.9	HPE	11.803	4.59	15.08197	14.426	0.016393

Appendix 3.4.6: Measures of Repair – Individual Data

Participant ID	Print exposure score	Grouping	Number of retraces	Number of repetitions
PL0001	0.63	HPE	2	7
PL0002	-1.18	LPE	6	11
PL0003	0.36	HPE	3	2
PL0004	-0.94	LPE	2	4
PL0005	-0.68	LPE	15	17
PL0006	-1.94	LPE	16	8
PL0007	-0.44	LPE	8	7
PL0008	0.52	HPE	42	16
PL0009	0.43	HPE	12	19
PL0010	0.1	HPE	0	1
PL0011	0.73	HPE	8	5
PL0013	0.13	HPE	6	5
PL0014	-0.98	LPE	11	9
PL0015	-1.18	LPE	10	11
PL0016	1.25	HPE	8	3
PL0017	-0.88	LPE	15	3
PL0018	0.28	HPE	11	3
PL0020	0.9	HPE	6	4
PL0021	0.56	HPE	12	2
PL0022	-0.7	LPE	11	2
PL0023	-0.31	LPE	4	3
PL0024	0.52	LPE	6	0
PL0025	0.79	HPE	6	15
PL0026	0	HPE	17	4
PL0027	0.1	HPE	7	3
PL0028	1.08	HPE	7	5
PL0029	0.56	HPE	5	0
PL0030	0.19	HPE	10	0
PL0031	0.02	HPE	14	1
PL0032	-2.17	HPE	16	10
PL0033	-0.27	LPE	11	11
PL0034	0.92	HPE	11	0
PL0035	0.7	HPE	2	0
PL0038	0.9	HPE	4	1

Appendix 5.1: Participant consent form

School of Psychology and
Clinical Language Sciences
Reading RG6 6AL

Participant Consent Form

Reading and writing difficulties in bi-literate bilingual persons with aphasia (PWA)

Please read the accompanying information letter and complete both pages of this form if you wish to participate in the research study.

Please read and tick each section to confirm your understanding and acceptance	Tick
I have **read and understood** the accompanying **information sheet**	

I have had the **opportunity to ask questions.**	
I understand that I can **withdraw from the research at any time** and without a reason**.**	
I agree to be **audio recorded if necessary**	
I agree for my **anonymous data to be shared** with other researchers	
I **agree to take part** in the research study	
I have **read and understood** the accompanying **information sheet**	
I have had the **opportunity to ask questions.**	
I understand that I can **withdraw from the research at any time** and without a reason**.**	
I agree to be **audio recorded if necessary**	
I agree for my **anonymous data to be shared** with other researchers	
I **agree to take part** in the research study	

Please **add your name and signature** to this **consent form.**

Name: __________Signature: __________ Date: ______________

Investigator's Name: __________ Signature: __________ Date: _________________

If you have **questions** then you can **call**:

Anusha Balasubramanian @ 8217737430

This application has been reviewed by the School of Psychology and Clinical Language Sciences Ethics Committee and has been given a **favourable opinion** for conduct

Appendix 5.2 Information sheet

School of Psychology and Clinical Language Sciences
Reading RG6 6AL

Information Sheet

Reading and writing difficulties in bi-literate bilingual persons with aphasia (PWA)

Researchers:

Dr. Arpita Bose

Lecturer in Clinical Language Sciences

School of Psychology and Clinical Language Sciences,

University of Reading, UK

Tel:

Anusha Balasubramanian

PhD Student

School of Psychology and Clinical Language Sciences,

University of Reading, UK

Tel:

You are being **invited** to take part in a **research** study conducted by the **University of Reading, Reading, United Kingdom.**

This **is information** about the research. You can **choose** whether you would like to **take part.**

What is the study about?

People with aphasia (PWA) can have **communication difficulties and also problems in reading and writing**. If they speak **more than one language**, then their language abilities, reading and writing difficulties in the two languages could be different**.**

We are **collecting information** from bilingual **people with aphasia** to understand how the reading and writing impairments differ in **two languages.**

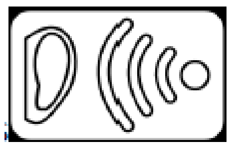
This **data will be anonymous**. Your name or personal details will not be identified.

In future, the anonymized data will be **shared with other researchers**, so they can look at reading and writing difficulties.

What will happen?

You will do some **tests**

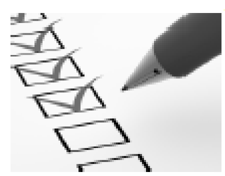
Speaking tests 

Listening tests 

Reading tests 

Problem solving tests

Attention and memory tests



You will complete **Questionnaires** with our help

If you are tired we can stop and carry on another day

Where will I be seen? 

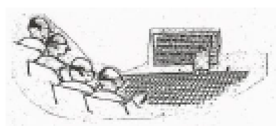
You can **choose**. We can visit you **at home** or you can **come** to **the clinic/hospital**

How many times will I be seen?

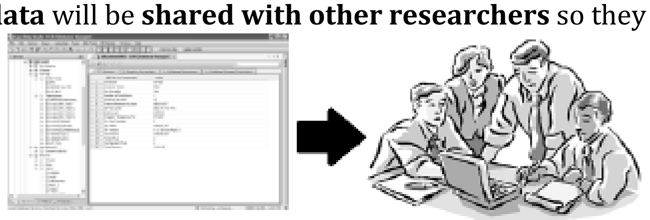
About 2-3 times, each session will last 1-2 hours.

What will happen?

The results will be **published** in **journals.** 

Talked about in **conferences.** 

The **anonymized data** will be **shared with other researchers** so they can look at reading and



writing difficulties.

All results are confidential 

What are the risks and burdens of taking part?

Some of the tests might be **difficult.** If you find them difficult the researcher **will give you a break.**

What are the Benefits?

- Help research 

- You may **help other people** with language difficulties in **the future**
- You may **understand** more **about** your own reading and writing

Do I have to take part?

No, taking part is **voluntary.** You choose whether you would like to take part.

If you decide to take part you can stop

- At **any time**
- **Without a reason**
- **Without it affecting** your **medical care**

Please ask any questions you have, at any time.

This application has been reviewed by the University of Reading Research Ethics Committee and has been given a favourable ethical opinion for conduct.

Thank you for participating in our research.

Dr. Arpita Bose & Anusha Balasubramanian

Appendix 5.3 Participant Stimuli

Appendix 5.3.1 Letter discrimination (PALPA 21)

Sr. No.	Target		Response	Sr, No.	Target		Response
1.				32.	Dream	DREAM	
2.	DREAM	dread		33.	Click	CLICK	
3.	TBRIE	tbrie		34.	Bownr	BOWNR	
4.	hsroe	HSUOE		35.	black	BLOCK	
5.	CROWN	crown		36.	house	HOUSE	
6.	ckltr	CKATR		37.	TRAIN	train	
7.	GRASP	grasp		38.	EEGRN	eergd	
8.	GNRIA	gnria		39.	EBAHC	ebnch	
9.	DEMON	lemon		40.	chair	CHAIR	
10.	eergn	EERGN		41.	kbocl	KBOCL	
11.	CHAIR	chain		42.	tower	TOWEL	
12.	CLICK	click		43.	gnria	TNRIA	
13.	LMEON	lmeon		44.	lmeon	DMEON	
14.	rough	BOUGH		45.	bribe	BRIBE	
15.	BENCH	bench		46.	CKITR	ckitr	
16.	KBOCL	kbacl		47.	greed	GREEN	
17.	BGHUO	rghuo		48.	RDAED	rdaed	
18.	rdaed	RDAEM		49.	CRTAK	crtak	
19.	HOUSE	horse		50.	demon	DEMON	
20.	train	TRAIN		51.	grasp	GRASP	
21.	lcokc	LCOKC		52.	TRACE	track	
22.	BWONR	cwonr		53.	WTOER	wtoel	
23.	BLACK	black		54.	HSROE	hsroe	
24.	ebahc	EBAHC		55.	track	TRACK	
25.	GREED	greed		56.	ROUGH	rough	
26.	crtak	CRTAE		57.	LCOKC	lcikc	
27.	BRIBE	tribe		58.	bench	BEACH	
28.	trace	TRACE		59.	ASGRS	asgrp	
29.	asgrs	ASGRS		60.	crown	BROWN	
30.	TRACK	trick		61.	AIHCN	aihcn	
31.	aihcn	AIHCR		62.	tbrie	BBRIE	
32.	TOWER	tower		63.	bghuo	BGHUO	

Appendix 5.3.2 Legality decision (PALPA 24)

Sr. No.	Target	Response	Sr. No.	Target	Response
1.	tnoas		31.	fresh	
2.	rsene		32.	long	
3.	dgaen		33.	dread	
4.	ntai		34.	prune	
5.	ejia		35.	bush	
6.	otge		36.	broad	
7.	eutf		37.	time	
8.	mnee		38.	like	
9.	aemf		39.	shove	
10.	ibao		40.	give	
11.	kfei		41.	shine	
12.	rcehe		42.	bull	
13.	tdha		43.	speed	
14.	rbuk		44.	lend	
15.	hwci		45.	steer	
16.	dmie		46.	sieve	
17.	tbrei		47.	womb	
18.	kgero		48.	pair	
19.	ngae		49.	need	
20.	rsdo		50.	have	
21.	ridu		51.	some	
22.	dtro		52.	same	
23.	mbuer		53.	mist	
24.	oostm		54.	touch	
25.	twse		55.	dove	
26.	ctreu		56.	most	
27.	lmafl		57.	bind	
28.	nvae		58.	clip	
29.	tlpi		59.	both	
30.	ncao		60.	dump	

Appendix 5.3.3: Visual Lexical Decision (PALPA 27)

Sr. No.	Target	Response	Sr. No.	Target	Response
1.	tnoas		31.	fresh	
2.	rsene		32.	long	
3.	dgaen		33.	dread	
4.	ntai		34.	prune	
5.	ejia		35.	bush	
6.	otge		36.	broad	
7.	eutf		37.	time	
8.	mnee		38.	like	
9.	aemf		39.	shove	
10.	ibao		40.	give	
11.	kfei		41.	shine	
12.	rcehe		42.	bull	
13.	tdha		43.	speed	
14.	rbuk		44.	lend	
15.	hwci		45.	steer	
16.	dmie		46.	sieve	
17.	tbrei		47.	womb	
18.	kgero		48.	pair	
19.	ngae		49.	need	
20.	rsdo		50.	have	
21.	ridu		51.	some	
22.	dtro		52.	same	
23.	mbuer		53.	mist	
24.	oostm		54.	touch	
25.	twse		55.	dove	
26.	ctreu		56.	most	
27.	lmafl		57.	bind	
28.	nvae		58.	clip	
29.	tlpi		59.	both	
30.	ncao		60.	dump	

Appendix 5.3.4: Non-Word repetition (PALPA 8)

Sr. No.	Target	Response
1.	Splant	
2.	sprawn	
3.	Striple	
4.	slurch	
5.	Drange	
6.	Plonth	
7.	Pelter	
8.	Clest	
9.	Grank	
10.	Gaffic	
11.	Inima	
12.	crealth	
13.	vater	
14.	drattle	
15.	Ampty	
16.	pallid	
17.	lerman	
18.	Larden	
19.	truggle	
20.	Ality	
21.	Egular	
22.	riety	
23.	accuty	
24.	funior	
25.	enitor	
26.	Adio	
27.	Splack	
28.	prench	
29.	ipical	
30.	anify	

Appendix 5.3.5 Spoken word and picture matching (PALPA 47)

No.	Target	Response	Close semantic distractor	Distant semantic distractor	Visually related distractor	Unrelated distractor
1	carrot		cabbage	Lemon	saw	chisel
2	Dog		cat	Kangaroo	beetle	butterfly
3	hosepipe		bucket	Well	snake	Frog
4	Hat		coat	Sock	iron	Ironing
5	Axe		hammer	scissors	flag	Kite
6	Belt		braces	Shirt	watch	clock
7	canoe		yacht	lifebelt	bowl	bottle
8	ladder		steps	Rope	ruler	satchel
9	television		radio	Record-player	toaster	Frying-pan
10	moon		star	planet	horseshoe	anvil
11	apple		orange	grapes	ring	necklace
12	Key		lock	Knob	leaf	flower
13	button		zip	Bow	coin	banknote
14	stool		table	Sofa	plug	switch
15	syringe		stethoscop	tablet	screwdrive	hinge
16	crown		tiara	gown	cake	bread
17	cobweb		spider	ladybird	wheel	wagon
18	candle		match	Lamp	lipstick	glove
19	lobster		crab	Fish	spanner	Nut
20	stirrup		saddle	bridle	hanger	jacket
21	Cow		horse	chicken	cradle	Bed
22	sword		shield	Gun	anchor	chain
23	comb		brush	mirror	centipede	Ant
24	Eye		ear	Hair	football	Bat
25	rake		hoe	scarecrow	fork	Salt
26	wall		fence	house	chest	rocking
27	underpants		vest	Tie	flowerpot	watering-
28	Nail		screw	pliers	pencil	letter
29	paintbrush		palette	easel	knife	kettle
30	parachute		balloon	plane	umbrella	puddle
31	dart		spear	Bow	toothbrush	razor
32	pram		baby	Teddy	bath	towel
33	pipe		cigar	ashtray	saucepan	rolling-pin
34	hammock		cot	Pillow	banana	cherry
35	needle		thimble	spinning-wheel	nailfile	tweezers
36	thumb		finger	Leg	pipe	cigarette
37	Bell		whistle	trumpet	lightbulb	battery
38	Shoe		boot	trousers	peanut	monkey
39	Mug		cup	Spoon	drum	Harp
40	Stamp		envelope	Pen	picture	Paint

Appendix 5.3.6: Written word-to-picture matching (PALPA 48)

No.	Target	Response	Close semantic	Distant semantic	Visually related	Unrelated distractor
1	Axe		Hammer	scissors	flag	Kite
2	belt		Braces	shirt	watch	clock
3	parachute		Balloon	plane	umbrella	puddle
4	syringe		Stethoscop	tablet	screwdrive	hinge
5	lobster		Crab	fish	spanner	Nut
6	carrot		Cabbage	lemon	saw	chisel
7	moon		Star	planet	horseshoe	anvil
8	thumb		Finger	leg	pipe	cigarette
9	television		Radio	record	toaster	frying pan
10	stamp		envelope	pen	picture	paint
11	sword		shield	gun	anchor	chain
12	dart		spear	bow	toothbrush	razor
13	comb		brush	mirror	centipede	Ant
14	stirrup		saddle	bridle	hanger	jacket
15	ladder		Steps	rope	ruler	satchel
16	Hat		Coat	sock	iron	Ironing
17	stool		table	sofa	plug	switch
18	bell		whistle	trumpet	lightbulb	battery
19	pipe		cigar	ashtray	saucepan	Rolling pin
20	Dog		Cat	kangaroo	beetle	butterfly
21	pram		baby	teddy	bath	towel
22	underpant		vest	tie	flowerpot	Watering
23	candle		match	lamp	lipstick	glove
24	Eye		Ear	hair	football	Bat
25	hammock		Cot	pillow	banana	cherry
26	hosepipe		bucket	well	snake	Frog
27	rake		Hoe	scarecrow	fork	Salt
28	Key		Lock	knob	leaf	flower
29	Shoe		boot	trousers	peanut	monkey
30	Wall		fence	house	chest	rocking
31	cobweb		spider	ladybird	wheel	wagon
32	button		Zip	bow	coin	banknote
33	crown		tiara	gown	cake	bread
34	Cow		horse	chicken	cradle	Bed
35	apple		orange	grapes	ring	necklace
36	paintbrush		palette	easel	knife	kettle
37	Mug		Cup	spoon	drum	Harp
38	Nail		screw	pliers	pencil	Letter
39	Needle		thimble	spinning	nailfile	Tweezers
40	Canoe		Yacht	lifebelt	bowl	Bottle

Appendix 5.3.7 Spelling sound regularity (PALPA 35)

Sr. No.	Target (Regular words)	Response	Target(Exception words)	Response
1.	cough		barge	
2.	yacht		context	
3.	colonel		plant	
4.	castle		cord	
5.	choir		pump	
6.	pint		Middle	
7.	iron		marsh	
8.	bouquet		check	
9.	island		cult	
10.	debt		free	
11.	soul		luck	
12.	bury		brandy	
13.	few		stench	
14.	gauge		flannel	
15.	pretty		wedding	
16.	quay		friction	
17.	sure		Tail	
18.	bowl		peril	
19.	mortgage		plant	
20.	Come		effort	
21.	ceiling		mist	
22.	shoe		envy	
23.	brooch		navy	
24.	routine		curb	
25.	break		Rub	
26.	wolf		smog	
27.	sword		chicken	
28.	answer		nerve	
29.	Blood		market	
30.	Tomb		take	

Appendix 5.3.8 Imageability and frequency reading task (PALPA 31)

Sr. No.	High imageability high frequency (HIHF)	Response	High imageability low frequency (LIHF)	Response	Low imageability low frequency (LIHF)	Response	Low imageability Low frequency (LILF)	Response
1.	Hotel		elephant		idea		mercy	
2.	marriage		alcohol		crisis		treason	
3.	Mother		feather		session		valour	
4.	Picture		monkey		thing		bonus	
5.	audience		tractor		thought		Clue	
6.	Plane		drum		opinion		dogma	
7.	Village		elbow		purpose		irony	
8.	Hand		gravy		effort		satire	
9.	Letter		spider		theory		analogy	
10.	Battle		wheat		attitude		episode	
11.	Church		axe		fact		gravity	
12.	Fire		cart		length		miracle	
13.	summer		funnel		manner		Pact	
14.	window		onion		moment		Plea	
15.	student		pig		quality		realm	
16.	Night		Pill		system		tribute	
17.	Radio		potato		character		wrath	
18.	hospital		Pupil		concept		Deed	
19.	Coffee		Slope		principle		Folly	
20.	School		Tobacco		member		Woe	

Appendix 5.3.9 grammatical class reading (PALPA 32)

Sr. No.	Adjectives	Response	Functors	Response	Nouns	Response	Verbs	Respons e
1.	ancient		Onto		career		hang	
2.	wide		Ought		scene		build	
3.	damp		Nor		mouth		follow	
4.	entire		Latter		client		listen	
5.	upper		Somehow		wisdom		ignore	
6.	equal		Hence		hero		shrink	
7.	severe		plus		image		develop	
8.	serious		thou		grief		run	
9.	regular		seldom		amount		hear	
10	gentle		beneath		virtue		meet	
11	red		nobody		concept		grow	
12	hard		meanwhil e		opinion		agree	
13	warm		else		ability		speak	
14	wrong		none		welfare		write	
15	happy		maybe		art		carry	
16	broad		whence		size		suffer	
17	dense		myself		role		describ e	
18	proper		upward		task		expect	
19	handsome		despite		bell		appear	
20	tragic		Anyone		sight		destroy	

Appendix 5.3.10 Letter length reading (PALPA 29)

Sr. No.	**3-letter**	**Response**	**4-letter**	**Response**	**5-letter**	**Response**	**6-letter**	**Response**
1.	Fox		door		smoke		bridge	
2.	Cup		Ship		ghost		cheese	
3.	Bed		duck		knife		tongue	
4.	Key		bird		glove		church	
5.	Car		book		house		priest	
6.	Bat		soup		horse		square	

Appendix 5.3.11 Non-word reading (PALPA 36)

Sr. No.	**3-letter**	**Response**	**4-letter**	**Response**	**5-letter**	**Response**	**6-letter**	**Response**
1.	ked		shid		snite		dringe	
2.	nar		doot		hoach		churse	
3.	fon		dufp		glope		shoave	
4.	bem		boak		hance		squate	
5.	cug		birt		snode		thease	
6.	kat		soas		grest		prutch	

Appendix 5.4 Kannada Stimuli

Appendix 5.4.1 RAP-K words and non-words

WORDS / NON - WORDS

READ

	WORDS	NON-WORDS	WORDS	NON-WORDS
1	ಮಲಯ malaya	ಗಳಜ gaLaja	ಕೆಲಸ kelasa	ಅಗೆಡು ageDu
2	ಪಯಣ payaNa	ನಕಜ nakaja	ಕೈಮರ kaimara	ಇಲಚ illacha
3	ರಮಣ ramaNa	ದಲಜ dalaja	ಜಳಕ jaLaka	ಒಗೆಳ ogeLA
4	ಕರಗ karaga	ಕನತ kanata	ಜೀವನ jiivana	ಊಗಲ oogala
5	ಮತದ matada	ಯತನ yatana	ಟಗರು Tagaru	ಔಧಷ oudhaSa
6	ವರಹ varaha	ಲಬತ labata	ಫಲಕ phalaka	ಈಳುವ iLuva
7	ಶತಕ shataka	ಸವದ savada	ಭಾರತ bhaarata	ಗುರಕ guraka
8	ಶಪಥ shapatha	ವಡಬ vaDaba	ಬಾಲಕ baalaka	ಗಕಾದ gakaada
9	ಶರಣ sharaNa	ಪಳಬ paLaba	ಭಾಷಣ bhaaSaNa	ರಬಹ rabaha
10	ಸದರ sadara	ಸಬವ sabava	ಮಲಗು malagu	ಸಬವ sabava

Appendix 5.4.2 RAP-K Reading Arka-Anuswara

ARKA / ANUSWARA

READING

	ARKA		ANUSWARA	
SlNo.	WORDS	NON-WORDS	WORDS	NON-WORDS
1	kaarmika	partavaneri	bhang	hemsuga
2	kaarkhaane	muryekhacha	oLaginda	vaashaantagi
3	niSkarSe	antalarja	kandante	tinkra
4	shourya	shasaktarva	kambani	khansiDi
5	karnaataka	navirdhavaSnu	chintane	angivaaga
6	vishvakarma	kavirnashva	sandharbha	neranja
7	sampuurna	aaNekarSa	samsthe	aralankaa
8	varnanaatiita	naatarnatiiva	deshaadyanta	taramnira
9	antarjala	bamurdaataat	aakrandana	ankuLiju
10	diirghakarna	gadgaaharSoo	saamskrutika	pamanta

Appendix 5.4.3 RAP-K Geminates and Polysyllabic

WORDS / NON - WORDS

READING

	GEMINATES		POLYSYLLABIC	
Sl. No	WORDS	NON-WORDS	WORDS	NON-WORDS
1	ಅಪ್ಪಣೆ appaNe	ನಜ್ಜಿಗೊ najjigo	ಹಲ್ಲುಜ್ಜುತ್ತಾ hallujjuttaa	ಇಂಪಾಸುಗಿ impaasugi
2	ಅಕ್ಕರೆ akkare	ಸುದ್ದಿಮು suddimu	ಹಿರೇಮಣಿ hireemaNi	ಸಿಂಗಸುರಿ singasuri
3	ಅಬ್ಬರ abbara	ನಪ್ಪಿಸೊ nappiso	ಹೆಜ್ಜೆಯನ್ನು hejjeyannu	ನಾಕೇರಿಳ naakeeriLa
4	ಎಚ್ಚರ echchara	ಹುನಬ್ಬಿ hunabbi	ಹೌಹಾರುತ್ತಾ houhaarutlaa	ಪಮಾಕ್ಷಸ pamaakSasa
5	ಕಟ್ಟಡ kaTTaDa	ತಗ್ಗುಹಿ tagguhi	ಹಂಚಿಕೊಳ್ಳು hanchikoLLu.	ಪಂತಿಚಾಯಿ pantichaayi
6	ಬಟ್ಟೆಯ baTTeya	ಒಟ್ಟುಗ್ಗ oTTugga	ಹೇಂಟೆಯನ್ನು heenteyannu	ವಾರುತಯ vaarutaya
7	ಕತ್ತಲು kattalu	ಚಿಪ್ಪಕ್ಕ chippakka	ರೆಕ್ಕೆಪುಕ್ಕ rekkepukka	ಸುತ್ತರಿಕ suttarika
8	ಕಳ್ಳುವ kaLLuva	ನೆತ್ತಕ್ಕು nettakku	ಪ್ರಾಮಾಣಿಕ praamaaNika	ಕಕೆಣಿಯ kakeNiya
9	ತಿನ್ನುತ tinnuta	ಉತ್ತಬ್ಬು uttabbu	ಪ್ರಧಾನಿಯ pradhaaniya	ಉಯರಾಯಿ uyaraayi
10	ಬಸ್ಸಿನ bassina	ಹುತ್ತಟ್ಟು huttaTTu	ಪ್ರತಿಯೊಂದು pratiyondu	ಗೋಕುಹಾಣು gookuhaaNu

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