University of Reading

# Lexical Selection and Factors Influencing Speech Production: Evidence from Kannada-English Bilinguals

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**PhD in Clinical Language Sciences**

January 2024

**University of Reading**

School of Psychology and Clinical Language Sciences

# Abstract

Bilingual lexical access models assume that semantic representations activate the lexical nodes simultaneously in both languages. The question is whether the activated lexical nodes from both languages compete for selection or not. Three hypotheses have been proposed to test the competitive lexical selection mechanism: language-specific lexical selection – which argues that competition is restricted to within language lexical nodes. Language non-specific lexical selection- supportive of cross-language competition and the dynamic view- is a combination of language-specific and language-non-specific views. This dynamic view is based on the language context hypothesis (Grosjean, 2001), which states that bilinguals can represent themselves anywhere on the continuum, depending on the activation level of non-target language. Bilingual in a monolingual context may lead to language-specific selection due to activation of the target language to greater levels, and when in a bilingual context, it can lead to language non-specific due to activation of both the languages and non-target language activation exceeding that of a monolingual context. Previous studies on bilingual lexical selection have shown lexical selection to be language-non-specific in bilinguals and language-specific at times. However, most of the studies have been conducted in highly proficient bilinguals speaking closely related languages, which has resulted in cross-language interference effects. These observed effects may be due to high proficiency and proximity between the languages. On the other hand, studies which investigated bilingual lexical selection in distant language bilinguals have yielded inconsistent and inconclusive results. In addition, they have been investigated in highly proficient bilinguals, and only a handful of studies have been carried out on different L2 proficiency levels. Moreover, previous studies have mainly studied lexical selection in one language direction, i.e., naming in L2 with L1 or L2 distractors. The present thesis investigates bilingual lexical selection in moderately proficient distant language Kannada-English bilinguals in both language directions. In addition, multiple factors have been shown to influence lexical selection in bilinguals. Specifically, proficiency, language dominance, language use and inhibitory control factors have been shown to modulate bilingual lexical selection. It is assumed that one way to resolve the competition from the activated lexical nodes in both languages is through interference suppression using inhibitory control mechanisms. The second aim of this study was to investigate the relationship between bilingual (proficiency and dominance) and inhibitory control factors and their influence on the lexical selection process. A Kannada picture and word stimuli set was developed in the first study; in the second study, four picture-word interference paradigms were developed with manipulations of distractor type, distractor language and language context to investigate the three lexical selection hypotheses, which included naming the pictures in Kannada with Kannada and English distractors and naming in English with English and Kannada distractors. A within-participant design was used with moderately proficient sequential bilinguals to investigate lexical selection in both language directions within the same bilinguals. The results showed an absence of distractor effects and the presence of distractor language and language context effects. Interaction between the distractor language and language context with bilingual factors and inhibitory control factors on the speed of lexical retrieval were observed. The results from the current thesis suggest that lexical retrieval is dynamic in that distractor language and language context effects are observed, which interact with bilingual and inhibitory factors.

# Acknowledgements

First and foremost, I would like to express my sincere gratitude for the scholarship awarded from the FELIX TRUST, which allowed me to pursue my PhD dream, which otherwise would not have been possible. I want to thank the University of Reading for allowing me to pursue my PhD dream, which otherwise would not have been possible. I would also like to thank the University of Reading for its constant support during these wonderful years.

I want to express my deepest gratitude to my supervisors, Professor Arlene Astell and Dr. Holly Robson. Thank you for constantly supporting, encouraging, and believing in me and for all your guidance throughout the journey. Thank you for patiently reading many drafts and providing insightful feedback, as well as for the inspirational discussions that you have offered. It was an honour and a great privilege to work under your supervision, and it has been a constant learning and growing process at the personal and professional levels.

A special thanks to Dr Lotte Meteyard for always being available and clarifying my doubts about mixed model analysis. It has been great working with you and learning to interpret the models from you. In addition, I would like to thank Dr Dan Brady, who helped guide the code during the development of stimuli in Gorilla software.

I would like to especially thank two people, Dr Prema Rao and Dr Suma Raju who believed in me and guided me to pursue my higher education, and this journey would have been a dream without their guidance and motivation.

I would take this opportunity to thank my PhD colleagues, Dr Anamaria Viec and Dr Anusha Balasubramanian for always being there for me through the ups and downs and supporting each other by motivating one another.

I would like to extend my thanks to the JSS Institute of Speech and Hearing, Mysuru, who facilitated the voluntary recruitment of students. I want to give my deepest appreciation to all the younger and older adults who took part in this study.

Finally, but most importantly, I would like to thank my husband, Karthik Aithal for being a constant source of energy, loving and taking care of me in his ways which is immeasurable. A huge thanks to my mother, Shashi B G who is miles away from me, who always assured me that everything will be okay and kept on pushing me to give my best at the time when things were going the other way. Last but not least, I would like to thank my best friend, Ms Sanchana Ramnath for always being there for me when I needed the most.

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# Declaration

I declare that this thesis is a presentation of original work, and I am the sole author. All sources are acknowledged as references.

Shrilekha Bangalore

# 1 Chapter 1: Introduction to the thesis

As globalisation advances, there is a growing prevalence that more than half of the world's population speaks more than one language, making bilingualism a norm rather than an exception (Grosjean, 2013). Bilinguals are defined as one who can effectively communicate in both languages during everyday conversations (Wei, 2020). Bilinguals actively use more than one language, but bilingualism arises in different ways. Bilinguals can be grouped into various types based on the *age of acquisition* (AOA) of a second language (L2) and *proficiency*. The AoA of the second language serves as an essential factor for categorising bilinguals, distinguishing between simultaneous and sequential bilinguals (Gross et al., 2014). Simultaneous bilinguals acquire two languages from birth or before one year of age (De Houwer, 2005). Sequential bilinguals acquire one language following another, and when L2 is acquired before the age of 5 years, native-like language organisation usually occurs (De Houwer, 2005). Late bilinguals acquire a second language after the age of 12 (Robinson et al., 2018).

Proficiency measures an individual's language ability, such as how well a person can understand, speak, read, and write in a specific language. (Peal & Lambert, 1962) categorized bilinguals as balanced and unbalanced based on proficiency. He defined balanced bilinguals as equal proficiency in both languages and unbalanced bilinguals as individuals with first/native language (L1) usually dominant over the other. Nonetheless, most researchers agree that balanced bilinguals with equal proficiency in both languages are rare in real life, and one language is typically dominant (Grosjean, 1982; Olsson &

Sullivan, 2005). Not all bilinguals are the same because they use their languages for different purposes in various domains of life to accomplish other things, such as formal education or personal relationships. Apart from AOA and proficiency, bilinguals differ based on how much they use each language to achieve multiple purposes (e.g., home vs work). (Grosjean, 2008) pointed out that the "amount of use of each language over the years plays a role on how well the language is known". Linguistic experiences such as speaking, listening, reading, and writing share and enhance their relationship. These linguistic experiences in bilinguals are complex and can involve language proficiency and usage changes over time. This change can impact the speed and accuracy of the psycholinguistic processes (comprehension and production tasks).

Research suggests that both languages are active while bilinguals listen, read, or plan to produce speech, irrespective of the response language (Colomé, 2001; Dijkstra & Kroll, 2005; Kroll et al., 2006). For instance, (Colomé, 2001) asked Catalan(L1) - Spanish(L2) bilinguals to decide whether a phoneme was present in the Catalan name for a picture shown. The phonemes were presented in Catalan /t/ for 'taula' or Spanish /m/ for 'messa' (translation equivalent) or /f/ as a control condition for the picture (table). The participants were slower to respond "no" when the phoneme appeared in translations equivalent to Spanish compared to the control condition. This delay in processing indicated that the non-target language (Spanish) was available during the processing in the target language (Catalan), and the non-target language was active up to the level of phonology (refer to sections 1.1 and 1.2 for stages involved in speech production). In this context, understanding the interactions that arise due to the parallel activation of languages and whether this activation leads to cross-linguistic competition or is restricted to within-language competition during the processing of producing the word in L1 and L2 influences the bilingual lexical selection.

The complexity of managing more than one language presents challenges that surpass those encountered when dealing with a single language. The need for bilingual individuals to maintain distinct languages and effectively coordinate between them raises a fundamental question at the core of extensive research on bilingual language processing. The cognitive ability of bilinguals to effectively control their language represents a remarkable achievement. Evidence suggests that both languages are active during comprehension (Blumenfeld & Marian, 2013; Wu & Thierry, 2010), and production (Caramazza & Costa, 2000; Spalek et al., 2014), even when only one language is required to process. Even highly proficient bilinguals encounter difficulty in completely suppressing the language that is not in use (Colomé, 2001; Gollan & Kroll, 2001; Hermans et al., 1998; Van Hell & Tanner, 2012). This indicates that bilingual individuals possess the necessary cognitive mechanisms for managing the two languages. However, there is still ongoing debate concerning whether activated elements in the two languages compete for selection, and if so, how this competition is resolved and at what level (Bloem & La Heij, 2003; Costa et al., 2006; Finkbeiner et al., 2006). One plausible mechanism proposed for resolving this competition is inhibition (Green, 1998; Linck et al., 2008).

The impact of managing two languages has been identified as conferring cognitive benefits, known as bilingual advantage (Bialystok, 2009; Green, 1998). Executive function (EF) is an umbrella term. It includes inhibition, conflict resolution (ability to inhibit task-irrelevant information), cognitive flexibility (ability to switch between tasks), and working memory (ability to store, manipulate, and update information on an ongoing task). An efficient working memory capacity is required to monitor and activate the two languages and choose the appropriate target language (Martin-Rhee & Bialystok, 2008; Miyake & Friedman, 2013). Additionally, bilingualism has been shown to protect against cognitive decline, meaning individuals who speak more than one language have shown a 4-year delay in the onset of Alzheimer’s disease compared to monolinguals (Alladi et al., 2013). While research on non-verbal executive function tasks largely favours the existence of a bilingual advantage, it would be an oversimplification to claim that the management of two languages consistently leads to improved EF. For example, bilingual participants may be disadvantaged in verbal tasks such as verbal fluency (naming items as many as possible in a minute from the given category or letter) compared to monolingual individuals (Zeng et al., 2019). Bilingual advantages are not found in all bilinguals, nor do they exhibit benefits in every task involving conflict resolution or benefits in EF throughout their lives (Kroll & Bialystok, 2013). The impact of bilingualism on executive functions (EFs) is the subject of ongoing exploration, and the inconclusive results (refer to section 1.6.1) on bilingualism and inhibitory control are further discussed.

The word production process has been extensively studied in monolingual and bilingual speakers. Various methodologies have been developed to investigate the stages involved in producing a word up to the point of articulation. These approaches include behavioural experiments using response time and accuracy measures in picture naming tasks and word repetition and neuroimaging measures such as FMRI, functional resonance imaging and electroencephalography (EEG) to see which areas of the brain are involved in different stages during word production. The present thesis is focused on word production using widely accepted picture naming tasks. Therefore, the rest of the thesis will be referred to as producing a word during picture naming. Models of bilingual word production are based on the models of monolingual word production with alteration for the addition of a second language. Understanding the stages of monolingual word production is an essential first step in exploring the mechanisms underlying bilingual speech.

## 1.1 Stages of word production during picture naming in Monolinguals

Word production has been intensively studied in monolingual speakers in psycholinguistics. There is a consensus over the necessary *stages (components of the system) and steps (mapping between components)* of the word production system. Following Levelt (1989), these stages are (1) conceptualisation – where *semantic* features of the word's concept are determined; (2) linguistic formulation – where the lexical representation or word form is identified and selected; and (3) articulation – where motor processes required to produce the word are retrieved. This thesis is primarily concerned with processes at the linguistic formation stage, which is referred to as *lexical access.* Lexical access is further subdivided into two phases. Lexical retrieval refers to selecting a lexical item or word that best corresponds to the semantic representation, and phonological retrieval, in which the sound structure of the lexical item is retrieved. As such, lexical access is also referred to as two-step-staged processing (Caramazza & Miozzo, 1997; Rapp

& Goldrick, 2000), whereby the first step maps semantic to lexical information and the second step maps lexical to phonological details. While the two-step processes are agreed upon, different theoretical positions have been put forward regarding the nature of the representation at each stage and the information flows across the steps. Two key word production/lexical access models reflect these positions: The Interactive Two-Step model (Dell & O'Seaghdha, 1992) and the WEAVER++ model (Levelt et al., 1999).

The first difference between the Interactive Two-Step model (Figure 1) and the WEAVER++ model (Figure 2) concerns the representation of semantic information. Conceptual information in the WEAVER++ model is represented as single semantic nodes, whereas the Interactive Two-Step model represents semantic information as activation patterns over a collection of semantic features. Despite this critical difference, both models allow activation to spread to semantically related lexical competitors of the target item through a process of spreading activation. In the WEAVER++ model, this is instantiated as activation spreading between semantically related conceptual nodes, which, in turn, map to corresponding lexical items. In contrast, in the Interactive Two-Step model, activation spreads from semantic information to semantically related lexical because of shared semantic features. Thus, lexical selection can be described as "competitive" in both models. To select a lexical item from this competitive system, both models rely upon levels of activity of lexical units and select the unit with the highest level. In addition, the WEAVER++ model includes a verification process which evaluates whether the selected lexical item represents the intended concept at the lexical level.

The second difference between the Interactive Two-Step model (Figure 1) and the WEAVER++ model (Figure 2) is how information can flow through the model. Information flow in the WAVER++ model can be described as "serial", in which processing at each stage must be completed before the next stage. In other words, phonological processing begins only after the lexical selection. In contrast, activation in the Interactive Two-Step model can be described as "cascaded", in which activation can flow to lexical and phonological stages before completion of higher-order stages. According to the cascaded/interactive view of lexical access, the spreading activation principle is applied between all the levels of representation involved in lexical access (the semantic, lexical, and phonological levels). By contrast, the serial stage models restrict this principle to the semantic and lexical levels, preventing the phonological activation of non-selected lexical nodes.

The third key difference between the models regards the direction of information flow across the steps of the model. WEAVER++, as a top-down model, advocates unidirectional information flow from higher to lower-order components. As processing is serial, lexical selection is completed before phonological encoding, and this model does not allow phonological processes to influence lexical selection. In the Interactive model, information can flow bottom-up and top-down. Interactivity enables activity at the lexical level to influence activity at the semantic level and information at the phonological level to influence lexical activation. In addition, it allows phonological properties associated with lexical items to boost the activation of the lexical item from bottom-up feedback. The interactive nature of processing in the interactive model enables this type of bottom-up influence.

Figures 1 and 2 summarise these key differences by using the example of the production of the word "cat".

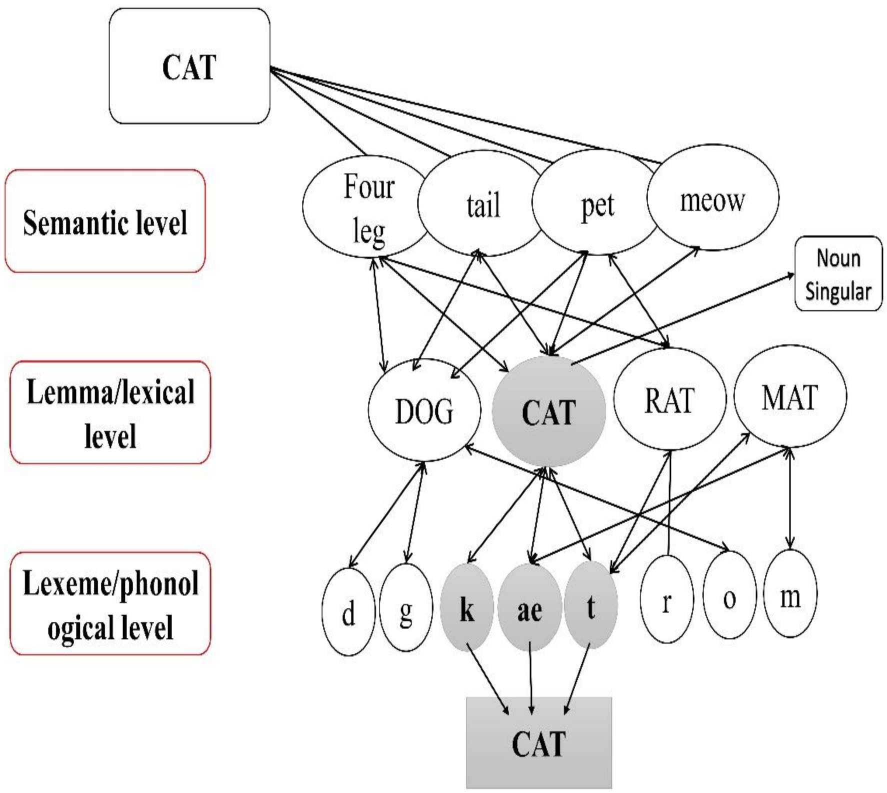


**Figure 1** Interactive two-step model of lexical access. This model's arrows are bi-directional and represent the interaction between the levels.

The spreading activation is carried out through a semantic, lexical, and phonological network. For instance, when naming a picture of a CAT, in the process of lexical retrieval, the semantic representation of CAT spreads activation through the network. This semantic representation activates the lexical unit for the target picture CAT, and semantically related lexical nodes which share the features with the target picture, such as DOG and/or RAT, and phonologically related words, such as MAT or RAT, get activated from the bottom-up spread of activation from shared phonological units (e.g., /ae/ and /t/). Lexical selection is made by selecting the highest activated lexical node with an appropriate grammatical category from the activated ones. Thus, this model assumes that the selection system is aware that the system is looking for singular nouns to be selected. Phonological encoding begins by boosting the activation of the selected word (CAT). The activation spreads again through the network in both directions (up towards the semantic and down towards the phonemes) for a fixed period. Following that, most activated phonemes get selected (kaet) and articulated.

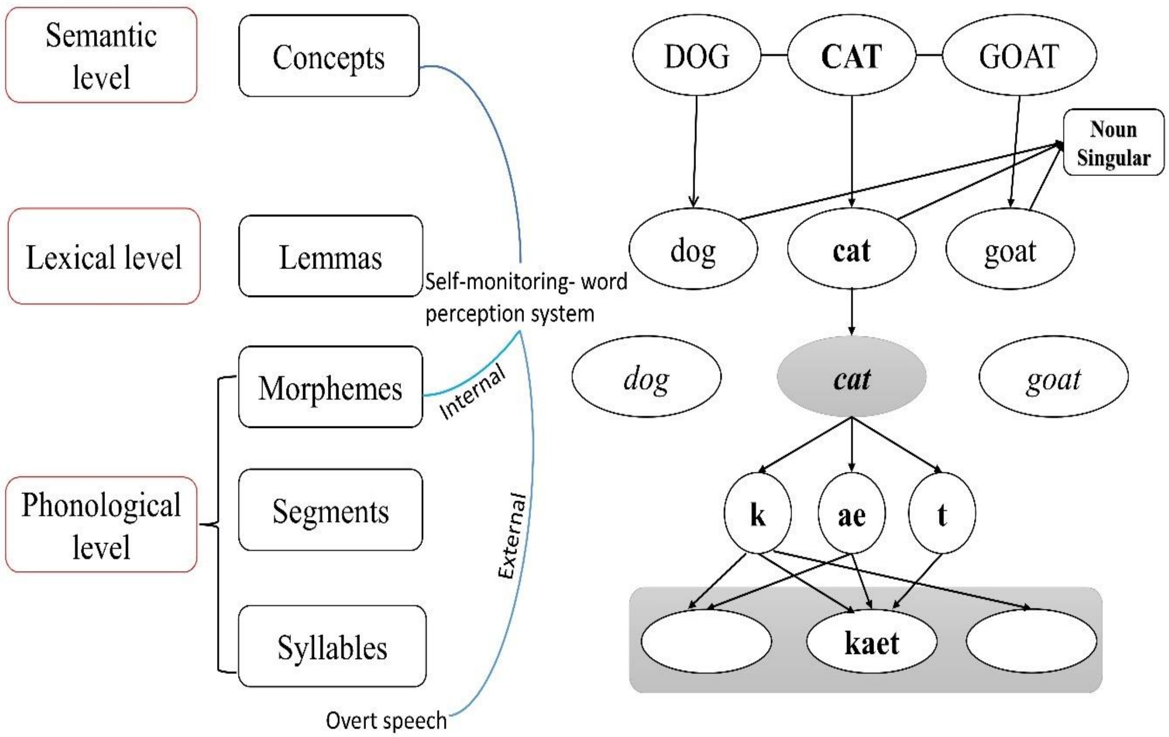


**Figure 2** WEAVER++ model of lexical access. The arrows in this model are unidirectional and represent that the activation flow is serial.

The WEAVER++ model of lexical access represents lexical concepts as single nodes, unlike the collection of features as described in an interactive model. In this example, when naming a picture of a CAT, the lexical concept (CAT) spreads activation to related concepts (e.g., DOG, GOAT) and lexical nodes (CAT, DOG and GOAT). As this model of lexical access proceeds in serial order, phonological properties are not activated during access to lexical nodes. The lexical selection mechanism is competitive as the selection of a lexical node depends on the activation of other lexical nodes (e.g., DOG and GOAT in the current example). If the intended lexical node CAT has reached the highest activation threshold, it gets selected compared to DOG and GOAT. In the next stage, phonological encoding begins only for the chosen lexical unit (CAT) as per the serial order of processing. The phonological level consists of multiple stages, which include: 1. Retrieval of *morphophonological code* – The speech sounds, or phonemes required of the target morpheme are activated and organised into a sequence /CAT/; 2. *Phonological encoding* – includes syllabification and metrics. Syllabification is a process to manage the phonemes /k/ /ae/ /t/ into syllable-sized units /kaet/ along with the intonation and stress patterns (metric coding) based on the language. *3. Phonetic encoding:* The speech production system is a set of stored representations of specific syllables. The system activates the appropriate syllable representations and places them in proper positions in the frame. The motor system uses this representation to prepare the gestural code for articulation. (Levelt et al., 1999) WEAVER ++ emphasises that self-monitoring is achieved through the cognitive process (attention control) at the conceptual level via the word comprehension systems (monitoring internal or external speech). When naming a picture of a CAT (refer to Figure 2), the phonological word representation of the picture name CAT is fed into the word comprehension system (internal), which examines the recognised word corresponding to the intended lexical concept chosen for production. The overtly articulated picture name is verified by comparing whether the recognised phonemes correspond to the selected lexical form in production (external monitoring).

Irrespective of the mechanism involved, both models (Interactive two-step and WEAVER++) agree that many semantic representations are activated to a certain extent during picture naming. Keeping this in mind, if the spreading activation works similarly in bilinguals, does semantic-level processing spread activation to both languages? If the answer is no, then the word production would proceed monolingually. However, if activation spreads between languages, the word production process must entail a considerable divergence from monolinguals to resolve cross-linguistic influence/competition. In this situation, bilinguals must select the right word in the correct language. How does a bilingual select the target lexical node and avoid the lexical node from the non-target language? Before moving on to the manner of lexical selection in bilinguals, which is the main focus of the present thesis, it is crucial to understand how the systems (semantic, lexical and phonological) are thought to be organised and represented differently in bilinguals from that of monolinguals.

## 1.2 Bilingual word production

The stages in bilingual word production are considered the same (semantic, lexical, and phonological), but the systems must differ in their organisation to accommodate two (or more) languages. The following section discusses how the semantic, lexical, and phonological systems are organised in bilinguals. Later, the manner of lexical selection in bilinguals will be discussed in detail.

### 1.2.1 Structural organisation of bilingual representation

Models of lexical access assume that the semantic system and phonological system are shared by the two languages of a bilingual (Colomé, 2001; Costa et al., 2003; Green, 1986;

Hermans et al., 1998; Kroll & Stewart, 1994; Wu & Thierry, 2010). For instance, studies investigating shared semantic concepts using semantic cross-language priming have discovered that in highly proficient bilinguals, the magnitude of priming effects remains the same, irrespective of language direction (Perea et al., 2008; Travis et al., 2017; Zeelenberg & Pecher, 2003). Cross-language semantic priming refers to the presentation of semantically related words in the opposite language of the response, e.g. Spanish target /bosque/, meaning forest, with the prime word /tree/ in English. Similarly, semantically related distractor words have shown interference effects irrespective of the distractor language (Runnqvist et al., 2012). Although some qualitative differences between language semantic priming effects have been found in relevant studies (Francis & Goldmann, 2011), they predominantly support the notion of shared semantic/conceptual representation across languages in bilinguals. This is reflected in both comprehension and production models of bilingualism (Bilingual Interactive Activation+, BIA+: (Dijkstra, 2003); Inhibitory Control Model, ICM: (Green, 1998); Revised Hierarchical Model RHM: (Kroll & Stewart, 1994).

With respect to how word forms are represented in bilinguals, three views have been proposed: ***1. Separate lexicon:*** The word forms from each language are described separately (Kroll & Stewart, 1994; Potter et al., 1984). **2. *Integrated lexicon:*** Word forms from both languages are stored in a single system: BIA+ model (Dijkstra, 2003). 3. *Subset view* proposed by (Paradis, 1985)*: W*ord form from each language is distinct but interconnected within a more extensive extended linguistic system. In other words, two subsets of word forms are represented in a single lexical system, each tagged by a language node (Bot, 1992; Green, 1998, 1986; Grosjean, 2001). Most of the current accounts of bilingual lexical organisation assume an integrated lexicon or form of integrated view (a subset concept with the inclusion of language node), meaning that words from different languages are stored together (Dijkstra et al., 2019; Green, 1998; Grosjean, 2001). In addition, it has been shown that the presence of parallel activation of words in both languages, even in a purely monolingual context (the situation in which there is no need for activation of the other language), is suggestive of non-selective lexical access (Kroll et al., 2006; Thierry & Wu, 2007).

The evidence for parallel activation comes from different studies, for example, *cognate* effects observed by (Costa et al., 2000; Hoshino & Kroll, 2008). Cognates are words which are similar in form and meaning. Catalan-Spanish bilinguals named the pictures with cognate names faster than those with non-cognate names, and the effect occurred both with picture naming in the more robust L1 (Catalan) and the weaker L2 (Spanish). However, it appeared to be larger in L2. Colomé (2001) reported that translation effects are seen during phoneme monitoring tasks. He conducted three experiments in proficient Catalan-Spanish bilinguals where participants provided pictures along with a phoneme which could be part of L1 (Catalan) or L2 (Spanish) or a neutral phoneme (does not belong to L1 or L2 picture name). The participant's task was to decide whether the given phoneme was in the Catalan name of the picture. The delayed response of participants to say no in the presence of Spanish phonemes for the target picture name compared to the neutral condition indicated the presence of non-target language during the processing of the target picture name in Catalan.

Similarly, recent studies have found non-selective phonological access in bilinguals, even in different script bilinguals, representing an integrated phonological system (Peleg et al., 2020; Zhou et al., 2010). For instance, Zhou et al. (2010) examined homophone priming (e.g., words with the same pronunciation /new-knew/ but different meanings) in Chinese-English bilinguals. Results revealed that homophone priming effects were present in the naming task and a lexical decision task in both directions (L1-L2 and L2-L1).

Given that lexical access appears to be non-selective, meaning semantic representation activates the lexicon from both bilingual languages simultaneously, even when they are required to respond in one language alone (Colomé, 2001; Costa et al., 2003; Hermans et al., 1998; Thierry & Wu, 2007; Wu et al., 2013), this results in what is known as the "hard problem" (Finkbeiner et al., 2006). Essentially, this refers to how bilinguals achieve lexical selection in the target language and how interference from the non-target language is avoided. The following section provides a critical overview of the lexical selection mechanism and the most relevant evidence supporting it.

### 1.2.2 Mechanisms of bilingual lexical selection

There are two opposing theoretical positions regarding the degree of cross-language lexical competition during lexical selection: (1) Language-specific accounts and (2) language-non-specific accounts. These accounts agree that lexical access is a competitive process. However, they differ on whether the competition is restricted to within-language lexical nodes or whether competition is between language lexical nodes.

#### *1.2.2.1 Language-Specific Accounts*

The ***concept selection account*** postulates that the intended language is already specified at the conceptual level (see Figure 3). This results in only the activation of lexical nodes from the target language with no activation of non-target lexical units. This account best aligns with serial production models, in which information flows relatively in a serial-order fashion from higher to lower-order elements (Bloem & La Heij, 2003; La Heij, 2005). Under this account, there is no interference from the non-target language as those lexical units do not reach sufficient activation levels to compete as they do not receive semantic input. While this account directly explains how bilinguals select words in the appropriate language, it presents several challenges that must be addressed. Firstly, a significant body of empirical evidence contradicts the notion of entirely serial processing in language production (Caramazza & Miozzo, 1997; Dell & O'Seaghdha, 1992; Navarrete & Costa, 2005). Additionally, experimental evidence shows that parallel activation of lexical items from both languages persists, even when bilinguals aim to communicate exclusively in one language (Colomé, 2001; Costa et al., 2003; Hermans et al., 1998; Thierry & Wu, 2007). Collectively, these cast doubt on the concept selection account and the extent to which it captures bilingual language control.

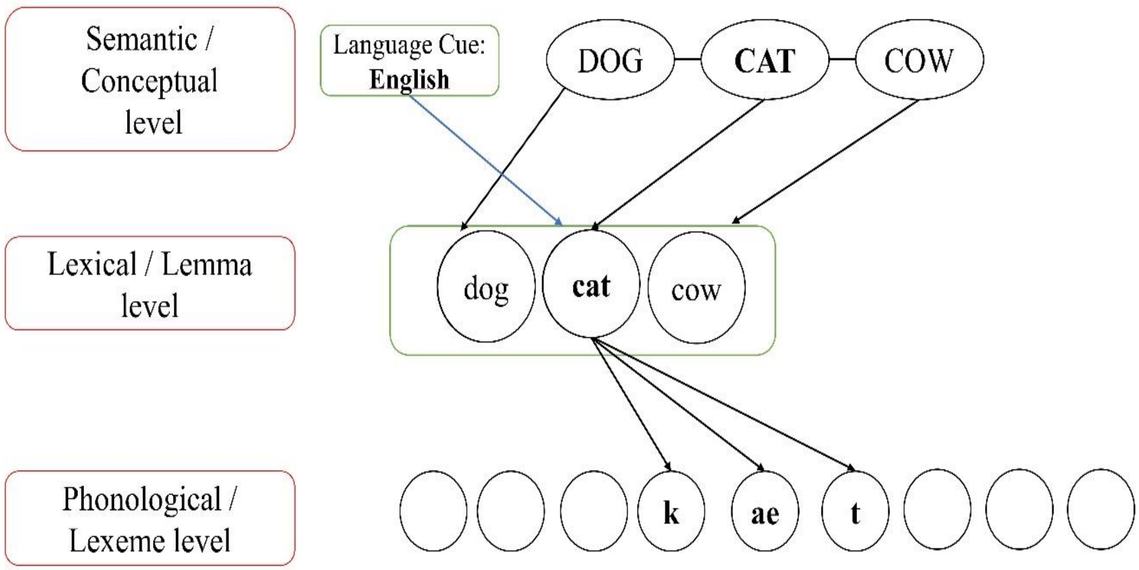


**Figure 3** Schematic representation of activation of only target language lexical nodes at the lexical level based on concept selection account of language-specific lexical selection.

***The language-specific selection account proposed by Costa and collaborators*** (Costa & Caramazza, 1999; Navarrete & Costa, 2005) embraces the spreading activation principle. Accordingly, this account posits that semantically related words activate languages (see Figure 4). However, words in the non-target language do. The selection of appropriate language is assumed to be instantiated as a monitoring device external to the lexicon, capable of directing the entire lexical search to the target language while ignoring the activated words in the non-target language.

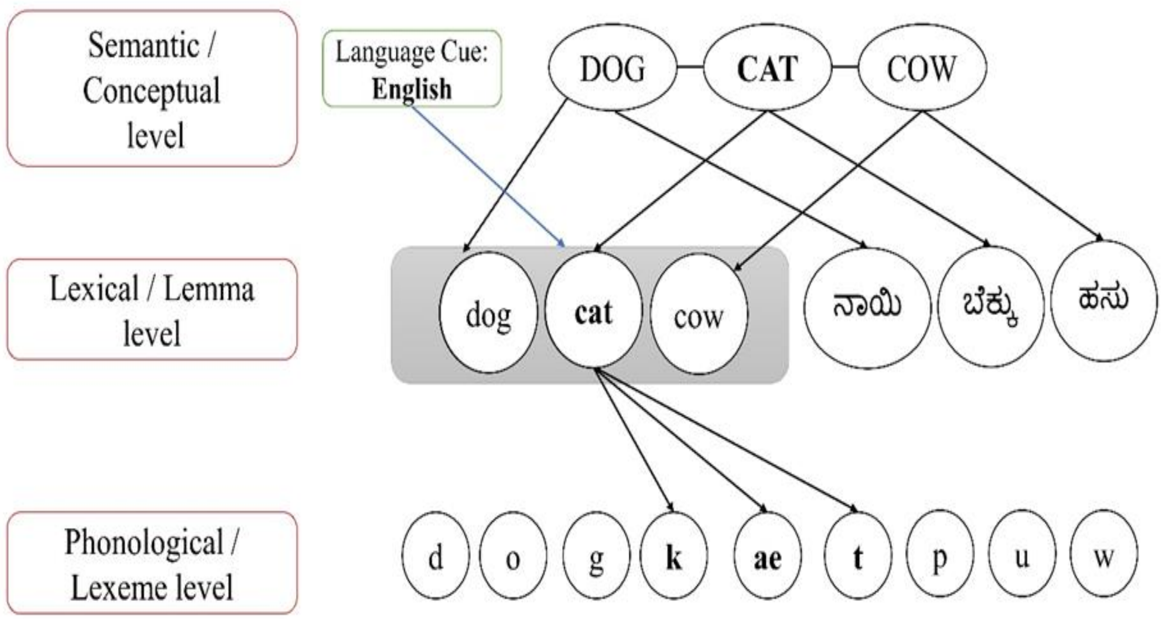


**Figure 4** Schematic representation of the activation of both language distractors according to the language-specific selection account. The Kannada English pair [CAT] illustrated. Arrows indicate activation. The shaded area indicates within language competition, and thickness suggests the activation of lexical nodes.

#### *1.2.2.2 Language non-specific accounts*

According to language non-specific accounts, not only the semantic representation simultaneously activates the target and related lexical nodes in both languages of the bilingual, but the non-target language translation equivalents also compete for selection (Bot, 1992; Green, 1998; Hermans et al., 1998; La Heij, 2005; Lee & Williams, 2001). An inhibitory control mechanism has been proposed to resolve this cross-language interference by suppressing the words from the non-target language (see Figure 5), known as The Inhibitory Control Model, ICM (Green, 1998, 1986). When a bilingual intends to speak in a specific language (e.g., English), the suppression of the non-target language (e.g., Kannada) is facilitated through an external task schema that regulates the output goal (e.g., "name in English"). The language schemas work to inhibit the activation of all word forms corresponding to incorrect language tags. Consequently, the translation equivalent lexical node and semantically associated words in the non-target language would be inhibited.

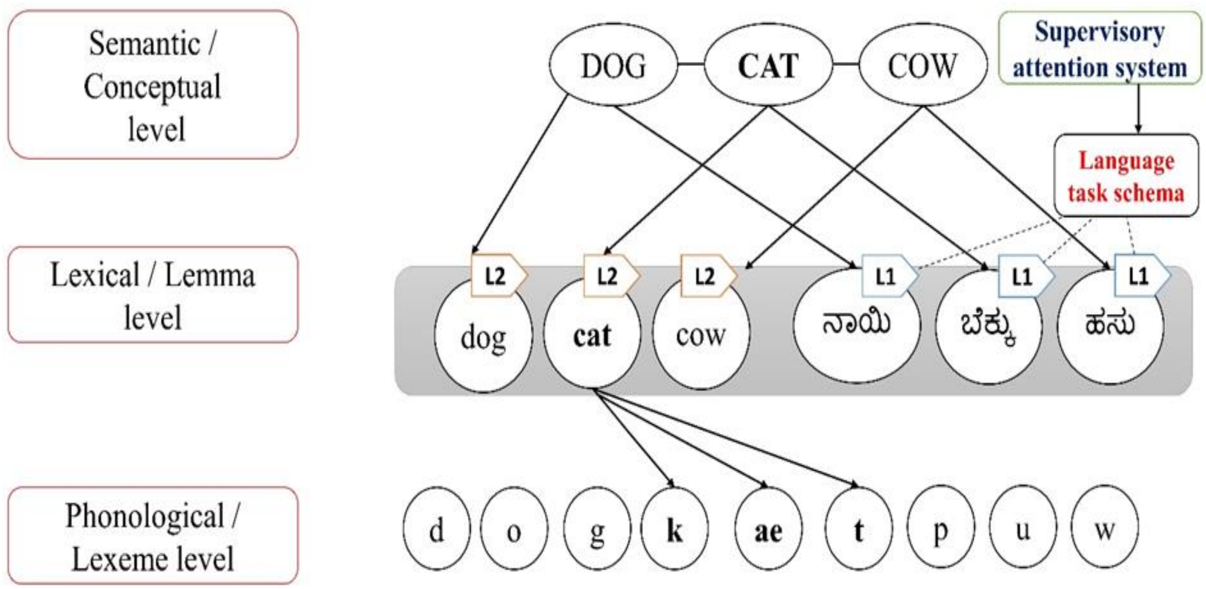


**Figure 5** Schematic representation of the activation of both language distractors according to the language non-specific selection account. The Kannada English pair [CAT] is illustrated. Arrows indicate activation. The shaded area indicates cross-language competition at the lexical level, and thickness suggests the activation of a lexical node.

There are several key assumptions related to the inhibitory control mechanism. Inhibitory control is important because the inhibition applied to a given language depends on the strength of activation of the represented lexical nodes, known as reactive inhibition. Therefore, when naming in L2, inhibition applied to L1 is higher than vice-versa. Additionally, the activation of previously inhibited lexical nodes requires more time. As a result, the stronger the inhibition applied, the more time is needed to overcome it. For example, recovering from L1 inhibition takes more time and cognitive resources than in the case of L2. Therefore, if the lexical selection is language non-specific, one can expect to see some correlation between the performance on language control and executive function tasks such as inhibitory control.

#### 1.2.2.3 The Dynamic Account: A Third Perspective

While the language-specific and language-non-specific accounts sit at opposite ends of a spectrum, a third account can be considered a combination of language-specific and language-non-specific positions within a bilingual in a specific context: the dynamic view of lexical selection. The dynamic view ***is based on Grosjean's language context hypothesis*** (Grosjean, 2001): Language context is the activation state of the bilingual's two languages and language processing at any given time (Grosjean, 2012). According to this view, bilingual individuals exist on a continuum between monolingual and bilingual contexts. In the monolingual context, lexical selection resembles a language-specific process, with higher activation for the target language and minimal activation from the non-target language. The target language will be activated to higher levels in the bilingual context, and the non-target language will be active more than in the monolingual context. This results in lexical selection resembling the language non-specific account. The language context consists of two components: the chosen base language and the comparative activation of the bilingual's two languages. Bilingual individuals can place themselves anywhere along the continuum, and the extent to which they move along it may vary between individuals.

The following section examines the evidence supporting language-specific, language-non-specific (inhibitory mechanisms) and dynamic views of lexical selection, which have relied heavily on the picture-word interference paradigm.

## 1.3 The method employed to study lexical selection in bilingual word production

The Picture-Word Interference (PWI) paradigm, introduced by Rosinski et al. (1975), is commonly used in bilingual word production studies to investigate the nature and locus of lexical competition during lexical selection. In this paradigm, participants are asked to name a picture in one language while ignoring a distractor word presented in the same or different language. Distractor words can be related to the target item in various manners, e.g., semantically or phonologically related. Distractor words can be presented in spoken or written forms and at different times compared to the presentation of the picture, known as Stimulus Onset Asynchrony (SOA). SOAs (Stimulus Onset Asynchrony) can be early/negative (distractor word presented before the target picture), zero (distractor word and target image appearing simultaneously), or late/positive (distractor word presented after the target picture). The presence and type of distracter effects provide insights into the nature of processing within and between stages of word production. At the same time, SOA supplies insights into the timescale of these processes.

PWI studies typically reveal two main effects: semantic interference at early and zero SOAs and phonological facilitation at later SOAs. Semantic interference effects manifest as slower naming responses when the distractor word is semantically related to the target picture compared to unrelated words. Semantic interference occurs because the distractor word receives activation from semantic units associated with the target picture and distractor, leading to enhanced lexical competition during selection (Costa et al., 1999; Levelt et al., 1999). Phonologically related distractor words at later SOAs result in facilitation effects by enhancing the activation of shared phonemes, leading to quicker lexical selection and naming responses (Bi et al., 2009; De Zubicaray et al., 2002; Schriefers et al., 1990). A further distractor type – phono-translation – has been used to explore cross-linguistic influence during word production. Phono-translation distractors are phonologically related to the target picture through translation. Another type of distractor – translation equivalent distractor – is a distractor word from another language. As mentioned earlier, examples for each of the distractors are provided in Table 1.

**Table 1** Examples of related (semantic and phono-translation) and unrelated distractors in English and Kannada for target picture naming in English (COW).

| **Variables** | **Target language English (cow)** | **Non-target language Kannada (hasu)** |
|---|---|---|
| Unrelated | pillow | dimbu (pillow) |
| Semantic | sheep | kuri (sheep) |
| Phono-translation | Hump | kallu (stone) |
| Translation | cow | Hasu (cow) |

## 1.4 Evidence supporting various lexical selection mechanisms

### 1.4.1 Cross-language interference effects in closely related languages:

Semantic interference is often seen as a reflection of the competition between semantically related words during lexical selection (Levelt et al., 1999; Lupker, 1979; Schriefers et al., 1990). Semantic interference has been explored in bilinguals through the PWI paradigm where the target is named in one language (e.g., English; table), and the distractor word is presented in other languages (e.g., Spanish; silla [chair]) (Abdel Rahman & Aristei, 2010; Aristei et al., 2012; Hermans et al., 1998).

Cross-language semantic interference has generally been interpreted as supporting language non-specific selection models like the Inhibitory Control Model: ICM (Green, 1998), which suggests that non-target language lexical nodes compete for selection during the processing of picture naming in the target language. However, (Costa et al., 1999) proposed an alternative explanation in which the locus of cross-language semantic interference is the target lexicon. They argue that the distractor word in the non-target language (silla) activates its translation equivalent in the target language (chair), and a delay in the selection of picture name (table) could be induced by translation (chair) rather than by the distractor word itself (silla means chair).

To find supporting evidence for their proposal, Costa et al. conducted a series of PWI experiments where the (Spanish) distractor word mesa (table) was the translation of the target picture name into English (table). Since the translation equivalents have strong overlap and the same semantic representation, one would expect interference if cross-language competition is at play in models like ICM. On the other hand, if cross-language competition develops from within language interference, as Costa et al. (1999) argued, one can expect a facilitation effect since the distractor word co-activates the same lexical entry as the picture through automatic translation. Indeed, facilitation was seen by (Costa & Caramazza, 1999). Some authors have argued that this facilitatory effect might be stronger than the cost of resolving cross-language competition (Abutalebi & Green, 2007; Hermans, 2004; Hoshino & Kroll, 2008), indicating that lexical competition might occur at the lexical level, but then it would be over-ruled by a stronger priming effect originating at the conceptual level.

As both language-specific and language-non-specific views can explain semantic interference, this effect cannot discriminate between lexical selection mechanism hypotheses in bilinguals. Instead, a semantic interference effect provides evidence for a competitive lexical selection process (Bürki et al., 2020).

In a PWI study by Hermans et al. (1998), highly proficient Dutch-English bilinguals named target pictures in their second language (L2), English, while ignoring auditory distractors in English or Dutch. Four distractor types were used: semantic distractors, phonological distractors, unrelated distractors, and phono-translation distractors. An example of the phono-translation distracter in Hermans et al. (1998), study is given for the target word "mountain", which is named in the presence of the distracter "bench", which is phonologically related to the Dutch for mountain "berg." The researchers hypothesized that the phono-translation distractors would cause interference by activating the translation word in the non-target language and may compete with the target word during lexical selection. The study also varied the stimulus onset asynchrony (SOA) between the target and distractor presentation to explore the time course of within and cross-linguistic effects. The results showed semantic interference effects in English at early SOAs (-300ms, -150ms, and 0ms) and in Dutch at -150ms SOA. Surprisingly, phonological facilitation effects were observed in English at all SOAs (-300ms, -150ms, 0ms, and +150ms) and in Dutch at +150ms SOA. Additionally, phono-translation interference effects were observed in English at 0ms and in Dutch at -300ms, -150ms, and 0ms. The authors concluded that cross-language activity occurs at the lexical level, as the phono-translation interference effects were present at the same level as the semantic interference effects.

Using two PWI experiments, Costa et al. (2003) replicated the phono-translation effects in highly proficient bilingual Spanish-Catalans. Native Spanish speakers named pictures in their L2 (Catalan) while ignoring auditory phono-translation and unrelated distractors presented in L1 at three SOAs (-150ms, 0ms, and +150ms). The results indicated a phono-translation interference effect at all three SOAs, similar to the study by Hermans et al. (1998). However, some participants reported noticing the relationship between the target's translation and distractor. Hence, the authors thought such interference might be due to participants strategically observing the relationship between the target's translation and distractor rather than an automatic process behind the presence of phono-translation interference effects. Therefore, Costa et al. (2003) conducted a follow-up experiment to investigate the reliability of phono-translation effects in a different set of highly proficient young Spanish-Catalan bilinguals by reducing related distractor conditions (phono-translation distractors) and increasing the unrelated distractor condition.

Results revealed that reliable phono-translation interference effects were still present when the pictures were named in L2 with distractors in L1. However, these effects were only observed at +150ms, an SOA typically associated with a phonological activity level. This suggests that distractor words were activated up to the phonological level and, through a bottom-up approach from the phonological level, can influence the lexical selection. Finally, (Hoshino & Thierry, 2011) conducted a similar experiment with highly proficient Spanish-English bilinguals with a single SOA of 0ms (i.e., picture and distractor presented simultaneously) and found a significant phono-translation interference effect. Overall, these studies (Costa et al., 2003; Hermans et al., 1998; Hoshino & Thierry, 2011) support the language non-specific lexical selection.

### 1.4.2 Cross-language interference in distant languages:

A few studies have explored cross-language activation with typologically distant bilinguals. Deravi (2009) conducted three PWI experiments with highly proficient early Persian French bilinguals. The participants named the pictures in their L2 (French) while disregarding visually presented distractors in their L1 (Persian) in Experiment 1 and auditorily presented distractors in their L1 in Experiment 2. In Experiment 3, the pictures were named in L1 (Persian), and auditory distractors were presented in their L2 (French). All three experiments yielded conflicting outcomes, making it challenging to interpret lexical selection as either language-specific or non-specific. Significant distractor-type effects were observed in Experiment 1 with L1 visual distractors.

Semantic, phonological, and phono-translation distractors facilitated the naming process in L2 compared to unrelated distractors at SOAs (-150, 0, and +150ms). However, experiment 2 with L1 auditory distractors yielded contrasting findings. It revealed facilitation effects of semantic and phonological distractors and interference from phono-translation distractors only at -300ms. Experiment 3 showed that L2 semantic, phonological, and phono-translation distractors facilitated picture naming in L1 at early SOAs (-300 and -150ms). However, at later SOAs (0 and +150ms), phono-translation and semantic distractors caused interference, increasing response time. Phonological facilitation effects remained at later SOAs. The activation of phonological distractors occurred early in the speech production stages, interacting with lexical and semantic levels through a bottom-up approach. While challenging to interpret, these results support a highly interactive word production network with evidence for language non-specific activity based on phono-translation effects. These results also highlight potential differences based on the modality of distractor (written vs. spoken). The authors also report that the effects observed in their study support Costa & Santesteban (2004) view that early bilinguals can attentively select the desired language.

Boukadi et al. (2015) also used PWI to study contextually proficient Tunisian Arabic and French speakers. They replicated the phono-translation interference effect with cross-language auditory distractors but found no effect when the picture and distractor appeared in the same language (monolingual context). As indicated by phono-translation interference effects, cross-language competition exclusively in a bilingual context supports the dynamic model of lexical selection in bilinguals proposed by Grosjean (2001).

According to the language context hypothesis, the non-target language is always active in monolingual and bilingual contexts. However, the activation level of the non-target language is minimal in a monolingual context (when the target picture and distractor are presented in the same language), leading to language-specific lexical selection. In contrast, in a bilingual context (where both the target and non-target languages are active), lexical selection occurs in a language-non-specific manner. Therefore, lexical selection can be dynamic, allowing bilinguals to perform in both language-specific and non-specific ways depending on the context.

Hoshino et al. (2021) investigated whether script differences can influence the manner and locus of the lexical selection process by comparing bilinguals with the same script (Spanish English) to those with different scripts (Japanese English). Their PWI paradigm included semantic, phonological, phono-translation, translation equivalent, and unrelated distractors. In Experiment 1, Spanish-English bilinguals performed a PWI task by naming in their L2 (English) while disregarding visually presented distractors in L1 (Spanish). In Experiment 2, Japanese-English bilinguals performed the same task. The results showed that both Spanish-English and Japanese-English bilinguals had facilitation effects in common for translation-equivalent distractors (e.g., target picture "dog" presented with a distractor in Spanish, "perro," or in Japanese-kanji, "inu" meaning dog). Spanish-English bilinguals exhibited results similar to previous studies using closely related scripts; they observed semantic interference (target picture "dog" with a distractor word "gato," meaning cat), phonological facilitation (target picture "dog" presented with a distractor word "doll"), but phono-translation facilitation effects (target picture "dog" with a distractor word "pega," which is phonologically related to the target picture in the Spanish language, "perro") instead of interference.

In contrast, Japanese-English bilinguals with different scripts showed no semantic interference, phonological facilitation, or phono-translation interference effects. The authors argued that the distinctive script acted as a perceptual cue from the visually presented distractors, guiding Japanese-English bilinguals to activate lemmas in the target language earlier in the speech planning process, resulting in competition for selection within the language and a language-specific approach. The authors interpreted that the phono-translation facilitation effect, unlike the interference seen in Hermans et al. (1998), is a consequence of their experimental methodology. They hypothesized that including translation equivalent distractors in their present study resulted in phono-translation facilitation because, like translation equivalent distractors, the phono-translation distractors activate the translation equivalent distractor, facilitating the naming response. In support of the argument, their earlier study Hoshino & Thierry (2011) in Japanese-English bilinguals resulted in a phono-translation interference effect like Herman's when there was no translation equivalent distractor.

Recently Chen et al. (2022) explored lexical selection in context rate to highly proficient Chinese-English bilinguals in both directions using the PWI paradigm. The study utilised three visual distractors presented simultaneously with the picture: semantically related, unrelated, and translation equivalent. Chinese-English bilinguals named the pictures in L1 and L2 while disregarding the distractors presented in the opposite language of naming (e.g., L1 naming with L2 distractors and vice versa). Semantic interference and translation facilitation suggest a language-specific lexical selection mechanism. According to that, semantic and translation distractors use the exact mechanism (within the language competitive view). For example, L1 semantic distractors activate its translation equivalent in L2, which competes with L2 while naming in L2, resulting in semantic interference (within language). Similarly, the L1 translation distractor uses the same mechanism while naming in L2, which activates the translation equivalent in L2, which is nothing but the target name, resulting in a facilitation effect. The results revealed a semantic interference effect (slower naming response with semantic distractors) and a translation facilitation effect (faster naming response when the distractors were the target names in the non-target language) compared to unrelated distractors in both L1 and L2 naming, supporting the language-specific lexical selection.

To summarise, previous research on bilingual lexical selection has shown the lexical selection to be language non-specific through the presence of semantic and phono-translation cross-linguistic interference effects (Costa et al., 2003; Hermans et al., 1998; Hoshino & Thierry, 2011). Moreover, these studies are also similar in their participants: highly proficient bilinguals speaking closely related languages, e.g., Dutch English (Hermans et al., 1998), Spanish English (Hoshino & Thierry, 2011) and Spanish Catalan (Costa et al., 1999, 2003). These languages share phonological, orthographical, or lexical properties. Thus, the proximity between the languages played a role in cross-language competition and interference effects. However, there is increasing support that language context/context modulates lexical selection and language control by the relative degree of activation of the two languages of a bilingual speaker (Abutalebi & Green, 2007; Kroll et al., 2006, 2012). Therefore, in some contexts (monolingual context, where the target and distractor are in the same language), bilinguals have been shown to use language-specific lexical selection mechanisms.

On the other hand, the previous research on bilinguals with distant languages and less advanced L2 proficiency resulted in varied patterns of lexical selection. For instance, contextually proficient Tunisian-Arabic French bilinguals showed dynamic lexical selection with auditory distractors (Boukadi et al., 2015) and language-specific lexical selection with visual distractors (Chen et al., 2022; Hoshino et al., 2021). Due to these inconsistencies, it is necessary to investigate the validity and reliability of cross-language effects by replicating the study in different distant language bilinguals with varied L2 proficiency. L2 proficiency is a vital factor in modulating the activation of non-target language and influencing the language selection in bilinguals (Green, 1998; Kroll et al., 2006, 2012), which will be discussed under bilingual factors in the next section.

## 1.5 Bilingual Factors

Bilingual language experiences are associated with diversity (age of L2 acquisition, how both languages are learned, proficiency, dominance, and how the two languages are used) and differ among bilinguals. For example, bilinguals noticeably differ in their second language (L2) proficiency relative to their L1 proficiency even when they have a similar learning environment (Roberts & Meyer, 2012). These differences in bilingual experiences have led researchers to investigate different aspects of bilingual factors and how they modulate language processing in bilinguals. Among these studies, many have concentrated on individual aspects of bilingualism [e.g., language proficiency (Costa & Santesteban, 2004); the age of L2 acquisition (Costa et al., 2006); language dominance (Chen et al., 2022); language experience (Bonfieni et al., 2020)]. However, a relationship exists across different variables of bilingual experience. In addition to the above factors of bilingualism, the linguistic pair L1-L2 and the typological distance between them operated by a bilingual influence language processing. Thus, it is necessary to investigate multidimensional aspects of bilingualism to capture its influence on lexical selection. The next section will discuss the controversial issue of typological distance in bilinguals and the importance of previous studies showing the influence of bilingual participant factors (proficiency and dominance) on the difference in language performance.

### 1.5.1 Typological distance and its operations in bilinguals

The typological distance of a language pair refers to how much difference or similarity between the languages impacts bilingual language processing. For instance, Pae (2018) reported that given the similarities based on the form between the Japanese Kanji and the Chinese written script, the attentional processes recruited by an L1 Japanese to learn Chinese written script differs from that of whose L1 is Indo-European.

This typological distance is a crucial yet underexplored factor, as controversy revolves around several key issues, which will be discussed further. For instance, behavioural researchers concerned with typological distance in bilinguals often isolate the linguistic parameter of script differences as a criterion to define typological distance, which in many instances pinpoints the comparison of Roman vs. non-Roman Scripts or alphabetic (e.g., English) vs. non-alphabetic language (e.g., Mandarin Chinese) writing systems. However, to what extent the script and writing systems represent the true nature of typological distance is not fully unpacked. For example, Korean and Japanese scripts broadly differ (which suggests that they are linguistically distant at first). However, they share solid structural similarities and linguistic roots (Oh & Yoon, 2016). Therefore, quantifying and defining linguistic distance can be challenging, considering the multiple linguistic aspects.

The linguistic distance can be measured in various ways, including phonological, grammatical, lexical, and syntactic differences. For example, the Japanese script kanji and Mandarin Chinese script Hanzi share significant overlap in their logographically but exhibit much less similarity to their phonetic and syntactic systems (Pae, 2018). Hence, the dichotomous term to what extent 'similar' or 'distant' is hard to define.

In the present thesis, phono-translation distractors are used to decide on the cross-linguistic influences of one language over the other. Thus, we consider the phonological differences between Kannada and English language pairs as a marker for determining the typological distance between languages.

Kannada is one of the major four Dravidian languages, predominantly spoken in the South Indian state of Karnataka. Globally, the Dravidian language is recognised as the fourth-largest family, encompassing more than 175 million speakers (Steever, 2015). The Kannada language comprises 43 phonemes, including ten vowels [V] (five short and long) and 33 consonants [C]. These consonants are classified into seven categories: stops, affricates, fricatives, nasals, laterals, flaps, and continuants. Among these, stop consonants and affricates feature voiced and unvoiced counterparts with aspirated style.

Phonologically, English and Kannada exhibit significant contrasts attributed to differences in word length, syllable structure, consonant clusters, and word neighbourhood effects. Kannada features of syllable structure: V, CV, CCV, and CCCV (mainly seen in borrowed/loan words). A distinctive feature of Kannada phonotactics (which refers to the study of rules governing the possible sequencing of phonemes) is that all words end with a vowel, unlike English, where a word can end with a consonant. In addition, the proportion of mono-syllabic words in English is much greater than that of bi- and multi-syllabic words. In contrast, Kannada predominantly features bi-, tri-, and multi-syllabic words, and mono-syllabic words are rare (Nag-Arulmani et al., 2003)In addition, Kannada has a simple CVCV word structure (e.g., 'a:-ne', 'mane', 'i-ru-li'). English, on the other hand, has significantly low ambisyllabic and CVCVCV word structures. The present thesis considers the above differences in the phonological structure of the Kannada and English languages as markers for describing the language pairs as distant.

### 1.5.2 The role of L2 proficiency is explained using the Revised Hierarchical Model (RHM, Kroll & Stewart, 1994).

The PWI task demonstrates the strength of competition between the lexical nodes depending on the activation levels of distractor words. The activation of distractor words depends on the flow of activation between the semantic-lexical networks (Costa & Santesteban, 2004; Levelt et al., 1999). Language proficiency plays a critical role in bilingual language control. Language control mechanisms in bilinguals are functionally dependent on high vs low proficiency (Costa & Santesteban, 2004). Therefore, language proficiency is an essential link between the lexico-semantic activation in bilinguals (Kroll et al., 2010; Kroll & Stewart, 1994). For instance, the Revised Hierarchical Model: RHM (Kroll & Stewart, 1994) postulates the existence of a direct link between the L2 lexical node and semantic store that gradually strengthens with increased L2 proficiency, and the link becomes bi-directional. Figure 6 below displays the RHM model. Issa et al. (2022) conducted a study on high- and low-proficient Arabic-English bilinguals to investigate the role of proficiency in the speed of lexical activation. They found no significant difference in reaction time between the low and high-proficient bilinguals while naming the pictures in L1 (Arabic). However, the role of proficiency significantly affected reaction time between the low and high-proficient groups while naming the pictures in their L2 (English). Bilinguals with higher L2 proficiency named the pictures in L2 significantly faster than low L2 proficient groups. The authors imply that bilinguals have a direct link between the semantic and lexical representation in highly proficient L2 speakers.

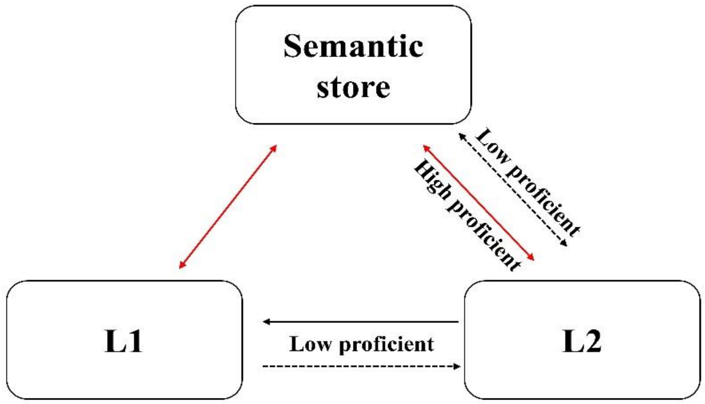


**Figure 6.** Revised Hierarchical Model (RHM, Kroll & Stewart, 1994)

RHM, this model represents the more robust connection between semantic and lexical and vice versa through darker bidirectional arrows in high L2 proficient bilinguals. The dotted bidirectional arrows represent the weaker links between the L2 lexico-semantic connections. Unidirectional arrows show L1-L2 lexical connections and darker unidirectional arrows represent the stronger L2-L1 lexical connections in low L2 proficient bilinguals.

### 1.5.3 Evidence for proficiency and dominance as modulating factors during lexical retrieval

#### 1.5.3.1 Language Proficiency

The PWI studies which investigated the lexical selection mechanism in bilinguals have shown cross-language interference effects through the presence of semantic and phono-translation interference effects in highly proficient bilinguals whose languages were closely related (Costa et al., 2003; Hermans et al., 1998; Hoshino et al., 2021). On the other hand, distant language bilinguals with less advanced L2 proficiency have shown lexical selection to be language-specific, at least in a monolingual context (Boukadi et al., 2015; Chen et al., 2022). Semantic and phono-translation interference effects in highly proficient bilinguals during the PWI task may be attributed to either proximity between languages (more similar languages lead to cross-language interference) due to higher L2 proficiency (L2 distractors are strongly activated) or both. According to the RHM model, in highly proficient bilinguals, L2 is conceptually driven, and thus, L2 semantic representation directly activates the L2 lexical nodes (Kroll et al., 2006, 2010). Higher L2 proficiency leads to more robust activation of L2 distractors. For instance, semantic distractors receive activation from both the distractor and the target picture in the PWI task, unlike unrelated distractors, which receive activation only from the distractor. Therefore, in the case of semantic distractors, activation within the semantic network and between the semantic and lexical nodes is increased, leading to competition between the target and activated lexical nodes from the distractor (Roelofs, 2018).

The previous experimental studies have shown semantic interference effects in highly proficient bilinguals when naming in L2 with L2 distractors (e.g., Dutch English (Hermans et al., 1998); Spanish English, (Hoshino & Thierry, 2011); French English, (Sudarshan & Baum, 2019); Chinese English, (Chen et al., 2022). This suggests that greater L2 proficiency activates the semantically related lexical nodes to sufficient levels to compete with the target selection in highly proficient bilinguals. However, semantic interference effects were absent when contextually proficient Tunisian Arabic-French bilinguals named the pictures in their L2 with L2 distractors indicative of semantic distractors not activated to an extent to cause interference may be due to less advanced L2 proficiency (Boukadi et al., 2015).

Cross-language activation up to the level of phonology has been found predominantly in high-proficient bilinguals and closely related languages using phono-translation distractors in PWI experiments e.g., Dutch-English (Hermans et al., 1998); Spanish-Catalan (Costa et al., 2003), although in French-English (Sudarshan & Baum, 2019) did not observe this effect. Despite this pattern in the literature, no significant associations have been observed between L2 proficiency and phono-translation distracter effects in PWI tasks. Three of the studies mentioned above that investigated the cross-language activation using phono-translation distractors in PWI tasks have found no significant effect of L2 proficiency on naming latencies (Boukadi et al., 2015; Klaus et al., 2018; Sudarshan & Baum, 2019).

#### 1.5.3.2 Language Dominance

The dominance of language may also have an impact on bilingual lexical selection. For instance, Dylman & Barry (2018) reported asymmetrical translation facilitation effects in different groups of highly proficient Spanish, English, Swedish-English, and English French bilinguals, with effects (translation facilitation) being more significant in L2 naming (faster response time) than L1. (Chen et al., 2022) also found similar effects in unbalanced Chinese-English bilinguals, but the magnitude of translation facilitation effects was smaller than in the previously reported study (Dylman & Barry, 2018). The presence of asymmetrical translation facilitation effects in bilinguals suggests language dominance impacting lexical selection.

On the other hand, smaller effects seen in Chinese-English bilinguals may be due to language dissimilarity compared to other studies [e.g., (Dylman & Barry, 2018); (Costa et al., 1999) in Catalan-Spanish; (Hermans, 2004) in Dutch-English (Roelofs et al., 2011) in Dutch-English bilinguals)]. Nonetheless, very few studies have compared lexical selection between the L1 and L2 production - lexical selection investigations in bilinguals have focused mainly on the influence of dominant L1 (Costa et al., 1999) in Catalan-Spanish; (Hermans, 2004) in Dutch-English; (Hoshino & Thierry, 2011) in Spanish English; (Hoshino et al., 2021) in Japanese-English, Spanish-English; (Roelofs et al., 2011) in Dutch-English; (Boukadi et al., 2015) in Tunisian-Arabic-French, (Sudarshan & Baum, 2019) in French-English bilinguals), while the investigations on the influence of less dominant L2 on L1 production are scarce (Costa et al., 1999) in Catalan-Spanish; (Klaus et al., 2018) in Dutch-English; (Dylman & Barry, 2018) in Spanish-English, Swedish-English; English-French bilinguals; (Chen et al., 2022) in Chinese-English bilinguals]. Klaus et al. (2018) investigated the phono-translation effects in Dutch English bilinguals who had acquired their L2 (English) during high school. In addition, this study examined the lexical selection in the opposite direction (naming in L1 with L2 distractors), unlike previous studies. Participants named the pictures in L1 while ignoring the auditory distractors in L2 (the less dominant language). The results revealed a significant phono-translation interference effect, which suggests that even L2 distractors can influence the dominant L1 naming. Overall, the above studies have shown that highly proficient bilinguals observed a relatively consistent pattern of interference effects in a monolingual context (naming in L2 with L2 distractors). Similarly, the absence of interference affects monolingual context (naming in L2 with L2 distractors) in less advanced L2 proficient bilinguals. Although these findings illustrate that L2 distractors were activated to a certain extent, sufficient to cause an interference effect in highly proficient bilinguals, the correlation or the mixed model analysis revealed no significant effect of L2 proficiency on the observed semantic or phono-translation interference effects on naming latencies. Therefore, the extent to which the L2 distractors are activated in less advanced L2 proficiency in distant language bilinguals is worth investigating as it reveals the direct effect of L2 distractors on naming latencies.

Similarly, language dominance has been shown to influence the lexical selection mechanism in bilinguals. Therefore, the influence of L1 and L2 distractors on L1 and L2 naming and the magnitude of difference in naming latencies between the L1 and L2 naming will reveal the language dominance effects on the lexical selection mechanism. To investigate how these bilingual factors influence lexical selection, measuring the linguistic profile of the participants in both languages is essential. The next section will discuss subjective and objective measures of bilingual language profiling.

### 1.5.4 Method used to capture the linguistic profile of bilingual participants.

Bilinguals are described based on several variables: proficiency, dominance, and language use (Gollan et al., 2012). Quantifying the level of bilingualism in terms of proficiency and dominance helps us to compare findings across studies of bilingualism in psycholinguistics (e.g., cross-linguistic comparisons to estimate the effects of bilingualism on language processing)

In bilingual research, language proficiency and dominance can be measured subjectively using questionnaires and objectively using tasks such as lexical decision tasks, lexical translation tasks, etc. Evidence shows that there may or may not be a relationship between subjective and objective measures. For example, (Gehebe et al., 2023) investigated the relationship between the subjective and objective measures of L2 proficiency across spoken and written modalities in young bilingual speakers of English and one other language. Strong correlations between the measures and modalities were seen for the high English exposed group, a correlation between the and modalities was significant but only as a measure of subjective rating in the medium English group, and a correlation between modalities was present in the low exposed group only as a measure of spoken measure. The current understanding is that combining subjective and objective measures would be more efficient than measuring them (Luk & Bialystok, 2013). Using multiple tasks to assess proficiency offers a more comprehensive understanding of the participant's language proficiency. This thesis uses objective and subjective measures to characterize the participants and as explanatory variables for experimental outcome measures.

In the present thesis, participants know more than two languages (either another Dravidian language, e.g., Telugu/Tamil/Malayalam or Indo-European language, e.g., Hindi or Indo-Aryan language, e.g., Sanskrit, through school or from the environment) as the exposure to languages in India is diverse. However, this thesis addresses the lexical selection mechanism in distant language Kannada-English bilinguals. Therefore, this thesis will use the term bilinguals rather than multilinguals. All participants were sequential bilinguals who were native speakers of Kannada and learnt English once they were introduced in School. The third language is either learnt in school as a part of the language curriculum (e.g., Hindi/Sanskrit) or another Dravidian language learnt at home due to the influence of either parent with a different native language background. The younger participants had acquired English between the mean age of 5-7 years, and older participants (who took part in the normative study) acquired English at the age of 12+ years. The younger participants were primarily taught all the subjects in English except during native language classes. The older adults who participated in this study were taught mainly in Kannada until they reached higher primary school (7th Grade), and they were all introduced to English mediums. Younger and older participants who participated in this thesis lived in their native language environment (Kannada). In addition, while recruiting, care was taken such that only participants who had Kannada as their native language and had acquired English at the school, plus exposure to both languages in their daily lives, were recruited. The data was collected from the Southwestern part of Karnataka, specifically from the cities of Mysuru and Bengaluru, where the residents are engaged with a minimum education of bachelor’s degree (Undergraduates) and work in a bi-/multilingual environment with high exposure to native language Kannada and English and other languages. Kannada is mainly spoken at home, with friends, and with colleagues in their day-to-day lives. Similarly, participants are exposed to English in school, college, and work environments while reading newspapers or watching TV daily.

## 1.6 Inhibitory control

The inhibitory control model, ICM (Green, 1998) assumes that lexical selection in bilinguals is language non-specific, meaning both languages are active at the lexical level and compete for selection. Accordingly, the parallel activation of two languages from the semantic representation raises the question of how bilinguals overcome the interference from the non-target language and select the intended language to respond. The inhibitory mechanisms suppress the activation of non-target language, enhancing the target language's lexical selection. These inhibitory mechanisms are hypothesised to be outside the language system, i.e., domain-general (Bialystok & Craik, 2010; Kroll et al., 2012).

### 1.6.1 Bilingualism and Inhibitory Control Factors

Bilingualism is hypothesised to result in superior executive function abilities due to the constant use of two languages. Executive functions such as inhibition (ability to suppress the dominant response), shifting (capacity to switch between tasks), and monitoring (updating the information in the working memory) are essential for cognitive control (Miyake et al., 2000). Although these executive functions are somewhat related, they contribute to language control differently. According to the IC model, both languages are parallelly activated in bilingualism, and non-target language needs to be suppressed (Green, 1998; Spalek et al., 2014) efficient language control, constant updates, and monitoring of the context and to whom they are speaking, switching between languages, and inhibiting the non-target language are essential.

Numerous studies have demonstrated superior cognitive functions in bilinguals compared to monolinguals using executive functioning tasks, e.g., switching tasks (Prior & MacWhinney, 2010), working memory e.g., digit backward tasks (Antón et al., 2019); inhibitory control, such as the Simon task (Bialystok, 2006; Bialystok et al., 2004; Martin-Rhee & Bialystok, 2008); and the Attention network task (Costa et al., 2008). In addition, some studies have demonstrated a correlation between bilingualism and executive function tasks (Bialystok, 2009; Stocco et al., 2014)There is also evidence that balanced bilingual participants (i.e., those with equal knowledge of two languages) perform better in the Stroop task than unbalanced bilinguals (Zied et al., 2004).

However, the findings on the "bilingual advantage" are not universal. Other studies failed to find a robust difference between bilinguals and monolinguals in any executive function (Clare et al., 2016; Paap et al., 2015; Paap & Sawi, 2014). The reason for differences in results is attributed to differences in methodology, type of bilinguals, and type of language pairs, which influence the activation of languages. For instance, lexical deficits in bilinguals are attributed to the weaker link hypothesis, which suggests that bilinguals use each of their languages less often than monolinguals. This creates a weaker link within the network, resulting in less rapid and less fluent production. Moreover, bilinguals not only differ from monolinguals, but differences exist within the group of bilinguals and varying profiles of bilinguals across studies (Kroll & Bialystok, 2013).

### 1.6.2 Tasks used to explore the inhibitory control.

As mentioned above, constant practice of language control in bilinguals could result in domain-general enhancement of executive functioning. This enhancement is measurable using behavioural assessments that evaluate executive functioning. Tasks that tap into inhibitory control are particularly interesting, which is the crucial mechanism in the IC model. Response inhibition suppresses irrelevant information that interferes with the target and focuses on relevant information to achieve goal-oriented behaviour. A conflict or interference arises when the responses differ from those required to reach the current goal. The ability to respond to stimuli depending on the current goal is essential to human performance. Prerequisites to such behaviour depend on cognitive control processes that enable the participant to respond to relevant stimuli and prevent responding to irrelevant or non-target responses. Common inhibitory control tasks include the Simon, Stroop, and Flanker tasks. In these tasks, task-irrelevant stimuli are used to induce conflict. However, task-irrelevant information is presented along with the task-relevant information, either response-compatible (congruent) or can be response incompatible (incongruent). The difference in naming latency between the congruent and incongruent trials is called the conflict or Stroop cost, depending on the task.

The Simon task (Simon & Rudell, 1967) involves responding to the colour of a given shape on the screen by pressing a pre-assigned button, e.g., a left-side key press for orange or a right-side key press for the green on the keyboard. The shape can be presented in two positions: orange on the left (congruent) and orange shape on the right side of the screen (incongruent). For example, Sudarshan & Baum (2019) investigated lexical selection and domain-general inhibitory control using the Simon task. Later, participants were divided into two groups based on differences in incongruent and congruent conditions (high-inhibitory control and low-inhibitory control groups). Interestingly, low inhibitory control participants showed phonological interference effects while it was absent in the high inhibitory control group. Thus, better inhibitory control makes resolving competition at the lexical level easy.

The Stroop task (Stroop, 1935) is another inhibitory control task where participants are asked to name the font colour of colour name words. The font colour and the words can be congruent or incongruent. For example, the word 'blue' in blue font represents the congruent condition, and the word 'blue' in green font represents the incongruent condition. Similar to Simon's task, Stroop involves inhibition of the written word form in the incongruent condition.

In addition to Simon and Stroop, the flanker task (Eriksen & Eriksen, 1974) has been adopted extensively. In this task, five arrows are presented pointing in the same direction with the centre arrow (>>>>>), known as a congruent condition, and if the centre arrow is flanked in the opposite direction to the rest of the arrows, represents the incongruent condition (<< > <<). In all three tasks, the difference in naming latency and/or accuracy between the incongruent and congruent conditions is calculated, which provides the participant with general inhibitory skills, known as *inhibitory cost*. Incongruent conditions will lead to longer response latency (Hernandez et al., 2000) .

Studies have shown bilingual advantage on various cognitive control tasks, including the Simon task (Bialystok et al., 2004; Cox et al., 2016), flanker task (Hernández et al., 2010), attention network task (Costa et al., 2008), and Stroop task (Marian et al., 2013; Singh & Mishra, 2013).

### 1.6.3 Evidence of inhibitory control as a modulating factor during lexical retrieval

Individuals with better inhibitory control displayed smaller differences in the Simon task, which correlated with smaller switch costs when a trilingual switched from their weak to a more dominant language (Linck et al., 2012). Smaller switch costs indicate better inhibitory control in bilinguals, resulting in rapid application of inhibition to non-target language, observed as smaller language switch costs. Another study reported that low proficient bilinguals with high inhibitory control displayed symmetrical language switch costs with executive function training, while those with low inhibitory control displayed asymmetrical switch costs (H. Liu et al., 2016). They speculate that executive functioning, to some extent, accounts for the smaller switch costs. Much of the evidence for the role of domain-general inhibitory control in lexical competition is found in correlational studies using separate measures of inhibitory control and language performance. Experimental support for the general role of inhibitory control in bilingual production is frequently shown in the context of *language-switching tasks* – which require a speaker to name items in a particular language, depending on cue (e.g., red colour to name the pictures in English and blue to name in Spanish). Asymmetrical switching costs and switching to L1 from L2 have been reported to be costly, meaning switching to a more dominant language requires a longer time (Guo et al., 2011; Verhoef et al., 2009). These findings generally suggest that L1 is much stronger than L2 in unbalanced bilinguals, and inhibition applied is directly proportional to the activation. Thus, inhibition applied to L1 must be stronger to produce the L2 with ease. Therefore, L1 inhibition persists into the following trial, and overcoming the inhibition applied to name in L1 is much more difficult and results in asymmetry (Gade & Koch, 2005; Philipp et al., 2007).

Sudarshan & Baum (2019) divided the participants into two groups based on their performance on the Simon task: low and high inhibitory groups. The low inhibitory control (Simon task) group showed delayed picture naming in English when naming the pictures associated with English phonological distractors compared to French phonological distractors.

**Table 2** Factors influencing lexical retrieval in bilingual word production.

| **Factors** | **Definition** | **Why does it affect lexical selection mechanisms** | **Measures** | **Refer to section no. / title** |
|---|---|---|---|---|
| **Proficiency** | Proficiency measures an individual's language ability, such as how well a person can understand, speak, read, and write in a specific language. | Higher proficiency leads to the activation of distractors, which can compete with the target lexicon and result in slower naming latency with related distractors than unrelated distractor conditions. | **Subjective** – measured through self-rated proficiency questionnaires such as LEAP- Q and **Objective** - using linguistic measures, e.g., L2 lexical decision (Lex-Tale (Lemhöfer & Broersma, 2012) | **1.6.2.1** |

| | | | | |
|---|---|---|---|---|
| | | | vocabulary tests, grammatical judgment tasks. | |
| **Dominance** | Language dominance is most often interpreted as referring to the relative strength of a bilingual's proficiency in each language, with the dominant language being the "more proficient" or "developed one." | Asymmetry in L1 vs L2 naming is observed. | Measured through the subjective questionnaire: Bilingual Dominance Scale (Dunn & Fox Tree, 2009) | **1.6.2.2** |
| **Inhibitory control** | "The ability to inhibit responses to irrelevant stimuli | Better inhibitory control is related to interference | Stroop and flanker tasks are used to explore the | **1.7** |

| | | | | |
|---|---|---|---|---|
| | while pursuing a cognitively represented goal" (Carlson & Moses, 2001) | suppression in bilingual language selection. | inhibitory control in bilinguals, and correlation analysis is carried out using linguistic processing to address the connection between the two tasks. | |
| **Typology** | Linguistic distance between the languages | Closely related languages have been shown cross-language interferences more consistently than distant languages | The current study uses distant language bilinguals (Kannada-English) | **1.5.1, 1.5.2** |

To sum up, bilingual experiences have consequences beyond language processing. In addition, these bilingual participant factors and inhibitory control have been shown to influence one another, although to what extent is unknown. Therefore, it is worth investigating how these factors influence lexical selection in bilinguals. Suppose the inhibitory control in bilinguals is domain-general. In that case, we should observe some correlation between the interference effects from the picture-word interference paradigm and inhibition cost from the inhibitory control task.

## 1.7 The present thesis

### 1.7.1 Problem Statement and Research Question

The literature on the nature of cross-language activity in bilingual lexical selection is contradictory and inconclusive. Most of the studies on bilingual lexical selection support the language non-specific hypothesis, where lexical items from both languages known to the bilingual compete for selection, and the item with the highest activation level is finally chosen for production. However, it has been shown that bilinguals can behave in a language-specific way in a certain context. Different conclusions are drawn on the manner of lexical selection, even in highly proficient bilinguals, and disagreement arises partly due to methodological differences in the experiments.

Moreover, the proximity between the languages studied, language typology (closely related vs distant), participant factors (e.g., proficiency, dominance), and experimental (e.g., use of distractors, distractor language, SOA, randomization, language context) might have played a role in previous research as they were conducted on bilingual participants who speak closely related languages (e.g., Catalan-Spanish, Dutch-English) and are equally proficient (highly proficient in both languages) bilinguals, summarised in Table 2. To determine which of these experimental factors (distractor type, distractor language, and language context), bilingual participant factors, and inhibitory control factors may influence lexical selection in bilinguals. Investigating lexical selection in lexically distant language bilinguals with a less advanced L2 proficiency can help validate the reliability and generalizability of cross-linguistic influences observed in closely related highly proficient bilinguals.

### 1.7.2 Objectives of the present thesis

This thesis investigates lexical selection in bilinguals with typologically distant languages - Kannada, a Dravidian language spoken in southwestern India, and English.

Previous research has shown that experimental factors (language context, distractor language, and distractor type), bilingual factors (proficiency, dominance), and executive function (inhibitory control) influence lexical selection. However, there is limited research on lexical selection in distant language bilinguals, and existing studies have yielded inconsistent results. A series of three studies have been conducted, which aim to (1) produce normative data in Kannada on a picture naming set to conduct psycholinguistic research with Kannada-English bilinguals; (2) exploit the PWI paradigm to investigate mechanisms of lexical selection in Kannada-English bilinguals and (3) investigate the relationship between bilingual and EF factors and word retrieval in Kannada-English bilinguals.

The present thesis is further subdivided into three chapters addressing three specific aims.

**Chapter 2**: The first study developed a normative database for picture stimuli from adult native Kannada speakers to facilitate the main aim of the thesis. The study generated naming responses for a subset of 180 items plus psycholinguistic parameters of these stimuli in Kannada, including a picture-name agreement, name agreement, familiarity, visual complexity, age of acquisition, and image agreement. This study aimed to establish a normative database in Kannada to control the selection of stimuli for the experimental task used to investigate lexical selection in bilinguals. Another aim was to provide such a database in Kannada, which was lacking, and resources will allow future psycholinguistic studies in Kannada language processing, which is beyond the scope of the present thesis. A manuscript describing the collection of this normative dataset is published (Bangalore et al., 2022), and provided as Chapter 2 in this thesis.

**Chapter 3:** The second study utilised four PWI paradigms to investigate lexical selection in Kannada-English bilinguals: Paradigm 1 (picture naming and auditory distractors presented in (L1) Kannada; Paradigm 2 (picture-naming in (L1) Kannada and auditory distractors presented (L2) English); Paradigm 3 (picture naming and auditory distractors in (L2) English); and Paradigm 4 (picture naming in (L2) English and auditory distractors in (L1) Kannada). These paradigms were selected to investigate cross-linguistic interference under monolingual and bilingual contexts while naming in both Kannada and English.

**Chapter 4:** The final empirical chapter aimed to investigate the bilingual and inhibitory control factors and their influence on lexical selection in bilinguals. This study measured the language profile of bilingual participants and the inhibitory control explored through Stroop and Flanker tasks. It explored associations with lexical retrieval during the PWI paradigm presented in Chapter 3.

# 2 Chapter 2: Standardizing norms for 180 coloured Snodgrass and Vanderwart pictures in the Kannada Language

This study has been published.

Bangalore, S., Robson, H., & Astell, A. J. (2022). Standardizing norms for 180 coloured Snodgrass and Vanderwart pictures in Kannada language. *PLoS ONE*, *17*(4 April). https://doi.org/10.1371/journal.pone.0266359

## 2.1 Abstract

This study presents normative data in Kannada for 180 coloured Snodgrass & Vanderwart pictures. Data are presented for naming latency, image agreement, picture-name agreement, familiarity, visual complexity, and age of acquisition (AoA). Sixty-eight native Kannada-speaking adults completed all tasks. The effects of the rated variables on naming latency were examined and compared with data on the same variables in other languages. A regression analysis revealed that image agreement, name agreement, familiarity, and age of acquisition all significantly impacted naming latency, while visual complexity and frequency did not. Although the correlations among rated variables in Kannada were equivalent to previous normative studies, the cross-linguistic comparison revealed that only AoA was strongly correlated with other studies. The findings highlight the importance of understanding the interplay of psycholinguistic variables on naming latency in different languages.

## 2.2 Introduction

Picture naming is widely used in speech production research to address psycholinguistic, neuropsychological, and bi/multilingualism questions (Navarrete et al., 2019). One of the most widely used sets of object-naming stimuli was produced by Snodgrass & Vanderwart, (1980). Their set comprises 260-line drawings with norms for four psycholinguistic variables shown to operate during picture naming provided by 219 American English speakers. Snodgrass & Vanderwart, (1980) split their participants into groups to collect ratings on the four psycholinguistic variables: image agreement (N=42), name agreement (N=40), familiarity (N=40), and visual complexity (N=40). The other 57 participants completed two additional image agreement tasks: Picture-Name agreement task (N=40) and Image Variability rating (N=17). Multiple subsequent studies have extensively investigated these variables with a colourised version of the images produced (Rossion & Pourtois, 2004).

Image agreement (IA) refers to the extent to which a given picture resembles an individual's visual mental representation of a given object. It plays a key role (Bakhtiar et al., 2013; Carroll & White, 1973) in accessing the perceptual representation of objects (Humphreys et al., 1988), whereby picture stimuli with high image agreement are named faster than those with low image agreement (Alario et al., 2004; Bakhtiar et al., 2013). Name agreement (NA) describes how much people agree on the dominant name for a pictured item. Many researchers, including (Snodgrass & Vanderwart, 1980), calculate the information statistic $H$ to examine name agreement. $H$ captures information on the number of different names given for a picture by the participants and is calculated using the formula (Shannon, 1948) $\boldsymbol{H = \sum_{i=1}^{K} \rho i \, log_2 \left(\frac{1}{\rho i}\right)}$, used by Snodgrass & Vanderwart (1980), where *k* refers to participants who gave an alternate name for an item. An item that achieves an *H* value of .0 has perfect name agreement, i.e., every participant gave the same name. (Snodgrass & Vanderwart, 1980) found that 21% of their 260 items achieved a score of .0. NA is a strong predictor of latency and accuracy of word retrieval and comprehension in typical and clinical populations (Bonin et al., 2003; Bose & Schafer, 2017; Tsaparina et al., 2011). Specifically, the names of pictures with high name agreement are comprehended and retrieved faster than those with low name agreement (Barry et al., 1997; Snodgrass & Yuditsky, 1996).

Familiarity (FAM) is an individual's acquaintance with the pictured object and to what degree they encounter or think of the object in their everyday life. More FAM concepts are named quicker and categorised faster than unfamiliar and low-familiarity items (Bakhtiar et al., 2013; Cuetos et al., 1999; Weekes et al., 2007). FAM effects are known to be reliable but vary across studies with healthy adults (Barry et al., 1997) because the influence of FAM on naming latency is inconsistent (Alario et al., 2004; Bakhtiar et al., 2013). The absence of FAM effects in naming pictures suggests that object identification is not sensitive to the frequency of occurrence (Alario et al., 2004). Visual complexity (VC) refers to the amount of detail present within an image, such as how lines are drawn, shape, and colour (where coloured images are used). The intricacy of an image influences the picture naming speed such that images with more (sufficient) relevant details are easier to identify and are named faster compared to images with fewer (insufficient) distinguishing features (Alario et al., 2004; Barry et al., 1997).

In addition to these commonly reported variables, several other psycholinguistic factors have been shown to influence performance on picture naming paradigms, including word frequency and age of acquisition (Bakhtiar et al., 2013; Carroll & White, 1973).Age of acquisition (AOA) refers to the age at which the words are learned. Typically, this is achieved by asking the adults to rate the age at which they estimate they learned the word according to the age range provided (Bakhtiar et al., 2013; Barry et al., 1997; Raman et al., 2014). The influence of AOA on lexical and semantic processing tasks (e.g., word naming, picture naming, and lexical decision) includes faster and more accurate responses for the words and concepts acquired earlier in life (Cortese & Khanna, 2007; Juhasz, 2005; Snodgrass & Yuditsky, 1996). Finally, word frequency measures how often a word is used. It is generally based on the written or spoken corpora obtained through objective databases such as Francis & Kucera (Francis et al., 1982) and Celex (Van der Wouden, 1990) rather than rating scales. Generally, naming latency decreases as frequency increases (Bakhtiar et al., 2013; Barry et al., 1997; Raman et al., 2014; Ramanujan & Weekes, 2020).

While these findings have been widely reported, there is growing recognition of the limitations of generalising norms across languages (Sanfeliu & Fernandez, 1996). First, cultural differences may result in some items being unknown in some parts of the world. For example, artichoke /asparagus /chisel /nut /pilers /plug /raccoon/wagon /wrench /French horn/ were unknown in Russian (Tsaparina et al., 2011). Other items may have very different frequencies of occurrence in different languages, such as harp/accordion/trumpet/flute, which are included in English norms but less familiar in Turkish (Raman et al., 2014). Second, images of items with low familiarity in any given culture may be perceived differently: e.g., /cigarette/ may be perceived as /pencil/. Third, some items may not have a specific name in a language and are known by their English names across cultures, such as /penguin/, /stapler/ etc. Fourth, relationships between conceptual and lexical representations differ across languages, and an image that evokes a specific and single name in English might generate a more general name or multiple names in another language. For example, /bird/ is referred to as /pakshi/ or /hakki/ in Kannada, a Dravidian language spoken by at least 44 million (CENSUS OF INDIA 2011 REPORT ON POST ENUMERATION SURVEY, n.d.) people in Karnataka in the Southwest of India, as well as linguistic minorities in Maharashtra, Andhra Pradesh, Tamil Nadu, Telangana, Kerala.

Normative data for the original black and white drawings of Snodgrass & Vanderwart (1980) and the subsequent coloured version (Rossion & Pourtois, 2004) have been obtained for several other languages [e.g., Persian (Bakhtiar et al., 2013); Turkish (Raman et al., 2014); for more see Table 3]. However, there have been few attempts to develop norms for Indian languages, although there are more than 1 billion speakers worldwide. A 2007 study with adult Malayalam speakers to gather norms for the black and white S & V (1980) pictures by George & Mathuranath (2007) reported that only 13/40 items were reliably identified by name. They also found low familiarity with the black-and-white items, which the authors interpreted as a reflection of the age (92/200 over 65), rural background, and low level of education (87/200, 0-4 years) of most participants. In a more recent study in Hindi (Ramanujan & Weekes, 2020), the most spoken Indian language, 59 Hindi-English bilingual students rated 158 coloured (Rossion & Pourtois, 2004) pictures in Hindi for image agreement, name agreement, familiarity, visual complexity, and age of acquisition. A further 40 different Hindi-English bilinguals named the items in Hindi for reaction time measures. Among the rated variables and computed word frequency and syllable length included, only four psycholinguistic variables (image agreement, name agreement, familiarity, and age of acquisition) predicted naming latency.

**Table 3** Summary of norming studies carried out in different languages.

| **Norms provided for black and White line drawings of Snodgrass &Vanderwart (1980)** | **Norms provided for a coloured version of S&V pictures by Rossion & Pourtois (2004)** |
|---|---|
| Dutch (Martein, 1995) | Mandarian Chinese (Weekes et al., 2007) |
| British English (Barry et al., 1997) | Modern Greek (Dimitropoulou et al., 2009) |
| French (Alario & Ferrand, 1999) | Russian (Tsaparina et al., 2011) |
| Spanish (Cuetos et al., 1999) | Persian (Bakhtiar et al., 2013) |
| Italian (Nisi et al., 2000) | Turkish (Raman et al., 2014) |
| Icelandic (Pind & Tryggvadóttir, 2002) | Hindi (Ramanujan & Weekes, 2020) |
| Chinese (Zhang & Yang, 2003) | |
| American and Chinese (Yoon et al., 2004) | |
| Japanese (Nishimoto et al., 2005) | |
| Canadian French (Sirois et al., 2006) | |
| Mandarian Chinese (Y. Liu et al., 2011) | |

Regarding other Indian languages, one study has been conducted in Kannada. The study involved 5–16-year-old (n=100) children providing Kannada norms for 260 Snodgrass and Vanderwart line drawings for one psycholinguistic variable: name agreement (Ahmed et al., 2013). They found pictures with a high-name agreement for 197/260 S&V (Snodgrass & Vanderwart, 1980). The poor name agreement for the remaining 63 items was due to items being identified as ambiguous, more than one specific name or items elicited English names. Generalising to adult speakers of Kannada is not straightforward, as name agreement scores have been shown to vary between children and adults (Pompéia et al., 2001). Additionally, the study is limited by only reporting name agreement rather than the other important psycholinguistic variables (i.e., familiarity, visual complexity, image agreement, word frequency, and age of acquisition) that influence picture naming in other languages (Alario et al., 2004; Bakhtiar et al., 2013; Carroll & White, 1973; Raman et al., 2014; Ramanujan & Weekes, 2020).

Given the prevalence of Indian language speakers and growing evidence from other language studies (see Table 4) that normative values are not directly transferable from US English, this study set out to develop norms for use with younger and older Kannada speakers. In Karnataka, the home state of Kannada, the levels of bilingual (40%) and multilingual (13%) speakers are substantially above the national average, with English being the most common second language. This provides an opportunity to explore the impact and infiltration of English words and items in the majority language - Kannada - which can inform normative studies in other Indian languages. Following the model of Snodgrass & Vanderwart (1980), we set out to collect ratings in Kannada for image agreement, picture-name agreement, familiarity, visual complexity, and AoA for 180 R&P(Rossion & Pourtois, 2004) colour pictures. The second aim was to validate the relationship between rated psycholinguistic variables, obtained word frequency data, and picture-naming latencies in native Kannada speakers who are late bilinguals (i.e., exposed to a second language after joining school, age >7) with English as their second language. The key purpose of generating Kannada norms is to encourage the practical use of pictures in psycholinguistic, cognitive, and clinical research. Acknowledging and understanding the exposure to two languages and where one language is preferred over the other is an important element of developing future materials. To add to the growing body of evidence regarding similarities and differences across different languages (Bakhtiar et al., 2013; Dimitropoulou et al., 2009; Raman et al., 2014), we also conduct cross-linguistic comparisons of the psycholinguistic variables between Kannada norms and other languages that have used the R&P coloured pictures (Rossion & Pourtois, 2004) and with the original S&V study of (Snodgrass & Vanderwart, 1980) black and white line drawings.

## 2.3 Method

### 2.3.1 Materials

This study selected 185 of the 260 colourised S&V pictures from Rossion & Pourtois (Rossion & Pourtois, 2004). Item selection was polled by the author and four volunteer participants (2 young adults [YA] and two older adults [OA]). All five were bilingual speakers with Kannada as their native language and learnt English after age 7 in

YA and 12 in OA. These participants were first asked to determine (1) if the pictured items were culturally familiar and (2) if they had an equivalent Kannada name. We excluded 75 pictures in total. Among them, 50 were not culturally familiar, and 25 pictures did not have an equivalent name in the Kannada language or cognates (i.e., '*artichoke*,' '*cigarette*,' '*accordion*,' '*stapler*,' '*penguin*,' etc.). Items referred to by their English "loan names" (now a routine part of Kannada vocabulary, e.g., '*shirt*,' '*belt*,' '*sweater*,' and '*helmet*') were retained because they had equivalent Kannada names.

From the final set of 185 items, five - sun, tiger, scissors, book, and ring - were chosen for practice trials as these items had a single dominant name and were familiar to the participants. The remaining 180 items were divided randomly into two sets of 90 items. Participants were randomly assigned to rate one set of 90 items and name the other set of 90. Thus, each of the 180 items was rated by 34 participants and named by the other 34 participants. Word frequency data for the S&V pictures in Kannada were obtained from the Sketch engine and included in the analysis.

Seventy-five participants were recruited to participate in the study. Each completed the Montreal Cognitive Assessment, MoCA (Nasreddine et al., 2005) Kannada version presented in Appendix A. Seven of these were excluded following cognitive screening using the MoCA. The remaining 68 participants were recruited in two age bands: 35, aged 19–30 (22 females and 13 males), and 33, aged 60–80 (14 females and 19 males). This was to inform future use of the norms in clinical tools, particularly for older adults.

Each participant completed the Modified Language Proficiency Questionnaire (MLPQ; see Appendix B). Twelve of the 68 participants were bilinguals, and the rest were multilingual. All were native Kannada (L1) speakers, of whom 66 had English (L2) as their second language and Hindi as their third language. The other two participants spoke a different second language and had English as their third language. All participants were late bi-/multilinguals, which means they were exposed to one language at birth (Kannada) and another language or languages (English and/or Hindi) later in childhood or adulthood (J. Paradis, 2011). English was acquired later among the OA group (12+ years) than the YA group (7+ years).

### 2.3.2 Procedure

Data were collected individually in two settings. Twenty YA participated at Jagadguru Sri Shivarathreeshwara Institute of Speech and Hearing Mysuru. The other 15 younger participants were not part of the JSS Institute, and all older adults participated in their own homes. The data were collected over two sessions on different days for each participant. After the participants provided informed consent in the first session, they completed the Montreal Cognitive Assessment MoCA (Nasreddine et al., 2005), which is the Kannada version. The MLPQ (Appendix B) was administered for demographic purposes and was not included in further analysis (see Table 4). In the second session, participants completed the rating tasks for one set of 90 pictures and the confrontation naming task for the other 90 items. Therefore, no participant named the same items that they rated, and this was counterbalanced to ensure that each item was named and rated by half of each group. Five-minute breaks were offered within the session following the naming or rating of 45 items. The overall session length varied between 90-120 minutes in total for YA and up to 150 minutes for OA.

### 2.3.3 Ethical procedure

The study received ethical approval from the School of Psychology and Clinical Language Sciences Research Ethics Committee at the University of Reading (2019-072-AA). The information sheet was provided in Kannada to each participant, and they were allowed to ask questions about what the study would involve. They were also informed that they were free to withdraw from the study at any point in time without giving any reason. Following this, they were asked to provide their written consent.

### 2.3.4 Task Design

In the present study, the tasks and order of completion were designed to collect data from the same participants for IA, PNA, FAM, VC, AoA, and naming. Name agreement scores were calculated from confrontation naming. Although normative and confrontation naming was conducted on the same day, both stimuli were different.

#### *2.3.4.1 Rating tasks*

Each rating task used a Likert rating scale from 1-5 (see supplementary material S2 for rating scale). All participants started with rating IA and PNA, followed by FAM, VC, and AoA. The order of presentation of pictures was pseudorandomized by creating four sets of the same 90 pictures, which were randomly presented across participants. Therefore, all participants started rating IA and PNA with one set, followed by FAM, VC, and AOA with another set of the same 90 items in a different order. It was necessary for the PNA rating to follow the IA rating as the participants had to be exposed to the lexical item for both these variables.

***Image agreement (IA) and Picture name agreement (PNA):*** To rate IA, the item name in Kannada was displayed to the participant on a white screen using Microsoft PowerPoint for three seconds in black font Nirmala UI, size ‘72’. This was followed by a blank screen, which appeared for five seconds, during which time the participant was required to imagine an image corresponding to the word. Later, after 5 seconds, they were shown an image representing an item. The participants were then asked to rate how good the match between their imagination and the displayed image on the Likert scale (1-5). For IA, 5 represents a good match between the name and image they had in mind, with numbers closer to 1 representing a poor match. If participants were unable to imagine a visual image within 5 seconds mentally, they were asked to report ‘cannot imagine’ (CI) for that item.

Following IA**,** participants rated PNA on how good/poor the match was between the name and picture on the same 1-5 scale. If they knew the item when they saw it but not the name that had been presented, they were asked to write ‘do not know the name’ (DKN) for that item. For any items that participants did not recognize, they were asked to report ‘do not know the object’ (DKO). To avoid bias in accepting the given name, and to elicit the widest and most common naming responses for the pictured items, participants could also write down their most common response in an extra column on the rating scale. This was required for items rated equal to or below 3 on the PNA rating.

***Familiarity (FAM), Visual Complexity (VC), and Age of Acquisition (AoA) rating tasks:*** In these rating tasks, as each item appeared on the screen, participants were asked to rate it for familiarity, visual complexity, and age of acquisition. As explained above, the 90 items were presented in a different order to the IA and PNA rating tasks. For each item displayed, FAM, VC, and AoA were rated on three separate Likert scales before moving on to the next picture for all 90 items. **FAM** was rated on a Likert scale based on their experience of hearing, seeing, and using those items (1-5). The FAM ratings were 5 = familiar, down to 1 = unfamiliar. Participants were asked to rate familiarity on lifetime experience, not on the immediate prior exposure from previous rating tasks.

**VC** ratings were judgments of the overall intricacy of the item displayed based on the shape, colour, and lines drawn. The 5-point Likert scale went from 5= sufficient details to 1 = insufficient to convey the item. Finally, participants were asked to rate the age at which they learned about each pictured item. Given that the Kannada-speaking population is largely bi/multilingual, it was deemed appropriate to obtain conceptual, rather than lexical, acquisition age. In this rating task, each point on the Likert scale represented an age range: 1 = 0-3 years; 2 = 3-6 years; 3 = 6-9 years; 4 = 9-12 years; and 5 = 12 and above years as such higher scores equate to later age of acquisition of a concept.

#### *2.3.4.2 Confrontation naming*

In the confrontation naming task, items were presented one at a time using Psychopy software version 3.1.2 (Peirce, 2009). Participants were asked to name each picture as soon as it appeared on the computer screen. The task comprised 3 blocks. The first block consisted of five practice trials to ensure the participant understood the task efficiently. The second and third blocks were the main tasks and included 45 items each, with a five-minute break provided between each block. Each trial consisted of a 500ms fixation followed by the presentation of the picture item. A 200ms beep was presented simultaneously with the picture stimuli, which acted as the cue for measuring reaction time. The picture remained on the screen for 3000ms, followed by a 2000ms blank screen.

Participants were instructed to say the first name that came to mind in the Kannada language as soon as they saw the picture. Specific instructions were given to elucidate any naming failures: “Do not know the object” (DKO) if they do not know the object, “Do not know the name” (DKN) if they know the object but cannot name it; and the tip of the tongue (TOT) if they know the name but are unable to retrieve it. Verbal responses were recorded with the Psychopy voice key, and the reaction time was measured from the onset of the presentation of the picture/beep stimulus. Reaction time and name response were extracted for each item for all the participants.

In addition to the ratings collected from the participants, word frequency data for 162 items were obtained from the Sketch engine Kannada web 2012 (KNWAC12) database (approximate word count: 11 million). Frequency data were log-transformed (Log10

(Counts per million) + 1) and included as a predictor of naming latency in a regression analysis alongside the rated variables.

## 2.4 Results

The overall mean and standard deviation on MoCA and MLPQ scores of the 68 participants are presented in Table 4. The MoCA scores are slightly but not significantly higher for the younger adults, and the MLPQ scores indicate high L1 proficiency in both groups, with above-average proficiency in L2.

**Table 4** Demographic data of the participants

| | **Groups** | |
|---|---|---|
| **Parameters** | **Younger (35)** | **Older (33)** |
| | *M* (SD) | *M* (SD) |
| Age | 23.77 (3.71) | 67.2 (4.44) |
| MoCA scores (30) | 28.17 (1.2) | 27 (0.93) |
| MLPQ - Overall L1 proficiency (100) | 82.37 (8.17) | 92.48 (4.56) |
| MLPQ - Overall L2 proficiency (100) | 74.97 (12.63) | 57.75 (12.84) |

*Note.* MoCA: Montreal Cognitive Assessment; MLPQ: Modified Language Proficiency Questionnaire; L1 (Kannada); L2 (English).

Item-by-item rating and name agreement data can be found in Appendix C. The first step in examining the data was to establish whether to keep the data from the younger and older adults separate or to combine them into one set. To address this, correlations were run between the YA and OA mean rating scores for each item for all psycholinguistic variables, plus the confrontation naming results (see Table 5). There were strong, significant positive correlations for all rated psycholinguistic variables and a context correlation for naming reaction time. However, all were significant at *p* <.01. These results were cross-verified using Fischer Z transformation tests, which showed no significant difference between the groups for each correlation across the psycholinguistic variables. As such, the group data were then combined to provide a descriptive summary, cross-linguistic correlations, and regression analyses.

**Table 5** Correlations between younger and older adults

| **Parameters** | ***r* value** |
|---|---|
| Image agreement | **.662**** |
| Picture name agreement | **.725**** |
| Familiarity | **.715**** |
| Visual complexity | **.585**** |
| Age of acquisition of the concept | **.735**** |
| Hstats (confrontation naming) | **.767**** |
| Hpercent (confrontation naming) | **.655**** |
| Reaction time (ms) | **.453**** |

*Note*. **Correlation is significant at 0.01 level.

The results of the rating tasks, name agreement, and reaction time for the 180 items are contained in Table 6. The mean scores are high for IA and PNA, indicating that the Kannada translation was representative of the image and vice-versa. Similarly, higher FAM and VC mean scores representative of the concepts were familiar, and there was sufficient detail to identify the concepts. Low mean rating scores were obtained on average for AoA, indicating that the concepts were acquired early in life (the majority before 6 years). The results of the rating tasks are explored separately before examining their combined influence on naming latency.

**Table 6** Descriptive statistics of rating and confrontation naming task

| | N | Mean | *SD* | Range | Median | Skewness |
|---|---|---|---|---|---|---|
| IA | 180 | 4.51 | 0.61 | 2.06 – 5.00 | 4.76 | -2.169 |
| PNA | 180 | 4.52 | 0.78 | 1.48 – 5.00 | 4.94 | -1.829 |
| FAM | 180 | 4.85 | 0.21 | 3.73 – 5.00 | 4.94 | -2.915 |
| VC | 180 | 4.64 | 0.21 | 3.76 – 4.94 | 4.71 | -1.341 |
| AOA | 180 | 2.54 | 0.70 | 1.26 – 4.18 | 2.50 | .200 |
| Hstats | 180 | 0.66 | 0.58 | 0.00 – 2.21 | 0.59 | .535 |
| Hpercent | 180 | 0.64 | 0.31 | 0.00 – 1.00 | 0.76 | - .582 |
| RT (ms) | 176 | 1634.78 | 312.96 | 816.50–2558.40 | 1635.65 | 0.223 |

Note. IA: image agreement; PNA: picture-name agreement; FAM: Familiarity; VC: Visual complexity; AOA: Age of acquisition of concept.

## 2.4.1 Rating task results

A small proportion of items received lower ratings (3 or below) in the rated psycholinguistic variables. On the IA task, 5.77% (40 items - *barrel, barn, beetle, blouse,* *cannon, chain, cloth pin, doorknob, desk, dresser, envelope, football, football helmet, frying pan, grasshopper, lightbulb, lobster, gloves, ostrich, nail filer, pitcher, pear, rhino, ruler, rocking chair, sweater, seahorse, seal, snail, snowman, suitcase, trumpet, mushroom, spinning wheel, vinyl, vest, vase, wagon, watering can, zebra*) of total responses were those that at least one participant could not imagine (CI response) from the given Kannada name.

In the picture-name agreement, the same items resulted in a DKN response, meaning that the given item names in Kannada were unknown to at least one person and comprised 3.30 % of the total responses. This suggests that in the image agreement task, the majority of "cannot imagine" responses were due to the Kannada name being unfamiliar rather than a lack of knowledge of the item. However, there were also "do not know the object" responses for10 items - *barrel, beetle, football, lobster, nail filer, ostrich, pear, seal, seahorse, snowman*, indicating that these 10 items were unfamiliar to at least one participant (1.05% of total responses). In addition to these, a further 23 items (*barrel, beetle, couch, football, fly, doorknob, lobster, nail filer, ostrich, pear, rhino, saw, seal, seahorse, snowman, stove, spinning wheel, vinyl, violin, watering can, wagon, zebra)* were rated as having low familiarity by at least one participant (3.6% of total responses), indicating low exposure to these items in daily life.

Regarding VC, 43/180 items (*apple, arrow, ball, barn, barrel, beetle, boot, bowl, broom, comb, doorknob, dresser, eye, fly, football, fox, hair, garbage can, ladder, lamp, leaf, leopard, lion, lobster, kettle, knife, monkey, necklace, nail filer, ostrich, pear, rhino, sailboat, seahorse, snowman, stove, seal, spinning wheel, vest, violin, vinyl, whistle and* *wagon*) were regarded by at least one participant as having insufficient visual detail (7.65% of total responses) to identify the item. AoA ratings revealed that 105 items, accounting for nearly 60% of the concepts, were learnt earlier in life before the age of 6 years.

Spearman's correlations were used to evaluate the relationship between the rated variables (Fig 7). There were strong to moderate significant correlations between the majority of variables except for familiarity with both image agreement ($r$ = 0.291) and visual complexity ($r$ = 0.27), which produced significant but weak correlations. These results mirror what has been reported in other studies.

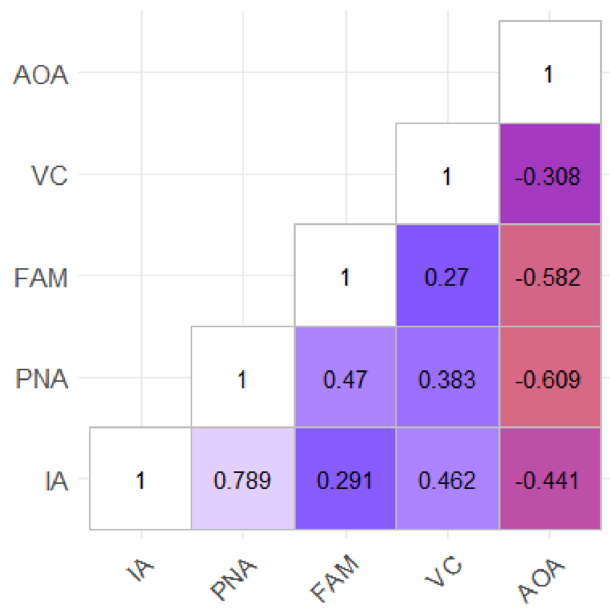


**Figure 7** Correlation matrix of rated psycholinguistic variables.

*Note*. Correlation ranges (-1 to +1). IA: image agreement; PNA: picture-name agreement; FAM: Familiarity; VC: Visual complexity; AOA: Age of acquisition of concept.

### 2.4.2 Confrontation naming results

Name agreement in the form of the *H*stats was calculated from confrontation naming data for each item (Table 4). *H*stats differs from *H*percent by considering all the naming responses given for an item, even if it is not named in Kannada. On the other hand, *H*percent is the percentage of name agreement obtained for each item by calculating only the total number of correct responses (items correctly named in Kannada) provided by the total number of participants multiplied into 100 (see Table 4 for summary statistics). Reaction time measures for four items (*Barn*, *Football*, *Lobster*, *and Sweater*) were removed from the confrontation naming latency as these items had zero correct responses, accounting for 2.2% of the 180 items RT.

The *H*stats scores for the 180 items demonstrated a range of name agreement from complete to very low name agreement across items. Forty-two items (24%) had *H*stats of zero, meaning they had complete name agreement. Twenty of the 180 items had an *H*stats score above 1.5, indicating very low name agreement (*arrow, barrel, bed, bird, boot, broom,p, clothespin, dress, iron, knife, owl, pear, socks, stove, umbrella, vase, wagon, watering can, zebra*) with multiple alternative naming responses. The remaining 118/180 items represent *H*stats scores below 1.5, suggesting more than one name was being used by participants to represent these items.

Confrontation naming data were analysed for reaction time (ms) and accuracy. Ten different types of naming responses were observed: (1) Correct items produced as the Kannada translation of the English item or a synonymous Kannada word = 63.6% of responses; (2) Naming failure (no response, e.g., the tip of the tongue or unknown item or unknown item name) = 17.69%. (3) Translation (correct English names) = 8%; (4) Semantic error: semantic substitution e.g., another item from the same semantic category = 4%; (5) Alternate names: semantically acceptable related Kannada names = 2%; (6) Superordinate error (name of the category of the target) = 1.92%; (7) Visual error (visually related item) = 2.1%; (8) Incomplete (partial name produced e.g., first or second half only) = 0.31%; (9) Description of the item = 0.19%; and (10) Unrelated (item not semantically or visually related to the target) = 0.19%.

Incorrect responses and naming failures were first removed, which accounted for 36% of the responses. Naming latencies with more than three standard deviations from the mean were excluded to reduce the effect of outliers, which resulted in 1.13% of total responses. Naming latencies for all 176 items are reported in the supplementary material *Appendix*. The overall mean naming latency for 176 coloured S&V pictures was 1634.78ms (*SD* = 313.78). Further, only correct responses were considered for the regression analysis and cross-linguistic correlations.

### 2.4.3 Predictors of naming latency

Simultaneous multiple linear regression analysis was conducted to validate the relationship between rated psycholinguistic variables and obtained word frequency on naming latencies. The dependent variable was mean RT (ms), and the independent predictor variables were IA, PNA, FAM, VC, AoA, Hstats, and Hpercent, as well as word frequency. PNA and *H*percent were removed from the final model as these variables were outside of multicollinearity tolerances: PNA (VIF = 4.75, PNA vs. IA r = 0.789); *H*percent (Condition Index = 143, *H*percent vs. *H*stats r = -0.814). The above psycholinguistic variables predicted naming latency in Kannada yielded an adjusted $R^2 = 0.638$, $F_{(6,156)} = 46.77$, and $p < .001$ (Table 7).

**Table 7** Standardized coefficients and R2 changes in multiple regression analysis.

| **Variable(s)** | **Beta** | ***t*** | ***p*** | **VIF** |
|---|---|---|---|---|
| **IA** | -.133 | -2.24 | .026 | 1.51 |
| **FAM** | .189 | 2.99 | .003 | 1.71 |
| **VC** | -.028 | -.53 | .591 | 1.19 |
| **AOA** | .389 | 5.57 | <.001 | 2.09 |
| **Hstats** | .556 | 8.96 | <.001 | 1.65 |
| **Word fq** | .013 | 0.22 | .820 | 1.34 |

*Note.* IA: image agreement, FAM: familiarity, VC: visual complexity, AOA: Age of acquisition of concept, and Hstats: name agreement scores, Word fq: Word frequency.

Four variables – IA, AoA, *H*stats, and FAM were significant predictors of naming latency, while VC and word frequency were not (Table 7). The most robust predictor was name agreement (*H*stats; $b = .556$, $t = 8.96$, $SE = 31.74$, $p < .001$), which suggests that reaction time is faster for items with greater name agreement. AoA of concept was also a strong predictor ($b = .389$, $t = 5.57$, $SE = 31.20$, $p < .001$), indicating faster reaction time for concepts acquired earlier in life. Items with higher image agreement (IA) scores were named more quickly ($b = -.133$, $t = -2.24$, $SE = 30.80$, $p < .01$). Of the four significant variables, item familiarity did not go in the expected direction; latency was slower for more familiar objects (*b* = .189, *t* = 2.99, *SE* = 119.07, *p* < .001). This unexpected change in the beta sign in the regression analysis is possibly due to positive net suppression[40]. This occurs when one predictor variable is more strongly correlated with other predictor variables, and these other variables are more strongly correlated with the dependent variable. In the current study, familiarity may have acted as a suppressor variable in the regression model as it showed a weak relationship with naming RT (r = 0.28) but a strong relationship with AoA (r = 0.58) and a moderate relationship with *H*stats (r = 0.43). In comparison, AoA and *H*stats both demonstrated a strong relationship with naming RT (r=0.54 and r=0.68, respectively). Neither visual complexity (*b* = -.028, *t* = -.539, *SE* = 81.38, *p* > .05) nor word frequency (*b* = .013, *t* = .22, *SE* = 32.95, *p* > 0.05) resulted as significant predictors of naming latency in Kannada.

### 2.4.4 Cross-linguistic correlations

Kannada results from rating and confrontation naming tasks were compared to previous norming studies in other languages using S&V (black and white or coloured) picture stimuli (Table 8). Results ranged from weak, non-significant correlations to strong, significant correlations (*r* = -.04 to *r* = .673). AoA demonstrated the most consistent and strong relationship with other languages, and visual complexity was the weakest. Kannada norms showed the strongest relationship to Persian, Turkish, and Hindi and only a limited relationship with English and French.

**Table 8 Comparison of psycholinguistic variables of the present study with original black and white line drawing and similar studies which have used colourised versions of Snodgrass and Vanderwart pictures.**

| Variables | S&V (1980) | R&P (2004) | Weekes et al., (2007) | Dimitropoulou et al., (2009) | Tsaparina et al., (2011) | Bakhtiar et al., (2013) | Raman et al., (2014) | Ramanujan et.al., (2020) |
|---|---|---|---|---|---|---|---|---|
| **(N)** | **179** | **180** | **163** | **180** | **179** | **139** | **179** | **130** |
| **Languages** | **American English** | **Belgian French** | **Mandarin Chinese** | **Contextrn Greek** | **Russian** | **Persian** | **Turkish** | **Hindi** |
| **IA** | .209** | .221** | .120 | NA | .257** | .412** | .334** | .423** |
| **FAM** | .099 | -.167* | .320** | NA | .340** | .257** | .291** | .400** |
| **VC** | -.040 | -.118 | -.050 | -.146 | .228** | -.185* | -.182* | .278** |
| **AOA** | NA | NA | .655** | .672** | NA | .673** | .671** | NA |
| **Hstats** | .130 | .063 | .200* | .216** | .028 | .245** | .460** | .210* |
| **Hpercent** | .078 | NA | .286** | .202** | .103 | .312** | .512** | .084 |
| **RT (ms)** | NA | .357* | .457* | NA | NA | .482* | NA | NA |

***Note.*** **Correlation is significant at 0.01 level. *Correlation is significant at 0.05 level. IA: image agreement; Name agreement: Hstats and Hpercent; FAM: Familiarity; VC:Visual complexity; AOA: Age of acquisition of concept and RT(ms): Reaction time in ms.

## 2.5 Discussion

This study is the first to provide psycholinguistic norms for coloured Snodgrass & Vanderwart (Rossion & Pourtois, 2004) pictures in Kannada from adult Kannada-English bilingual speakers. Ratings were collected for five psycholinguistic variables: image agreement (IA), picture-name agreement (PNA), familiarity (FAM), visual complexity (VC), and age of acquisition (AoA) in line with previous normative studies [e.g. Mandarin Chinese (Weekes et al., 2007); Persian (Bakhtiar et al., 2013); Turkish (Raman et al., 2014); Hindi (Ramanujan & Weekes, 2020)]. These normative data are intended for use in the development of psycholinguistic, cognitive, and clinical experimental paradigms.

The majority of the 180 items were well-known to the participants and easily interpretable, as indicated by their high ratings for IA, PNA, FAM, and VC. However, responses to some items indicate caution is required in selecting items for experimental materials depending on the nature of the task. For example, a proportion of the translated Kannada names were unknown to the participants, and they could not imagine objects from the translated Kannada names. Such lexical items would not be appropriate for lexical decision, recognition, or comprehension experiments. Similarly, a large proportion of items had more than one commonly produced name in confrontation naming, which has implications for the design and interpretation of word production, recognition, and recall tasks. In addition, it is important to consider the limits of the items normed in the current study. The mean ratings were high for all psycholinguistic variables using the 5-point Likert scale (>4.5/5), indicating limited variation within the data. This lack of variation is likely to impact the ability to make experimental manipulations and may reduce the power to detect experimental effects. AoA had greater variation; however, the Likert scale used was relatively arbitrary in terms of representing age bands.

Despite the removal of culturally inappropriate items, only 64% of confrontation-naming responses were classed as correct. Items that were rated below 3/5 for IA, PNA, FAM, and VC were more likely to elicit incorrect responses in the confrontation naming task. The majority of non-correct responses (36%) were naming failures (i.e., cannot produce the name, which includes DKN, DKO, and tip of the tongue responses), translation errors (English name produced), or semantically related responses. Naming failures of items in confrontation naming was not surprising, given that in the PNA task, 40 items were rated as unknown, or the Kannada name was unknown by at least one participant. The percentage of naming failures was relatively higher in confrontation naming (17.9%) compared to picture-name agreement rating (4.35%), and this highlights the nature of the task involved. The presence of naming failures in both tasks suggests that not all participants are equally exposed to all the items. The naming errors resulted from participants not knowing the Kannada names for pictured items or using more familiar English names. The participants in the study were bilinguals who are used to switching between languages and so may be used to using English rather than Kannada names for some items. However, the present study emphasizes that items that are present in both language and cultural environments may still elicit naming failures (e.g., *barn, nail filer, broom, blouse, garbage can, etc*.) as these are taken from American English and drawn according to Western style and slight changes in the picture according to Indian environment might result in better rating and naming responses.

Nevertheless, a definitive explanation of the linguistic and/or cultural source of naming failures requires further experimental testing. Hence, we suggest that based on these norms, stimuli selection should pay careful attention to the psycholinguistic variables and naming latency depending on the task at hand. Further, these norms are helpful for future decisions of whether to accept certain responses as acceptable or not in Kannada-English bilinguals in speech production or comprehension assessments.

In the present study, greater image agreement and name agreement (*H*stats) and younger age of concept acquisition predicted faster naming latencies. Visual complexity of the coloured pictures and word frequency were not significant predictors (Table 7). Together, these variables, with familiarity, accounted for 62.3% of the variance in explaining naming latency. These findings replicate previous psycholinguistic research on word retrieval, e.g., in French (Alario et al., 2004), Mandarin Chinese (Weekes et al., 2007), Persian (Bakhtiar et al., 2013), and Hindi (Ramanujan & Weekes, 2020), indicating that the psycholinguistic ratings and name agreement statistics produced for Kannada-English bilinguals in the current study are reliable. However, there is a degree of dialectal variation within the Kannada-speaking population across Karnataka, and, therefore, some caution might be taken when applying these norms to populations outside of the southwest part of Karnataka where the data were collected.

As noted by Alario et al. (2004), AOA and NA are reported to have independent effects on naming latency. In the current study with adult Kannada speakers, NA was the most robust predictor of naming latency, followed by AOA. Alario et al. (2004) proposed that name agreement (*H*stats) reflects the stage of lexical retrieval involving accessing the spoken word. It is generally assumed that an object with more than one possible name will slow down the naming response because of competition between activated words (Ramanujan & Weekes, 2020; Snodgrass & Yuditsky, 1996). In the present study, because the participants were bilinguals, they needed to suppress multiple activated words as well as select the correct language. Hence, name agreement may have a relatively stronger influence on naming latency, and our study supports another recent study on the relationship between Hindi-English bilinguals and name agreement (Ramanujan & Weekes, 2020).

Familiarity influenced naming latency, but unexpectedly, in the regression analysis, the coefficient of familiarity was positive. This could have resulted in familiarity suppressing the error variance of variables AoA and *H*stats more than predicting the variance of naming latency. Another possible reason for the positive correlation may be high-rated familiarity. Despite clear instructions on rating familiarity, there may have been an influence on rating the low-frequency items as familiar based on the previous exposure to the items in the image agreement rating. The influence of FAM on naming latency is inconsistent across studies (Alario et al., 2004; Bakhtiar et al., 2013). The present study is in line with the Spanish (Cuetos et al., 1999); Mandarin Chinese (Weekes et al., 2007); and Hindi (Ramanujan & Weekes, 2020) Studies that depicted the influence of familiarity on naming latency were opposite to the predicted direction.

We also found significant effects of image agreement on confrontation naming latencies, and this is well-matched with the results of previous studies using black and white line drawings in American English (Snodgrass & Vanderwart, 1980), French (Alario et al., 2004) and Spanish (Cuetos et al., 1999). In contrast, a normative study on Mandarin Chinese (Weekes et al., 2007) reported IA to be a non-significant predictor based on the quality of the images. However, more recent studies using coloured S&V pictures in Persian (Bakhtiar et al., 2013) and Hindi (Ramanujan & Weekes, 2020) have found IA to be a significant predictor of naming latency. Although image agreement depends on the quality of the image per se, cultural effects also play a role in determining the effects on naming latency. For example, within the present study, we noticed that the item named ‘lamp’ in Kannada elicited a mental representation quite different from the object depicted in the coloured S&V stimuli. This highlights the importance of norming items within languages.

In the present study, visual complexity had no significant effects on naming latency in Kannada, which is compatible with recent studies using similar coloured S&V pictures [e.g., Mandarin Chinese (Weekes et al., 2007) Persian (Bakhtiar et al., 2013) and Hindi (Ramanujan & Weekes, 2020)]. The cross-linguistic comparison of Kannada norms with other studies showed the least compatibility for visual complexity. This suggests that details required for visual object recognition are not very sensitive in predicting the speed of naming for coloured S&V pictures.

Finally, word frequencies were not significant predictors of naming latency in Kannada. This is in line with previous studies in French (Alario et al., 2004), Mandarin Chinese (Weekes et al., 2007), and Hindi (Ramanujan & Weekes, 2020). It is challenging to include word frequency data obtained from a corpus as a variable where there is a large discrepancy for items with low name agreement.

Our main purpose in this study was to establish Kannada norms for the coloured S&V stimuli. Cross-linguistic comparisons were conducted to compare the Kannada normative data with data from seven different language studies that had used coloured S&V pictures (Rossion & Pourtois, 2004) and with the original S & V (Snodgrass &

Vanderwart, 1980) study (Table 6). It is important to note that cross-linguistic correlations emphasize the significance of having language-specific norms. The correlation strength varied from very low to moderate to high levels between *r* = -0.04 and *r* = 0.673. The Kannada norms collected here closely resemble those in Persian (Bakhtiar et al., 2013) on all the variables (IA, FAM, VC, AOA, *H*stats, *H*percent, and RT) and Turkish (Raman et al., 2014) except for RT. There was also close correspondence with Mandarin Chinese (Weekes et al., 2007) except for two variables (IA and VC) and Hindi (Ramanujan & Weekes, 2020), except for *H*stats. The remaining studies (Rossion & Pourtois, 2004; Snodgrass & Vanderwart, 1980) correlated weakly but significantly with the Kannada norms for one or two variables. Overall, AOA was the only variable that correlated significantly and was consistently sensitive across studies. In the present study, AOA was measured in terms of concept acquisition rather than word learnt (Bakhtiar et al., 2013; Dimitropoulou et al., 2009; Raman et al., 2014; Weekes et al., 2007) and the age at which concepts are learnt is similar to the age at which the object names are also learnt. Variable cross-linguistic correlations are not surprising, given that the familiarity and frequency of the stimuli vary across culture and linguistic environments (Bakhtiar et al., 2013; Clarke & Ludington, 2018; Zhou et al., 2010).

## 2.6 Conclusion

In summary, this is the first study to report norms for 180 Snodgrass & Vanderwart colourized pictures provided by Rossion & Pourtois (2004) in Kannada from adults. Normative data were provided for six psycholinguistic variables: image agreement, picture-name agreement, familiarity, visual complexity, age of acquisition of concept, and name agreement measures (Hstats). The psycholinguistic variables predicted confrontation naming latencies. Cross-linguistic comparisons highlighted the need for developing such norms for different languages and how exposure to S&V pictured items differs across cultures and linguistic environments. The norms produced in the present study are reliable and can be used to produce experimental paradigms and clinical assessments in Kannada-English bilinguals.

# 3 Chapter 3: Lexical Selection in Kannada-English Bilinguals

## 3.1 Introduction

Models of lexical access state that semantic representation activates the lexical nodes in both languages of bilingual even when the task requires the use of one language only (Costa et al., 1999; Hermans et al., 1998; Kroll et al., 2006). In addition, the semantic representation not only activates the target lexicon but also related semantic representations, which, in turn, activate corresponding lexical representations (Dell, 1986; Levelt et al., 1999). Therefore, the main question in bilingual research is how bilinguals select the correct word in the right language from all the activated lexical nodes. This debate concerns the role of competition in the process of lexical selection. To resolve this competition, three views have been proposed: **1**. ***language-specific*** (Costa & Caramazza, 1999) – competition is restricted to within language; **2. *language-non-specific*** (Green, 1998) **–** between language competition and **3. dynamic views** (Grosjean, 2001) – a combination of language-specific and language-non-specific views depending on the language context (refer to Chapter 1, section 1.2.2 for more details). Adjudicating between these views requires examining the presence and degree of cross-language during word production.

The existing research on lexical selection in bilinguals has shown that it is mainly language-non-specific. However, language-specific can also exist depending on certain contexts (Boukadi et al., 2015; Kroll et al., 2006). For instance, Kroll et al. (2008) suggest that the lexical selection process is, not surprisingly, modulated by a host of factors, such as language proficiency (Kroll et al., 2006; Van Hell & Tanner, 2012), language similarity (Boukadi et al., 2015) and language context Alario et al. (2004).

The PWI paradigm is most often used to explore bilingual lexical selection. In this paradigm, participants are asked to name the picture while ignoring the distractor presented in L1 or L2. The presence or absence of interference effects observed from the related distractors (semantic, phonological, phono-translation, translation) compared to unrelated distractors helps us to understand the competition at lexical selection in bilinguals (Belke, Meyer, et al., 2005; Hermans et al., 1998; Levelt et al., 1999; Sudarshan & Baum, 2019). Although the studies have shown that the presence of semantic interference effect suggests lexical competition (Aristei et al., 2012; Costa et al., 2005), semantic interference alone cannot be taken as evidence for differentiating the language-specific or language-specific mechanisms because both views can explain the presence of semantic interference effects (Costa & Caramazza, 1999; Hermans et al., 1998). However, the phono-translation interference effect, on the other hand, indicates cross-language activation during lexical selection by causing a delay in picture naming (Boukadi et al., 2015; Hermans et al., 1998). Therefore, phono-translation interference effects are more reliable in differentiating between the language-specific (within-language) vs language-non-specific (between-language) lexical selection mechanism. The present study's focus is on the manner, rather than the time course, of lexical selection. Therefore, to investigate lexical selection by competition, well-established semantic and phono-translation distractors were considered, which have been shown to have effects at 0ms SOA representing the lexical level (Boukadi et al., 2015; Costa et al., 2003; Hermans et al., 1998).

Language context has also been shown to influence the lexical selection mechanism in bilinguals. For example, Boukadi et al. (2015) have shown that lexical selection can be language-specific in a monolingual context and language-non-specific in a bilingual context. Moreover, the decades of research on lexical selection predominantly focused on highly proficient bilinguals with proximity between the languages in Dutch-English (Hermans et al., 1998) in Catalan-Spanish bilinguals (Colomé, 2001). The dynamics of lexical selection in bilinguals with less advanced L2 proficiency in typologically distant bilinguals are less explored and remain interesting also due to inconsistent findings [e.g. Tunisian Arabic-French bilinguals, (Boukadi et al., 2015); Japanese English bilinguals (Hoshino et al., 2021)]. The proximity between the languages and or high L2 proficiency might have facilitated the cross-language activation and resulted in language-non-specific ways in earlier studies. On the other hand, the lexical selection mechanism has shown varied patterns of results within the distant language bilinguals (language non-specific in Persian French bilinguals, (Deravi, 2009); Dynamic lexical selection in Tunisian Arabic-French bilinguals (Boukadi et al., 2015); Language specific in Japanese English bilinguals (Hoshino et al., 2021).

To summarise, previous research has shown that distractor type, language context, and distance between languages shape the lexical selection in bilinguals. However, the existing research primarily focused on closely related languages in highly proficient bilinguals, leaving a gap in understanding how these mechanisms work in distant language bilinguals with less advanced L2 proficiency. In addition, inconsistent findings among the distant languages are present. Hence, it is important to understand the reliability of these findings by studying the lexical selection mechanism in different distant language bilinguals.

## 3.2 The present study:

To address this gap, the present study manipulates three factors: distractor type (semantic, phono-translation, unrelated), distractor language (Kannada, English), and language context (monolingual vs. bilingual). These factors allow us to explore whether there is an influence from the non-target language during naming responses. By investigating lexical selection in both language directions within the same bilingual individuals, this study aims to provide insights into the flexibility of lexical selection and the influence of language context. The picture-word interference paradigm will be used where the participants will be asked to name the picture in L1 or L2 while ignoring the distractors presented in the same or opposite language of naming. This paradigm will allow us to investigate the lexical selection mechanism in both language directions within the same bilingual.

## 3.3 Hypothesis

The language-specific, language-non-specific, and dynamic accounts predict different performance patterns across these experimental manipulations.

**Prediction 1:** If the lexical selection mechanism is language non-specific, we expect a phono-translation interference effect from phono-translation distractor in all the PWI paradigms. It is assumed that phono-translation distractors can boost activation of the item name in the non-target language, meaning lexicons from both the languages of the bilingual are active, and competition between the lexicons is increased during lexical selection. Longer naming latencies indicate a phono-translation interference effect with the phono-translation distractor condition compared to the unrelated distractor condition.

**Prediction 2:** If the lexical selection mechanism is language-specific, we expect the **absence** of a phono-translation interference effect in all the PWI paradigms. Suppose the item name is not activated in the non-target language. In that case, the phono-translation distracter will have minimal effect as it will be phonologically and semantically unrelated to activated lexical units. In this way, it should behave like an unrelated distracter.

**Prediction 3:** The dynamic view of lexical selection predicts phono-translation interference effects when a speaker is performing the PWI task in a bilingual context (paradigms 2 and 4) but not in a monolingual context (paradigms 1 and 3). The dynamic view claims that bilingual speakers can suppress the activation of non-target language generated from the phono-translation distractor and proceed in a language-specific way when speaking in a monolingual context; however, when both languages are activated to higher levels, as in a bilingual context, lexical access proceeds in a language-non-specific manner, resulting in significant phono-translation effects.

## 3.4 Method

### 3.4.1 Ethics Statement

School of Psychology and Clinical Language Sciences, University of Reading (Ref: 2021-086-AA) approved this study. All participants provided informed consent before participating in the study.

### 3.4.2 Experimental Manipulations:

This study used a repeated measures design and examined performance on four versions of a PWI paradigm: (1) Monolingual Kannada (ML) – naming language and distracter language will be Kannada. (2) Bilingual Kannada-English (KE) – naming in Kannada, distracters in English. (3) Monolingual English (ME) – naming and distracters in English. (4) Bilingual English-Kannada – naming in English, distracters in Kannada. Figures 8 and 9 below describe the three lexical selection hypotheses based on the presence or absence of interference effects in both languages.

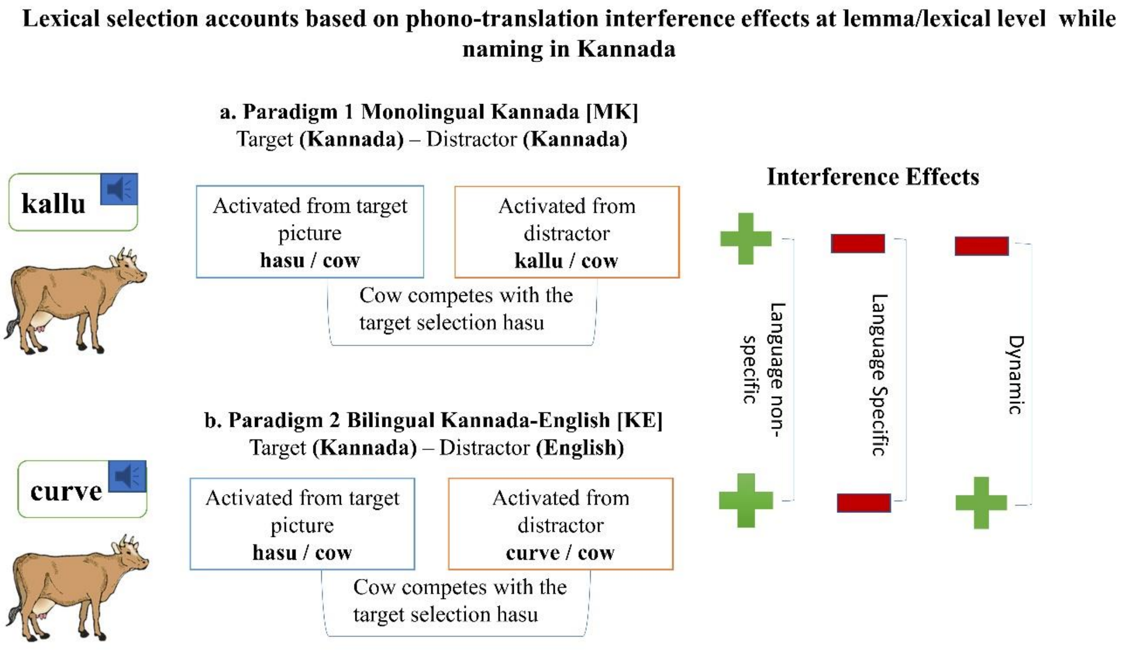


**Figure 8** Monolingual Kannada and Bilingual Kannada-English PWI paradigms

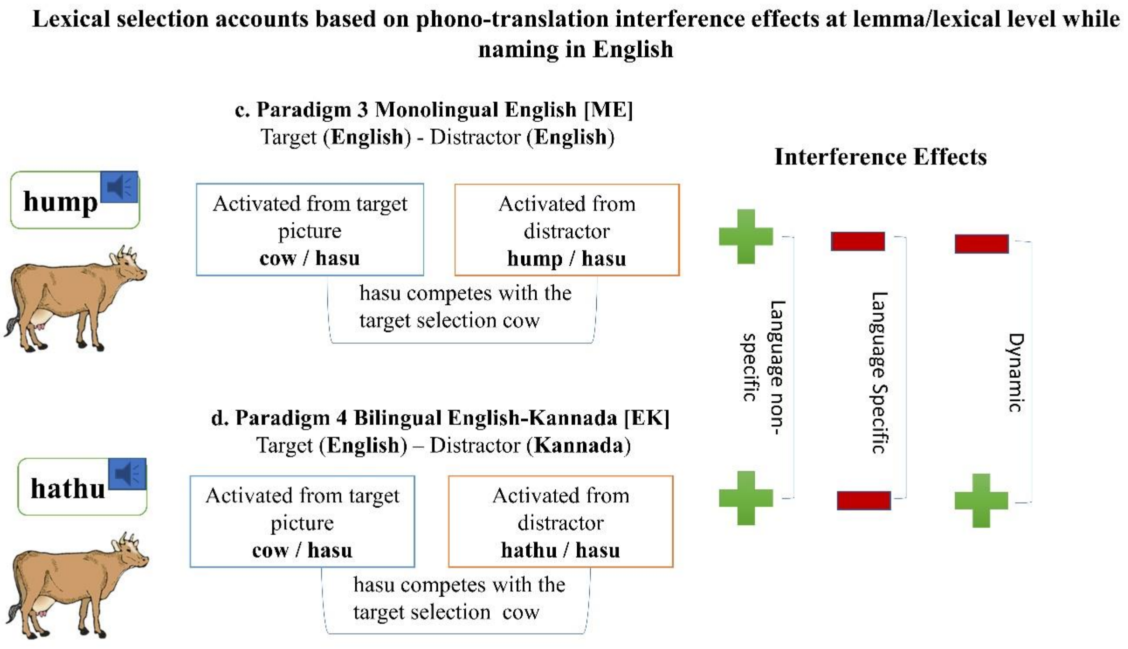


**Figure 9** Monolingual English and Bilingual English-Kannada PWI paradigms

### 3.4.3 Participants

A total of 36 Kannada-English sequential bilinguals, aged 19-35 (M = 27.62 years, SD = 3.98), were recruited from Mysuru and Bengaluru in the Southwestern part of Karnataka, which are predominantly Kannada-speaking regions. Participants met the inclusion criteria if they spoke Kannada as their native language and English as their second language, which was in active use in their daily lives. They were required to have access to a laptop, keyboard, headphones, microphone, and a reliable internet connection to participate in the online study. All participants had normal or corrected-to-normal vision and no history of hearing, communication, neurological, or psychological disorders.

The study was administered through Gorilla (www.gorilla.sc). Language proficiency was assessed using a self-rated language background questionnaire (Modified Language Proficiency Questionnaire, MLPQ; see Appendix B) and a Bilingual Dominance Scale, BDS (Dunn & Fox Tree, 2009) See Appendix D. Additionally, participants completed cognitive measures, including the Stroop and Flanker experiments to assess inhibitory control and an English Lexical Decision Task (Lemhöfer & Broersma, 2012) as an objective measure of L2 proficiency, this chapter focuses specifically on the PWI paradigms. In contrast, Chapter 4 will provide a detailed description, analysis, and discussion of other factors, such as bilingual participant characteristics and inhibitory control measures mentioned above.

### 3.4.4 Materials

#### *3.4.4.1 Target pictures*

We selected twenty-six coloured pictures with a high name and image agreement from the previous normative study described in Chapter 2. In this normative study, name and image agreement emerged as a significant predictor of naming latency in Kannada. Item selection also followed criteria based on the previous PWI studies (Hermans et al., 1998; Székely et al., 2003) such that all pictures chosen had non-cognate names in Kannada and English. In addition to the target pictures, six images that met the criteria were selected for practice trials.

#### 3.4.4.2 Distractor words

Three types of distractor words were chosen for each picture in both Kannada and English. Table 9 provides examples of each distractor type, and a complete list of target and distractor words for each paradigm can be found in Appendix E.

***Semantically related distractors***: Distractor words from the same semantic category as the target were selected. These words were obtained from the thesis "Mental Lexicon of Nouns and Verbs in Adult Speakers of Kannada" (Prarthana, 2015). Care was taken to ensure that the semantic distractors were not phonologically related to the target picture name in either Kannada or English. The semantic distractors used in English were translations of the Kannada semantic words.

***Phono-translation distractors***: These distractor words were phonologically related to the target picture's name in the non-target language. The phono-translation distractors were only related through translations of the Kannada or English target names. They were not semantically or phonologically related to the picture names in either language. The distractor words for Kannada were sourced from the book "Morphophonemic Analysis of the Kannada Language Relative Frequency of Phonemes and Morphemes in Kannada" by (Ranganatha, 1982), while for English, words were selected from the Celex database (Van der Wouden, 1990). Four sets of distractors were prepared, two for each language.

***Unrelated distractors***: These distractor words were not semantically or phonologically related to the target or related to the target through translation. They were chosen from the same book (Ranganatha, 1982), and the exact words were translated to create an English distractor list.

All the distractors were matched for age of acquisition and imageability using the CELEX database [$p > 0.10$]. The mean number of shared phonemes between the target picture names in the non-target language and the phono-translation distractors varied across the lists (1.69, 1.97, 2.18, 1.81). In most cases, an attempt was made to match the first syllable (two phonemes) of the target picture name in the non-target language with the phono-translation distractor. Additionally, the phonological overlap index (POI) was calculated for the four sets of phono-translation distractors (two in each language) and compared between the Kannada and English lists [$p > 0.1$]. The POI formula used was: (number of shared phonemes between response and target x 2) / (total phonemes in target + total phonemes in response). The mean POI across the four sets of phono-translation distractors was 0.4.

**Table 9** Examples of target-distractor relationship to the target picture naming. Target picture: "Cow (hasu – in Kannada)."

| **Variables** | **Monolingual Kannada** | **Bilingual (Kannada-English)** | **Monolingual English** | **Bilingual (English-Kannada)** |
|---|---|---|---|---|
| Unrelated | dimbu (pillow) | Pillow | Pillow | dimbu (pillow) |
| Semantic | kuri (sheep) | Sheep | Sheep | kuri (sheep) |
| Phono-translation | kallu (stone) | Curve | Hump | hathu (climb) |

### 3.4.5 Stimulus recording

Auditory distractors were recorded by the author, whose native language is Kannada, who learnt English sequentially from the age of 5 years. Distractors were recorded in a soundproof room (acoustically isolated booth at the University of Reading) wearing Sennheiser HD280 circum-aural headphones with a microphone placed approximately 6 inches from the speaker's mouth. Acoustic recordings of the distractors were amplified through the M-Track II audio interface and digitized at a resolution of 32 bits with a sampling rate of 44.1kHz, captured in Audacity (version 2.4.0). Each distractor word was recorded three times in isolation. Further, in post-processing, distractor words were spliced by hand in Audacity (version 2.4.0). In the next step, to enhance the audio quality as a fine-tuning, finalized auditory distractors proceeded in Audacity for noise reduction, compression, normalization, equalization, and amplification. Distractor words with speech disfluencies or amplitude inconsistencies were removed, and the ones with more naturally spoken were selected to list one individual .wav file. Lastly, each distractor word was individually converted to single .wav files (with the removal of pauses before and afterword production). Similarly, the target and six picture names of practice trials were recorded in Kannada and English and enhanced by the same process as distractor words for the familiarisation phase.

### 3.4.6 Procedure

The PWI paradigm was preceded by a familiarisation phase, as in previous studies (Boukadi et al., 2015; Hermans et al., 1998; Sudarshan & Baum, 2019). This phase was included to reduce the probability of participants using synonyms when naming the pictures (although high name agreement also reduced the likelihood of this). The use of synonyms could potentially disrupt the relationship between the target and distractor words, leading to errors during target picture naming in the actual paradigm. The familiarization phase comprised two lists, one for each language, and consisted of twenty-six target pictures along with their associated names in Kannada and English. Participants were instructed to observe the pictures and listen attentively to their names, which were presented auditorily through the headphones. They were instructed to use the same names when naming the pictures in the main PWI experiments. Each picture was displayed for 2500ms while its name was heard. Participants could manually advance to the next picture at their own pace by pressing the "SPACEBAR" button or allow the pictures to progress after 2500ms automatically. Gorilla randomly assigned participants to either the Kannada or English familiarization phase, and they were subsequently directed to perform naming with an associated paradigm in the same language as they received the familiarization phase. An example of the familiarization phase (10 a) and PWI experiments (10 b) is illustrated in Figure 10.

In the PWI paradigm, a target picture was presented on each trial paired with an auditory distractor word. Participants were instructed to ignore the presented auditory distractors and name the picture in the target language as quickly as possible. All four paradigms included the same 26 target pictures with three distractors each, resulting in a total of 312 responses per participant (4 x 26 x 3). Additionally, six extra pictures were used for practice trials. Target pictures and distracters were presented with a single SOA of 0ms. This SOA produced the most consistent distracter effects in previous research studies, as seen above. To prevent strategic relationships from developing based on the sequential occurrence of the same target picture and similar distractors, the presentation order of target-distractor pairs was pseudo-randomized. A minimum of eight different trials separated repeated target exposure.

Each trial began with a 250ms fixation cross followed by a 1000ms blank screen followed by the target picture and distracter word. The recording window started with the presentation of the picture. The picture remained on screen for up to 2500ms, and naming responses were recorded through the microphone. The trial ended at 2500ms or after detecting a naming response, whichever was quicker. A pause of 1000ms was added before the next fixation mark for the beginning of the following target picture. Each trial lasted a maximum of 4750ms, see Figure 10(b).

Each paradigm was split into training and two testing blocks to allow participants to have a break. Participants' verbal responses were recorded through Gorilla. Participants were requested to use headphones/earbuds with a microphone to listen and record the response.

Participants were instructed to name the pictures in Kannada or English, depending on the paradigm they received. They were instructed to name the picture as quickly as they could while ignoring the distractor word simultaneously presented through headphones in the trial phase and during actual naming.

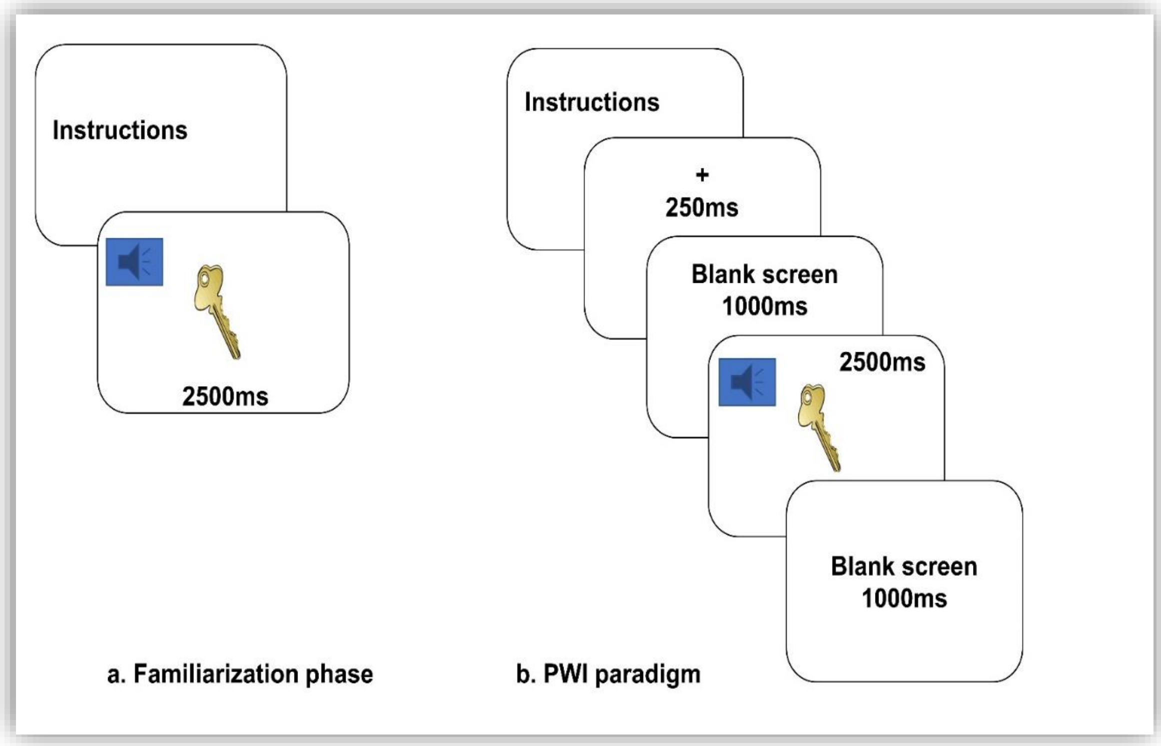


**Figure 10** (a) Display of familiarisation and (b) picture-word interference (PWI) experimental presentation.

### 3.4.7 Data cleaning

Four participants' data were removed from all the experiments due to missing data from one or more tasks (inaudible/ more noise / not recorded – due to microphone issues). The recorded naming data from the remaining 32 participants were downloaded from Gorilla and were analysed for naming latencies and accuracy using check vocal software (Protopapas, 2007). Inaccurate responses were removed. Responses below

300ms or +/-2 standard deviation of the participant's mean reaction time were excluded as outliers. Outlier analysis was calculated for each distractor type separately. Table 10 below provides the percentage error for each paradigm.

**Table 10** Total percent errors per paradigm, including outliers.

| **Paradigms** | **Errors, including outliers in the parenthesis** |
|---|---|
| Monolingual Kannada | 9.29 (4.08) |
| Bilingual Kannada-English | 5.52 (4.1) |
| Monolingual English | 2.54 (4.32) |
| Bilingual English-Kannada | 2.84 (4.2) |

## 3.5 Results

### 3.5.1 Descriptive statistics

Naming latency/reaction time descriptive statistics for each distracter type in each paradigm are presented in Figure 9 and Table 11, along with accuracy scores. The presented study is intended to measure the effects of distractor type, distractor language, and language context on naming latency and accuracy.

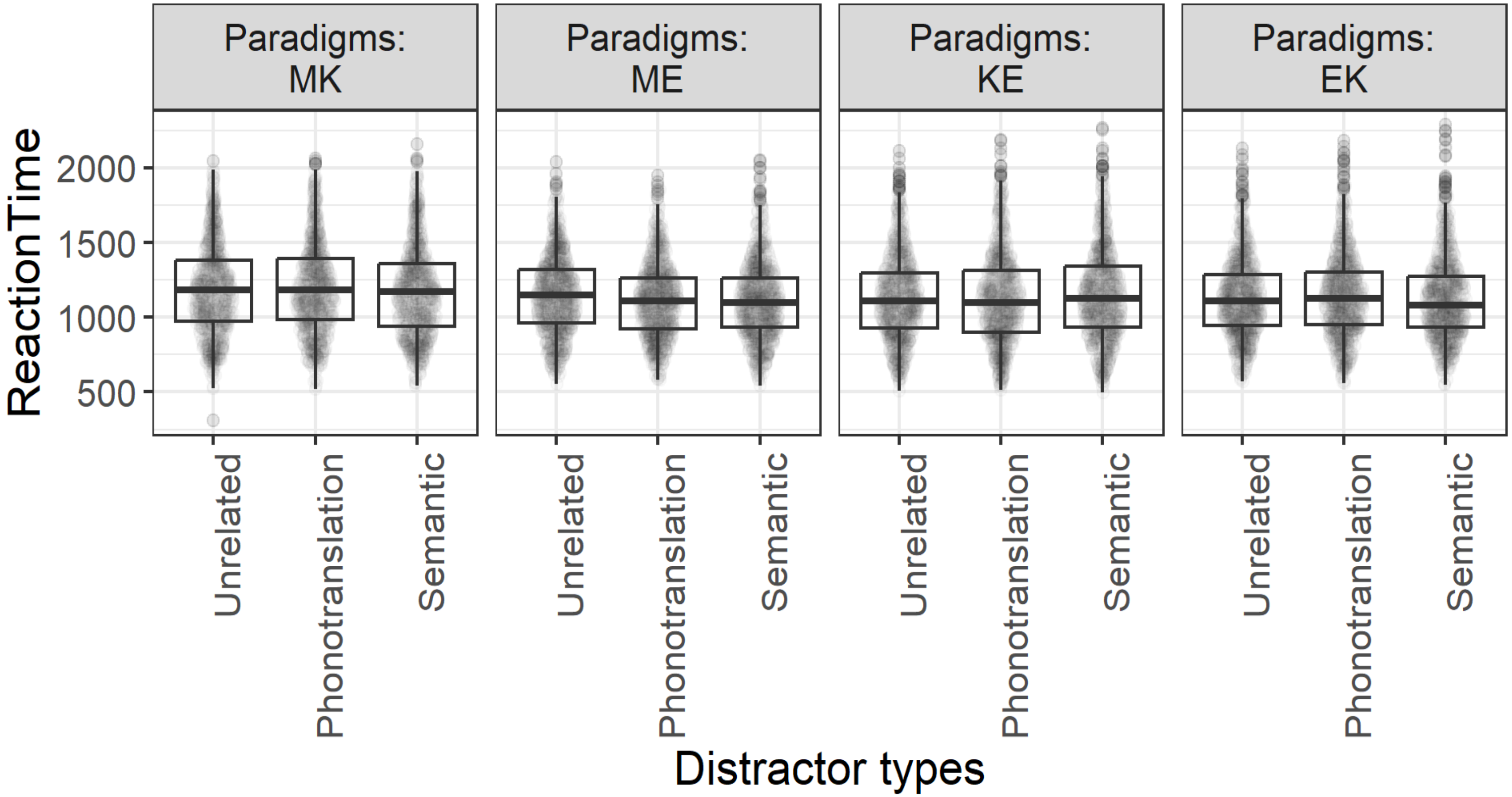


**Figure 11** Box plot representing a comparison of Reaction Times across paradigms by distractors.

The box plot displayed in Figure 11 illustrates the distribution of naming latency across distractor types within each of the PWI paradigms. Each box plot represents the median (middle line) and variability (interquartile range) of naming latency. The box plot shows not much difference in naming latency across the distractor types within each paradigm.

**Table 11** Mean and standard deviations for picture naming latencies and accuracy for each distractor type in each PWI paradigm

| **Variables** | **MK** | | **KE** | | **ME** | | **EK** | |
|---|---|---|---|---|---|---|---|---|
| | RT (ms) | Accuracy (%) | RT (ms) | Accuracy (%) | RT (ms) | Accuracy (%) | RT (ms) | Accuracy (%) |
| Unrelated | 1208 (129) | 85 (3.6) | 1125 (97) | 90 (3.0) | 1154 (131) | 94 (2.3) | 1138 (85) | 94 (2.5) |
| Semantic | 1188 (140) | 88 (3.2) | 1171 (123) | 91 (2.8) | 1112 (94) | 94 (2.4) | 1129 (78) | 93 (2.5) |
| Phono-translation | 1214 (105) | 86 (3.4) | 1141 (129) | 90 (3.1) | 1114 (106) | 91 (2.8) | 1151 (88) | 92 (2.8) |

Participants took longer to name in the MK paradigm, with a mean reaction time of 1203.33 ms compared to the other paradigms (KE with 1145 ms, ME with 1216, and EK with 1139 ms). Similarly, the accuracy data from Table 11 show that bilingual participants had more errors in the MK paradigm, with an average accuracy of 86.33%, compared to the KE paradigm, with 90.33%, and the ME and EK paradigm, with 93%. Reaction times were normally distributed, and visual inspection of residual plots revealed no apparent deviations.

To interpret further, pairwise comparisons were conducted to explore the differences in reaction time across four PWI paradigms: Monolingual Kannada (MK), Bilingual Kannada-English (KE), Monolingual English (MK), and Bilingual English-Kannada (EK). Below, Table 12 represents the comparisons.

**Table 12** Pair-wise comparisons between the paradigms on reaction time measure

| **Paradigms** | **Estimate** | **Std error** | **Z ratio** | ***p-value*** |
|---|---|---|---|---|
| MK vs KE | 54.28 | 7.28 | 7.45 | <.001*** |
| MK vs ME | 72.43 | 7.23 | 10.01 | <.001*** |
| MK vs EK | 57.96 | 7.24 | 8.00 | <.001*** |
| ME vs KE | -18.15 | 7.15 | -2.53 | < .05* |
| ME vs EK | -14.47 | 7.10 | -2.03 | .174 |
| KE vs EK | 3.68 | 7.16 | .51 | .955 |

Participants displayed significantly higher reaction time in the Monolingual Kannada (MK) paradigm compared to all other paradigms. In addition, participants were significantly quicker in the Monolingual English (ME) paradigm compared to the Bilingual English-Kannada (EK) paradigm. The other combinations did not yield any significant difference between the paradigms.

### 3.5.2 Linear Mixed Effects Modelling

Statistical analyses were performed in R (R Core Team, 2022) with the lme4 package (Bates et al., 2015). Mixed effects models were fit with all the data from the four paradigms.

The dependent variable is the Reaction time measured in ms. The independent predictor variables are the distractor type with three levels (dummy coded as 1 = Unrelated, 2 = Semantic, and 3 = Phonotranslation), distractor language with two levels (dummy coded as 1 = Kannada and 2 = English), and language context with two levels (dummy coded as 1 = Monolingual and 2 = Bilingual). The predictor variables, also called fixed effects in the linear mixed models, were introduced with interaction terms between them. We started with a maximal random effects model that included varying intercepts for participants and items and a random slope structure with interaction terms between the fixed factors [reaction time ~ distractor type * distractor language * language context + (1 + distractor type * distractor language * language context | participants) + (1+ distractor type * distractor language * language context | items]. This maximal random structure model failed to converge. Therefore, the random effect structure was simplified by removing the interaction terms between the fixed factors for random slopes and intercepts that varied by participants and items [reaction time ~ distractor type * distractor language * language context + (1+ distractor type + distractor language + language mode | participants) + (1+ distractor type + distractor language + language mode | items)]. Further, this simplified random intercept and slope structure model was then compared to the random intercept-only model [reaction time ~ distractor type* distractor language * language context + (1 | participants) + (1 | items)] using the Chi-squared test and maximum likelihood. Most importantly, significant results remained unchanged when the simplified random structure model was compared against a model with no slopes (i.e., random intercept model). Therefore, we report (see Table 13) that the simplified maximal random structure model that did converge represents the best fit for our data ($\chi 2$ = 449.18, df = 28, $p$ = <0.001). The model's intercept, corresponding to Distractor Type = Unrelated, Distractor Language = Kannada and Language Context = Monolingual  is at 1204.17ms (95% CI [1140.73, 1267.62], $t$ (9013) = 37.20, $p$ < .001).

**Table 13** Best fit random structure model (Reaction time)

*Reaction time ~ distractor type * distractor language * language context + (1 + distractor type + distractor language + language context | participant) + (1 + distractor type + distractor language + language context |items)*

| **Parameters** | **Estimates** | **Std error** | **CI** | **t value** | ***p*-value** |
|---|---|---|---|---|---|
| (Intercept) | 1204.24 | 32.41 | 1140.66 – 1267.83 | 41.29 | <.001*** |
| **Distractor type** | | | | | |
| Unrelated vs Semantic | -18.96 | 12.72 | -60.31 – 22.38 | -.899 | .37 |
| Unrelated vs Phonotranslation | 10.07 | 19.43 | -28.03 – 48.18 | .519 | .60 |
| **Distractor Language** | | | | | |
| Kannada vs English | -50.50 | 16.83 | -83.49 – -17.52 | -3.00 | **<.003*** ** |
| **Language Context** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Monolingual vs Bilingual | -66.92 | 18.06 | -102.35 – -31.50 | -3.70 | **<.001*** ** |
| **Two-way interaction effects** | | | | | |
| **Distractor language * Language context** | | | | | |
| Kannada vs English * Monolingual vs Bilingual | 53.09 | 16.96 | 19.84 – 86.35 | 3.13 | **.001**** |
| **Distractor Type * Distractor language** | | | | | |
| Unrelated vs Semantic * Kannada vs English | -21.50 | 17.05 | -54.83 – 11.82 | -1.26 | .205 |
| Unrelated vs Phono-T* Kannada vs English | -51.60 | 17.10 | -85.12 – -18.08 | -3.01 | **.002**** |
| **Distractor type * Language context** | | | | | |
| Unrelated vs Semantic * Monolingual vs Bilingual | 12.81 | 17.03 | -20.58 – 46.21 | .75 | .451 |
| Unrelated vs Phono-T * Monolingual vs Bilingual | 7.81 | 17.11 | -25.67 – 41.44 | .46 | .645 |
| **Three-way interaction effects** | | | | | |
| **Distractor type * Distractor language * Language context** | | | | | |
| Unrelated vs Semantic* Kannada vs English * Monolingual vs Bilingual | 50.60 | 23.92 | 3.17 – 96.95 | 2.09 | **.03*** |
| Unrelated vs Phono-T* Kannada vs English * Monolingual vs Bilingual | 26.86 | 24.06 | -20.30 – 74.03 | 1.11 | .264 |
| **Random Effects** | | | | | |
| | **Variance** | | **sd** | **Correlation** | |
| Participant (Intercept) | 24749.12 | | 157.32 | | |
| Items (Intercept) | 5237.5 | | 72.37 | | |

| | | | |
|---|---|---|---|
| Semantic distractor \| participant (slope) | 141.2 | 11.88 | -.33 |
| Semantic distractor \| item (slope) | 7527 | 86.76 | -.51 |
| Phono-translation \| participant (slope) | 469.4 | 21.67 | -.58 |
| Phono-translation \| item (slope) | 5469.5 | 73.96 | -.63 |
| Distractor language Eng \| participant (slope) | 4001.3 | 63.26 | -.43 |
| Distractor language Eng \| item (slope) | 317.9 | 17.83 | .24 |
| Language context Bi \| participant (slope) | 5244.9 | 72.42 | -.07 |
| Language context Bi \| item (slope) | 414.6 | 20.36 | .35 |
| **Model fit** | | | |
| $R^2$ | Marginal | Conditional | |
| | .012 | .353 | |

Key: p-values for fixed effects calculated using Satterthwaite's approximations. Confidence Intervals have been calculated using the Wald method.

### *3.5.2.1 Main effects (Reaction time):*

The model found no effect of distractor type, indicating that neither semantic (*b* = -18.96, *p*= .37) nor phono-translation distracters (*b* = 10.07, *p* = .60) interfered with naming latency over and above unrelated distractors. A main effect of distractor language was observed; participants responded significantly faster when the distractors were present in English (*b* = -50.50, p < .003) compared to Kannada. Furthermore, language context demonstrated a significant main effect; participants were significantly faster in naming the pictures in a bilingual context (*b* = -66.92, p < .001) than in the monolingual context.

### *3.5.2.2 Interaction effects (Reaction time):*

Three two-way and three-way interactions were observed: (1) A significant interaction was observed between distracter language and language context (*b* = 53.09, p = .001); (2) a two-way interaction between distractor type and distractor language (*b* = -51.60, p = .002), and (3) a three-way interaction between distractor type, distractor language, and language context (*b* = 50.60, *p* = .03).

Post hoc pairwise comparisons with simple contrast coding were performed further to unpack the interaction effects using *emmeans: Estimated Marginal Means, aka Least-Squares Means*—r package version 1.10.5 by Lenth (2024). Emmeans provide multiple simultaneous comparisons based on a normal approximation. *Z* ratio greater than 2 was predicted as significant effects corresponding to an alpha of 0.05 or lower.

Despite the model demonstrating a good fit with the data, as indicated by marginal ($R^2$ = .012) and conditional ($R^2$ = .353) R-squared values, it is important to note that the model explains only a small proportion of the variance in RT. In conclusion, this mixed-effects model highlights the influential role of distractor language, language context, and their interactions on RT in bilingual contexts. However, the limited explanatory power of the model suggests the existence of additional unexplored factors contributing to variability in reaction times among participants and items.

#### *3.5.2.2.1 Two-way interaction between the distractor language and language context*

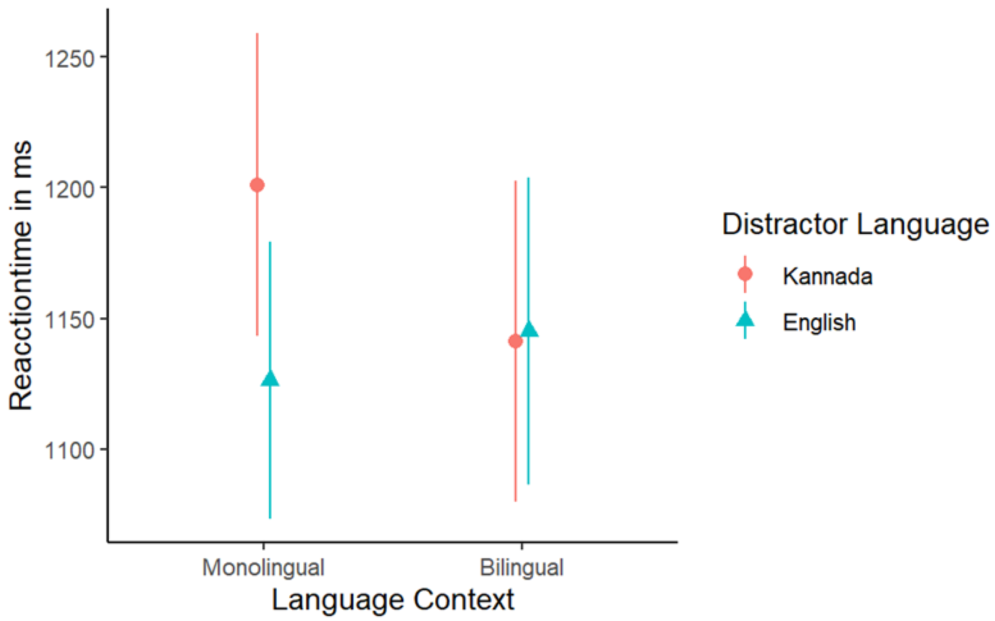


**Figure 12** Displaying interaction effects between distractor language and language context on naming latencies

Figure 12 shows the two-way interaction between the distractor language and language context. Bilinguals were significantly slower in naming the pictures in the monolingual contexts when the distractors were present in their native language, Kannada, than in English. In contrast, there were no significant differences in naming the pictures in the bilingual context irrespective of distractor language, and these results are supported by the post-hoc comparisons presented in Table 14.

**Table 14** Post hoc factor level comparisons between the distractor language and language context

| | Monolingual Context | | | | Bilingual Context | | | |
|---|---|---|---|---|---|---|---|---|
| Distractor Language pair | Estimate | SE | Z ratio | *p-value* | Estimates | SE | Z ratio | *p-value* |
| Kannada vs English | 74.71 | 13.5 | 5.547 | **.001** | -3.8 | 13.4 | -.284 | .776 |

### *3.5.2.2.2 Two-way interaction between the distractor language and distractor type*

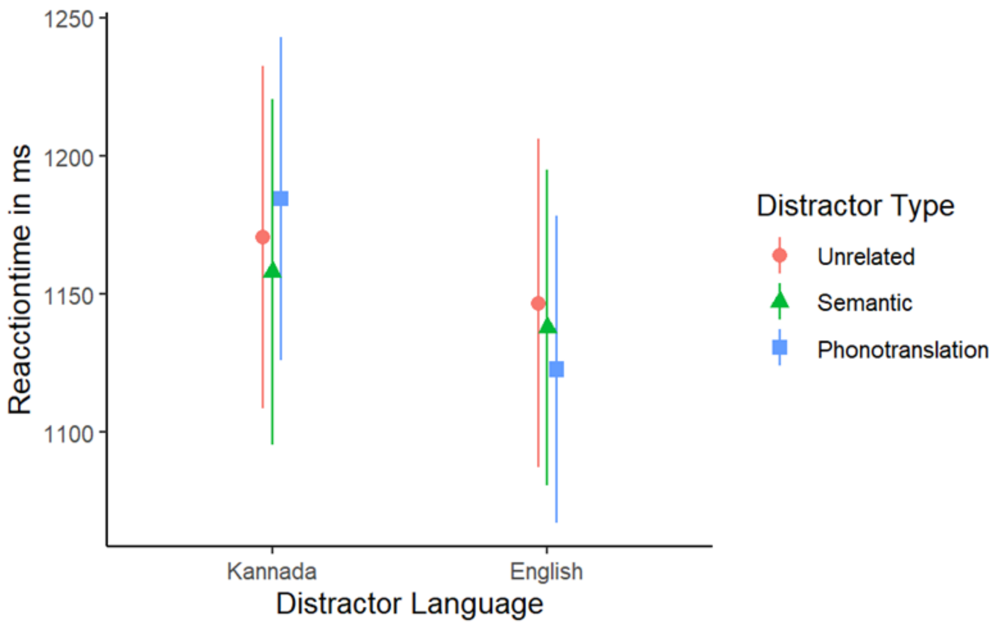


**Figure 13** Interaction between distractor type and distractor language on naming latencies

Significant interaction effects were observed between the distractor type and distractor language, as shown in Figure 13. Bilinguals were significantly slower in naming the pictures accompanied by phonotranslation distractors when presented in the Kannada language than in English. However, there was no significant effect of distractor language on semantic and unrelated distractors. Post-hoc comparisons supporting the results are presented in Table 15.

**Table 15** Post-hoc factor level comparisons between the distractor language and distractor type

| **Distractor Language pair / Distractor Type** | | Estimate | SE | Z ratio | *p-value* |
|---|---|---|---|---|---|
| | Unrelated | 24 | 14.3 | 1.64 | .094 |
| **Kannada vs English** | Semantic | 20.4 | 14.3 | 1.48 | .13 |
| | Phonotranslation | 62 | 14.3 | 4.32 | **.001** |

#### *3.5.2.2.3 Three-way interactions between distractor type, distractor language and language context.*

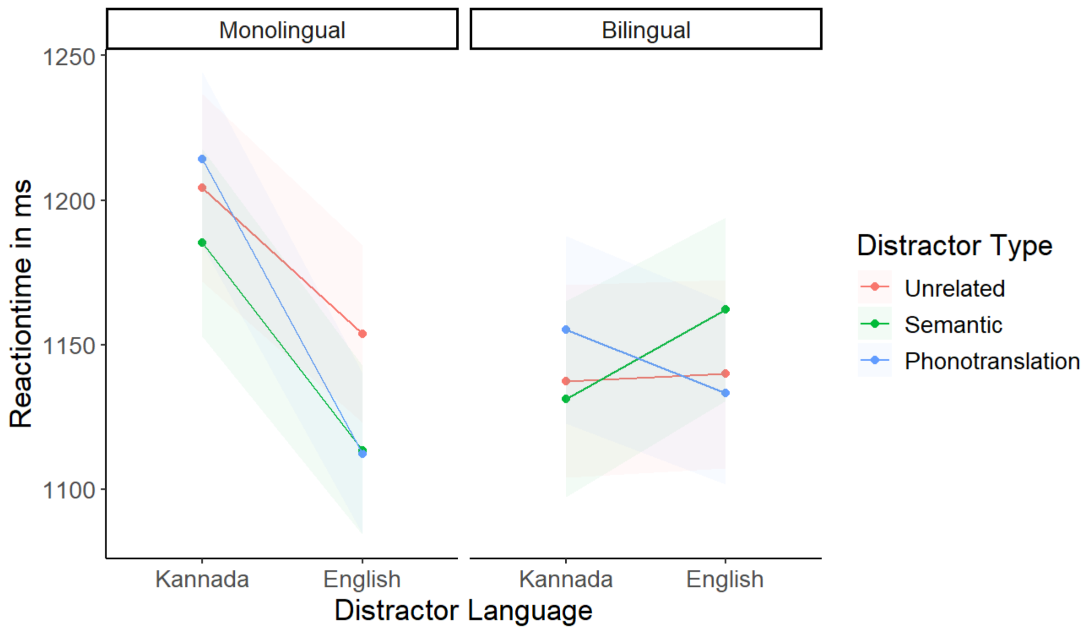


**Figure 14** Displaying three-way interactions between distractor type, distractor language, and language context on naming latencies

The three-way interactions between the distractor type, distractor language and language context produced a significant effect, as represented in Figure 14. To unpack this three-way interaction, a simple pairwise comparison was carried out as a post-hoc analysis (see Table 16) using the emmeans package in r by comparing the distractor type split by language context and distractor language, which yielded no significant effects. The three-way interaction effect may have emerged from consistent effects of distractor language and language contexts across distractor types. The effect of distractor language was present for all distractor types in a monolingual context; this effect only occurs for semantic distractors in a bilingual context. Similarly, consistent effects of language context occur for all distractor types when distractors were presented in Kannada but only for semantic distractors when distractors were presented in English.

In other words, bilinguals showed no significant difference in naming latencies between the distractor types irrespective of distractor language and language context. Concerning the distractor language effects, bilinguals were significantly slower in naming the pictures when the distractors were present in Kannada language than in English across the distractor types in the monolingual context. However, in the bilingual context, bilinguals took longer naming latencies for only the semantic distractors when the distractors were presented in English than in Kannada. Language context effects revealed that bilinguals were significantly slower in naming the pictures in the monolingual context than in the bilingual context when the distractors were presented in the Kannada language across the distractor types. In contrast, bilinguals were significantly slower in naming the pictures in the bilingual context than in the monolingual context for semantic distractors alone when presented in the English language.

**Table 16** Post hoc comparisons of three-way interactions (Distractor type* Distractor language * Language context)

| **Language Context** | **Monolingual** | | | | **Bilingual** | | | |
|---|---|---|---|---|---|---|---|---|
| **Distractor Language/Distractor Type pair** | | | | | | | | |
| | **Estimate** | **SE** | **Z ratio** | ***p-value*** | **Estimate** | **SE** | **Z ratio** | ***p-value*** |
| | Unrelated vs Semantic | | | | Unrelated vs Semantic | | | |
| Kannada | 19.04 | 21.1 | .903 | .945 | 6.18 | 20.8 | .297 | .999 |
| English | 40.46 | 20.08 | 1.94 | .373 | -22.37 | 20.9 | -1.07 | .893 |
| | Unrelated vs Phonotranslation | | | | Unrelated vs Phonotranslation | | | |
| Kannada | -9.92 | 22.2 | -.51 | .995 | -17.92 | 19.1 | -0.93 | .936 |
| English | 41.51 | 19.1 | 2.17 | .250 | 6.66 | 19.2 | .346 | .999 |
| | Semantic vs Phonotranslation | | | | Semantic vs Phonotranslation | | | |
| Kannada | -28.95 | 17.6 | -1.62 | .570 | -24.1 | 17.4 | -1.38 | .735 |
| English | 1.05 | 17.4 | .06 | 1.00 | 29.03 | 17.5 | 1.66 | .558 |
| **Distractor type / Distractor Language pair** | | | | | | | | |
| | Kannada vs English | | | | Kannada vs English | | | |
| Unrelated | 50.42 | 16.7 | 3.02 | **.030** | -2.50 | 16.6 | -.15 | 1.00 |
| Semantic | 71.85 | 16.6 | 4.32 | **.001** | -31.05 | 16.6 | -1.87 | **.06** |
| Phonotranslation | 101.85 | 16.7 | 6.09 | **.001** | 22.09 | 16.6 | 1.32 | .770 |
| **Distractor Language** | **Kannada** | | | | **English** | | | |
| **Distractor Type/Language context pair** | | | | | | | | |
| | Monolingual vs Bilingual | | | | Monolingual vs Bilingual | | | |
| Unrelated | 66.81 | 18 | 3.70 | **.011** | 13.89 | 17.9 | .77 | .999 |
| Semantic | 54 | 18 | 3.00 | **.002** | -48.94 | 17.9 | -2.74 | **.006** |
| Phonotranslation | 58.81 | 18 | 3.26 | **.001** | -20.96 | 18.0 | -1.16 | .991 |

### 3.5.3 Accuracy Analysis

Accuracy analyses used generalised, linear mixed-effects models (binomial link function) to investigate the influence of fixed factors: distractor type, distractor language and language context on naming accuracy. Table 11 presents the accuracy data for the PWI task. The coding and process of accuracy analysis were performed similar to reaction time analysis starting from a maximal random structure model with interaction effects between the fixed factors that varied by participants and items (*Accuracy ~ distractor type * distractor language * language context + (1 + distractor type * distractor language * language context | participant) + (1 + distractor type * distractor language * language context |items) which gave warning on max function and did not produce the output.* The next model was simplified by removing the interaction terms between the fixed factors from the random slope and intercept that varied by participants and items (*Accuracy ~ distractor type * distractor language * language context + (1 + distractor type + distractor language + language context | participant) + (1 + distractor type + distractor language + language context |items)* and this simplified random structure model (random intercept + slope) did converge and produced an output. To evaluate the best-fit model for our data, a simplified random structure model was compared with the random intercept-only model (*Accuracy ~ distractor type * distractor language * language context + (1 | participant) + (1 | items)*. Comparing the two models using the chi-squared and maximum likelihood tests, the simplified random structure model was significantly better ($\chi 2$ = 57.14, df = 28, *p* = < .001) with lower AIC values than the random intercept-only model. Therefore, we report the simplified random structure model in Table 17 as the best-fit model of our data.

The model's explanatory power related to the fixed effects alone was very too small (marginal R2) at .03. The model's intercept, corresponding to Distractor Type = Unrelated, Distractor Language = Kannada and Language Context = Monolingual, is at 2.06 (95% CI [1.63, 2.49], p < .001). Further, to interpret significant interactions, the emmeans package was used (Lenth, 2024) to make post hoc comparisons between fixed effects.

**Table 17** Best fit model of accuracy analysis

*Accuracy ~ distractor type * distractor language * language context + (1 + distractor type + distractor language + language context | participant) + (1 + distractor type + distractor language + language context |items)*

| **Parameters** | **Estimates** | **Std error** | **CI** | **z value** | ***p*-value** |
|---|---|---|---|---|---|
| (Intercept) | 2.05 | .22 | 5.08 – 12.11 | 9.29 | <.001*** |
| **Distractor type** | | | | | |
| Unrelated vs Semantic | 0.18 | .19 | 0.81 – 1.76 | .91 | .359 |
| Unrelated vs Phonotranslation | .067 | .19 | 0.73 – 1.57 | .34 | .732 |
| **Distractor Language** | | | | | |
| Kannada vs English | 1.71 | .19 | 2.19 – 4.76 | 5.91 | **<.001*** ** |
| **Language Context** | | | | | |
| Monolingual vs Bilingual | .85 | .20 | 1.57 – 3.53 | 4.15 | **<.001*** ** |
| **Two-way interaction effects** | | | | | |
| **Distractor language * Language context** | | | | | |
| Kannada vs English * Monolingual vs Bilingual | -1.62 | .26 | .12 – 0.33 | -6.15 | **<.001** ** |
| **Distractor Type * Distractor language** | | | | | |
| Unrelated vs Semantic * Kannada vs English | -.39 | .26 | 0.40 – 1.13 | -1.50 | .133 |
| Unrelated vs Phono-T* Kannada vs English | -.58 | .25 | 0.34 – 0.91 | -2.34 | **.019** ** |
| **Distractor type * Language context** | | | | | |
| Unrelated vs Semantic * Monolingual vs Bilingual | -.33 | .25 | 0.44 – 1.18 | -1.31 | .189 |
| Unrelated vs Phono-T * Monolingual vs Bilingual | -.32 | .24 | 0.45 – 1.17 | -1.32 | .186 |
| **Three-way interaction effects** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| **Distractor type * Distractor language * Language context** | | | | | |
| Unrelated vs Semantic* Kannada vs English * Monolingual vs Bilingual | .66 | .36 | 0.95 – 4.01 | 1.81 | .065 |
| Unrelated vs Phono-T* Kannada vs English * Monolingual vs Bilingual | .80 | .35 | 1.12 – 4.49 | 2.28 | **0.02** |
| **Random Effects** | | | | | |
| | **Variance** | | **sd** | **Correlation** | |
| Participant (Intercept) | .08 | | .29 | | |
| Items (Intercept) | .86 | | .93 | | |
| Semantic distractor \| participant (slope) | .008 | | .09 | -.25 | |
| Semantic distractor \| item (slope) | .32 | | .56 | -.65 | |
| Phono-translation \| participant (slope) | .019 | | .13 | -.01 | |
| Phono-translation \| item (slope) | .32 | | .57 | -.45 | |
| Distractor language Eng \| participant (slope) | .003 | | .06 | -.34 | |
| Distractor language Eng \| item (slope) | .048 | | .22 | .24 | |
| Language context Bi \| participant (slope) | .03 | | .19 | -.40 | |
| Language context Bi \| item (slope) | .20 | | .45 | -.72 | |
| **Model fit** | | | | | |
| $R^2$ | Marginal | | Conditional | | |
| | .035 | | The model could not generate. | | |

### 3.5.3.1 *Main effects (Accuracy)*

The model found no effect of distractor type on the accuracy, indicating that neither semantic (*b* = -.18, *p*= .359) nor phono-translation distracters (*b* = .06, *p* = .732) interfered with percent correct accuracy scores over and above unrelated distractors. A main effect of distractor language was observed; bilinguals' performance on naming pictures was less accurate with Kannada distractors than with English (*b* = -1.71, p <

.003. The significant main effect of language context revealed that bilinguals were less accurate in the monolingual context than in the bilingual context (*b* = .85, p < .001).

#### *3.5.3.2 Interaction effects (Accuracy)*

A few two-way and three-way interactions were observed. (1) A significant interaction was observed between distracter language and language context (b =-1.62, p = <.001); (2) a two-way interaction between distractor type and distractor language (b = -.58, p = .019), and (3) a three-way interaction between distractor type, distractor language, and language context (b = .80, p = .02).

##### *3.5.3.2.1 Interactions between distractor language and language context (Accuracy)*

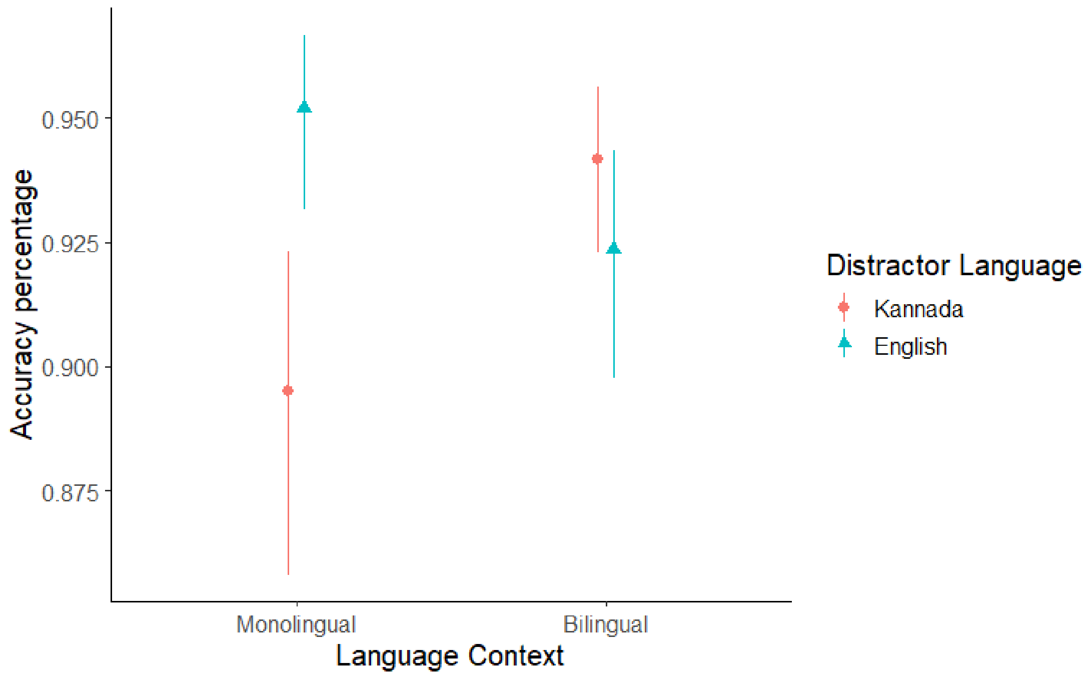


**Figure 15** Interaction between Distractor language and language context (Accuracy)

Figure 15 shows the two-way interaction between the distractor language and language context. Bilinguals were less accurate in naming the pictures in the monolingual contexts when the distractors were present in their native language, Kannada, than in the English [b = -.84, p =.001] with an effect size of d = -.84. In contrast, there was no significant differences in naming accuracy in the bilingual context irrespective of distractor language [b= .28, p=.524 with an effect size d = .28] and these results are supported by the post-hoc comparisons presented in Table 18.

**Table 18** Post-hoc comparison between the distractor language and language context (Accuracy)

| | **Monolingual Context** | | | | **Bilingual Context** | | | |
|---|---|---|---|---|---|---|---|---|
| Distractor Language pair | Estimate | SE | Z ratio | *p value* | Estimates | SE | Z ratio | *p value* |
| Kannada vs English | -.84 | .12 | -1.08 | **.001** | .28 | .12 | .05 | .524 |

#### *3.5.3.2.2 Interaction effects between distractor language and distractor type on accuracy*

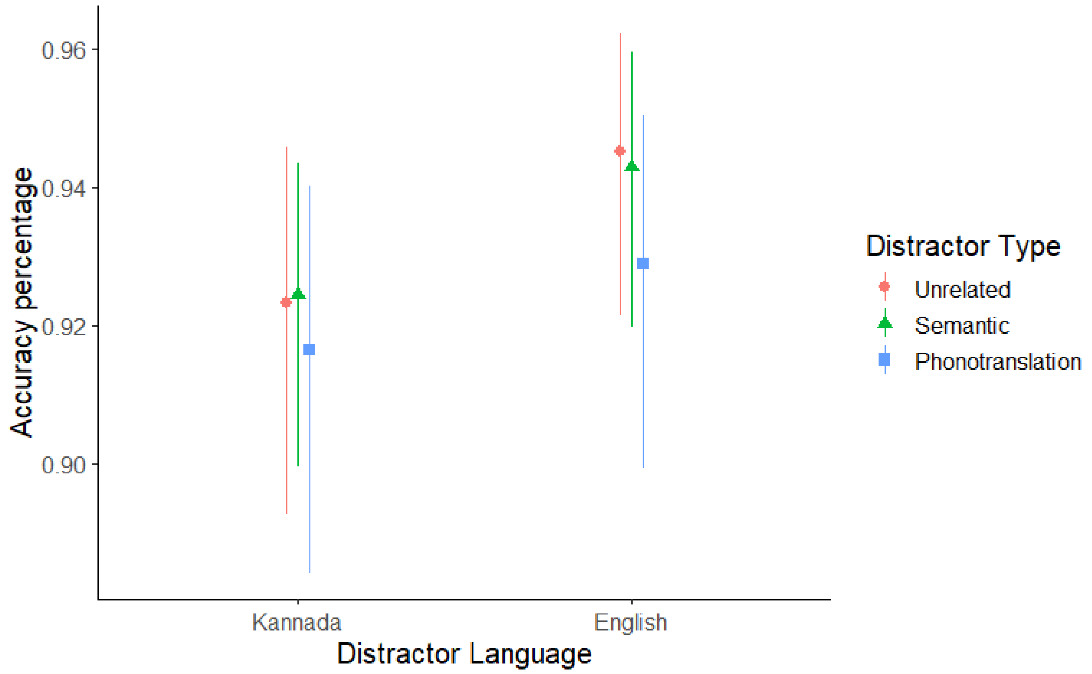


**Figure 16** Interaction between distractor language and distractor type (Accuracy)

Significant interaction effects were observed between the distractor type and distractor language, visualised in Figure 16. Bilinguals were significantly less accurate in naming with Kannada distractors than English in unrelated and semantic conditions. However, there was no significant effect of distractor language on phonotranslation distractors for accuracy scores. Post-hoc comparisons supporting the results are presented in Table 19.

**Table 19** Post hoc comparison between the distractor type and distractor language (Accuracy)

| **Distractor Language pair / Distractor Type** | | Estimate | SE | Z ratio | *p value* |
|---|---|---|---|---|---|
| **Kannada vs English** | Unrelated | -.36 | .14 | -2.45 | **.041** |
| | Semantic | -.30 | .14 | -2.08 | **.037** |
| | Phonotranslation | -.17 | .13 | -1.29 | .193 |

#### *3.5.3.2.3 Three-way interaction effects between distractor type, distractor language and language context on accuracy scores.*

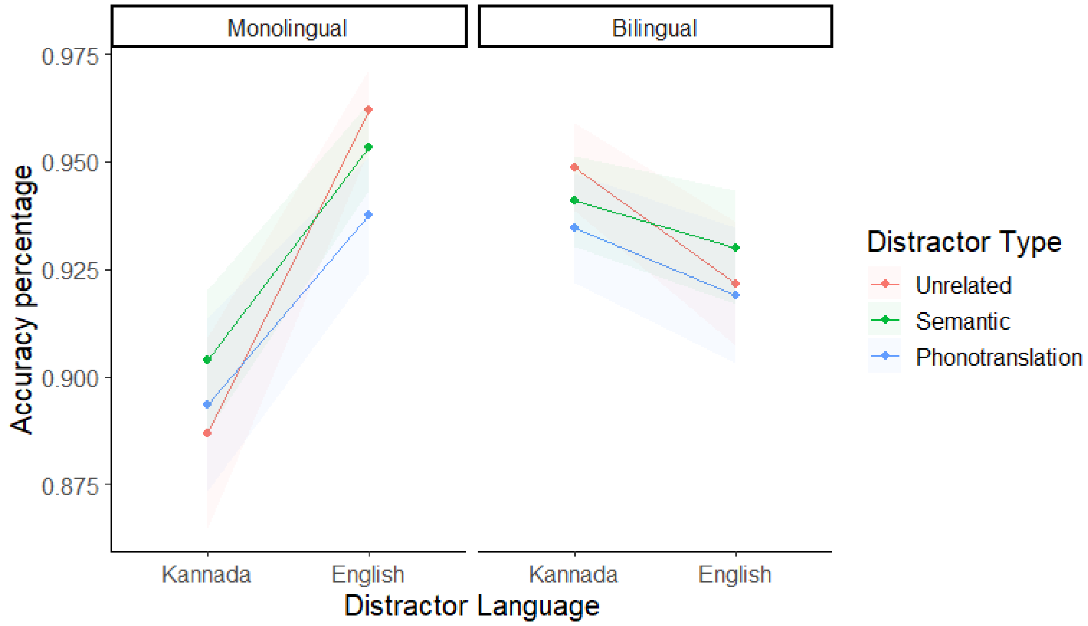


**Figure 17** Post hoc comparisons of three-way interactions (Accuracy)

To interpret the three-way interaction between distracter type, distracter language and language context, simple pairwise comparisons were carried out as post-hoc analyses (see Table 20). Naming accuracy was compared between distractor types split by language context and distractor language conditions. No significant distractor pair effects were observed on accuracy scores, irrespective of distractor language and language context.

The three-way interaction effects may have emerged from inconsistent effects of distractor language and language contexts across distractor types. Therefore, naming accuracies were compared between the distractor language split by distractor type and language context, which further revealed that the effect of distractor language on accuracy scores was present for all distractor types in a monolingual context; this effect only occurs for unrelated distractors in the bilingual context. In other words, bilinguals performed less accurately with Kannada distractors than the English distractors irrespective of distractor type (unrelated, semantic, phonotranslation) in the monolingual context. On the other hand, in the bilingual context, participants were more accurate with the English than Kannada language distractors in unrelated conditions but no significant effects in semantic and phonotranslation conditions. The above results are presented in the post hoc analysis in Table 20.

Similarly, consistent effects of language context represented that participants' performance was less accurate in the monolingual context than in the bilingual context for all distractor types presented in the Kannada language. On the other hand, participants' performance was more accurate in the monolingual context than in the bilingual context in unrelated and semantic conditions. However, no significant language context effect was on accuracy scores in phonotranslation conditions with English distractors. The results are represented in the post hoc analysis in the Table 20.

**Table 20** Post hoc comparisons of three-way interactions (Accuracy)

| **Language Context** | **Monolingual** | | | | **Bilingual** | | | |
|---|---|---|---|---|---|---|---|---|
| **Distractor Language/Distractor Type pair** | | | | | | | | |
| | **Estimate** | **SE** | **Z ratio** | ***p value*** | **Estimate** | **SE** | **Z ratio** | ***p value*** |
| | Unrelated vs Semantic | | | | Unrelated vs Semantic | | | |
| Kannada | -0.18 | .19 | -.91 | .629 | .15 | .23 | .64 | .79 |
| English | .21 | .25 | .84 | .672 | -.12 | .21 | -.57 | .83 |
| | Unrelated vs Phonotranslation | | | | Unrelated vs Phonotranslation | | | |
| Kannada | -.06 | .19 | -.34 | .937 | .25 | .23 | 1.11 | .507 |
| English | .52 | .24 | 2.15 | .080 | .03 | .21 | .18 | .982 |
| | Semantic vs Phonotranslation | | | | Semantic vs Phonotranslataion | | | |
| Kannada | .11 | .19 | .59 | .824 | .10 | .22. | .488 | .880 |
| English | .30 | .22 | 1.34 | .372 | .16 | .20 | .77 | .719 |
| **Distractor Type/Distractor Language pair** | | | | | | | | |
| | Kannada vs English | | | | Kannada vs English | | | |
| Unrelated | -1.17 | .19 | -5.9 | **<.001** | .45 | .19 | 2.30 | **0.02** |
| Semantic | -.77 | .19 | -4.00 | **.001** | .17 | .19 | .91 | .358 |
| Phonotranslation | -.58 | .17 | -3.28 | **.001** | .13 | .18 | 1.26 | .205 |

| Distractor Language | Kannada | | | | English | | | |
|---|---|---|---|---|---|---|---|---|
| **Distractor Type/Language context pair** | | | | | | | | |
| | Monolingual vs Bilingual | | | | Monolingual vs Bilingual | | | |
| Unrelated | -.85 | .20 | -4.15 | **<.001** | .76 | .22 | 3.40 | **.001** |
| Semantic | -.52 | .20 | -2.51 | **.010** | .43 | .2.2 | 1.94 | **.051** |
| Phonotranslation | -.53 | .19 | -2.68 | **.007** | .28 | .20 | 1.38 | .165 |

### *3.5.3.3 Comparison between the reaction time and accuracy models*

Reaction time and accuracy results were compared in Table 21. The main effects and interactions were consistent between the models. Post-hoc pairwise comparisons (Tables 16 and 20) indicated some differences in the source of the interaction effects because differences between distracter language and/or language context emerged for different distracter types. However, it is important to note that the effects were small across the board. For example, the greatest reaction time difference in post-hoc comparison was estimated as 0.1s for the difference between English and Kannada phonotranslation distracters. In the accuracy analysis, the greatest difference was a mean of 1.17 items, again for the difference between English and Kannada distracters, but this time in the unrelated condition. These small effects raise questions about whether the differences observed between the models are spurious and make interpretation challenging.

**Table 21** Comparison of effects observed from accuracy and naming latency models

| Parameters | Reaction time model (-) Absent (+) Present | Accuracy model (-) Absent (+) Present | No effect / Same / Different direction of effects |
|---|---|---|---|
| Distractor type | - | - | No |

| | | | |
|---|---|---|---|
| Distractor language | + | + | Same |
| Language context | + | + | Same |
| Distractor language * Language context | + | + | Same |
| Distractor language * Distractor type | + | + | Different |
| Language context * Distractor type | - | - | No |
| Distractor type * Distractor language * Language context | + | + | Different |

## 3.6 Discussion

This study used a PWI paradigm to explore lexical selection in Kannada-English bilinguals by examining how **Distractor type** [unrelated vs related (semantic, phono-translation)]; **Distractor language** [Kannada (L1) vs English (L2)]; and **Language context** [monolingual vs bilingual] influenced naming latencies and accuracies.

The findings revealed key insights: No significant statistical effects of distractor type on naming latencies and accuracies were observed, indicating no difference in naming with unrelated or related distractors. However, the effect of distractor language and language context was observed in terms of both naming latency and accuracy.

Participants were slower and less accurate at naming with Kannada (L1) distractors than with English (L2) distractors and slower and less accurate at naming in the monolingual context than in the bilingual context.

### 3.6.1 Lack of distractor effects

The present study used a well-established PWI paradigm to investigate the lexical selection mechanism in bilingualism (Costa & Caramazza, 1999; De Zubicaray et al., 2002; Hermans et al., 1998; Hoshino et al., 2021; Levelt et al., 1999) and, specifically, the "0ms" SOA was chosen, as it had shown reliable phono translation interference effects in previous studies (Costa et al., 2003; Hermans et al., 1998; Hoshino & Thierry, 2011). Three lexical selection accounts were assessed: language-specific (Costa et al., 2005) language-non-specific (Green, 1998) and dynamic (Grosjean, 2001). These three accounts made different predictions regarding the response pattern expected across PWI paradigms.

The present study showed that distractor type alone did not influence the naming latencies and accuracies. However, the interaction between distractor language and distractor type was observed in the reaction time and accuracy analyses. Post hoc analyses showed less accurate naming with Kannada distractors than English in unrelated and semantic conditions and slower naming latencies in the phonotranslation condition. Based on the predictions from the three accounts, the results of the present study are most consistent with language-specific lexical selection accounts; this interpretation is predicted based on the ***lack of phono-translation interference*** effects. There was no evidence to claim that L1 or L2 distractors activated the L1 or L2 name of the picture, which is phonologically encoded, as indicated by the absence of significant interference in all four paradigms. The absence of phono-translation effects indicates the distractors may not have activated the target lexicon in non-target language through phono-translation distractor to cause any cross-language interference effects. These results are consistent with those (Sudarshan & Baum, 2019) who investigated high-proficient French-English bilinguals and did not find a phono-translation interference effect in their study, which they attributed to higher proficiency in their bilinguals and kept the two languages separate without causing interference. However, this study also failed to identify semantic interference effects from semantic distractors. Semantic interference effects were well-established and have been observed to produce competition at the lexical level in almost all previous studies (Costa & Caramazza, 1999; Green, 1998; Hermans et al., 1998; Sudarshan & Baum, 2019). Moreover, other PWI studies have shown semantic interference and phono-translation interference effects, at least in a bilingual context [e.g. (Boukadi et al., 2015; Deravi, 2009; Klaus et al., 2018)]. As such, a semantic distractor was used to establish if the paradigm was sensitive in detecting the interference effects. As ***no semantic interference effects*** were observed in the present study, it is not possible to discriminate a language non-specific account from a lack of paradigm sensitivity.

Semantic interference effects depend on factors such as the nature of the relationship between the distractor word and the to-be-produced target word, which influence the semantic interference effects. For instance, facilitation effects can occur if the semantic relationship between the target and distractor is thematic, e.g., mouse and cheese (de Zubicaray et al., 2013), or non-categorically related, e.g., dog-bone (Xavier Alario et al., 2000). Another factor, familiarization, has been shown to influence the effects of interference (Collina et al., 2013; Gauvin et al., 2018). For instance, Collina et al. (2013) were the first to examine the role of familiarization empirically using a between-subject design and found that the group that had familiarization of pictures showed significant interaction with semantic interference effect, and the group with no familiarization showed facilitation effects. Moreover, the semantic effect is modulated by the repetition of a given target-distractor pair. Lupker argued that the semantic interference effect might be reduced the second time the target-distractor pair is presented. In the current study, semantic distractors were categorically related, and the familiarization phase was used to control for variance in picture naming. Therefore, distracter selection was optimized to detect semantic interference effects. Although two repetitions of the semantic and unrelated distracters occurred, it was still expected that interference effects should be detectable, especially in the first paradigm.

The present study finding is in line with the absence of distractor effects in distant language bilinguals, namely Hoshino et al. (2021), who showed the absence of both semantic and phono-translation interference effects in Japanese-English bilinguals and supported language-specific lexical selection mechanism. According to Hoshino et al. (2021), the difference in typology and different scripts between the languages acts as a cue at the earlier stage of language processing of the to-be-named picture and results in language-specific lexical selection. However, the context of distractor presentation might have an effect (Hoshino's study used visual distractors, and the present study used auditory distractors).

An alternative position was put forward by Chen et al. (2022), who showed that the semantic interference effects were present only in highly proficient bilinguals but absent in low proficient bilinguals in distant languages, such as Chinese-English bilinguals. In the present thesis, bilinguals were moderately proficient based on the objective measure and reported self-rated proficiency scales. Although they reported using both languages in their day-to-day life, the dominance scores revealed they were more dominant in their L1 than L2. Therefore, we might not have observed a significant interference effect due to insufficient activation of distractors at the lexical level based on their L2 proficiency and dominance. This may be true when the distractors were presented in English, but they cannot be applied to the more dominant language, L1. Although we did not find strong interference effects in any of the paradigms, pairwise comparisons revealed bilinguals in the present study took a longer time to name the pictures in Kannada when accompanied by Kannada distractors (MK paradigm) compared to all other paradigms. This suggests that native language distractors are difficult to ignore when naming the pictures in L1. However, it may result in the activation of more lexical items but may not have reached the threshold of activation to cause any significant interference effect.

To sum up, the fact that we did not observe any significant interference effects between the related (semantic and phono-translation) and unrelated distractor types was because the effects were of similar magnitude between them, and maybe even if interference effects were present, we were not able to observe these effects as we did not have a no distractor condition.

### 3.6.2 Distractor language

Distractor language effects revealed that bilinguals were faster in naming the pictures when accompanied by English distractors compared to Kannada distractors, suggesting that L2 distractors had less influence on lexical selection. This effect may be due to moderate proficiency in L2, resulting in distractors that may not have had sufficient activation to cause interference. In addition, interaction effects between distractor language and language context were observed in the reaction time and the accuracy analyses see Figure 12a. Post hoc analyses found slower and less accurate naming with Kannada distractors than English distractors for all the distractor types in the monolingual context. The same effect occurred in the bilingual context, but to a lesser extent: significant differences were found for unrelated distracters in the accuracy analysis and semantic distracters in the reaction time analysis. Previous studies have investigated the lexical selection mechanism in one language direction (naming in L2 while ignoring the L2 and L1 distractors), showing the influence of L1 distractors on L2 naming (Costa et al., 2003; Hermans, 2004; Hoshino et al., 2021; Sudarshan & Baum, 2019). However, the present study demonstrates that the influence of L1 was significantly higher in Kannada-English bilinguals when naming in their L1 than in L2.

### 3.6.3 Language context

The Kannada-English bilinguals in the present study showed that they were significantly faster in naming the pictures in a bilingual context compared to a monolingual context. The three-way interactions between the distractor type, distractor language and language context were observed. Further, the post hoc analyses revealed less accurate naming and longer naming latencies in the monolingual contexts than in the bilingual contexts for all the distractor types when the distractors were presented in the Kannada language. However, with the distractors presented in English, unrelated and semantic distractors had more accurate naming responses in the monolingual contexts than in the bilingual contexts. However, this effect was not replicated in the reaction time analysis. English phonotranslation distractors did not show any effects of language context on accuracy or latencies. Language context results support the language-specific lexical selection, which showed that within-language interference is greater than cross-language interference. According to the dynamic view of lexical selection (Grosjean, 2001), in a monolingual context (target naming and distractor are in the same language), the target language will be activated to a greater extent, and the non-target language is not completely off but activated to a lesser extent; whereas, in a bilingual context (target naming and distractor are in opposite languages): target and non-target languages will be activated to a greater extent. In support of the dynamic view, Boukadi et al. (2015) study found that distant language Tunisian-Arabic and French bilinguals showed an absence of phono-translation in the monolingual context, suggesting language-specific lexical selection. In addition, the absence of a semantic interference effect in monolingual contexts in their study was attributed to less advanced L2 proficiency among participants.

On the other hand, bilinguals displayed stronger cross-language interference in bilingual context by displaying phono-translation interference effects, supporting language non-specific lexical selection. Overall, (Boukadi et al., 2015) support the dynamic view of lexical account (a combination of language-specific and language-non-specific views). In the present study, although we did not find the semantic interference effect, Kannada English bilinguals displayed stronger within-language interference (MK paradigm) than cross-language interference (EK paradigm). Given that those bilinguals in the present study were more proficient and dominant in their L1 compared to L2, the stronger interference from within language distractors is not surprising and supports the language-specific lexical selection. However, similar effects were expected in bilingual contexts while naming in L2; however, faster naming responses were observed in bilingual contexts. The possible alternative explanation could be that semantic, lexical, phonological, and orthographical units within the language will have stronger connections than between language networks in distant language bilinguals. In addition, with less advanced L2 proficiency, the connections between the lexico-semantic networks in L2 are not as strong as L1- conceptual and vice-versa. Another alternative explanation is that the life-long experience of bilingualism may have led to enhanced inhibitory control skills, and this would, in turn, as a habit, suppress the distractors in the non-target language easily in a bilingual context.

The mixed model analysis also revealed that there are unaccounted factors beyond those included as fixed factors (distractor type, distractor language, and language context) in the model, which substantially contribute to the observed individual differences in reaction time. There are still differences in reaction time among participants and items that are not specifically attributed to those factors. These differences could be due to participant characteristics or item-specific attributes that impact reaction time but are not explicitly accounted for in the model. Understanding and acknowledging these random effects are important as they highlight that there are unmeasured or unaccounted-for factors unique to participants and items that play a role in contributing to the variability observed in reaction times. In the next chapter, these individual participant-related factors, such as proficiency, dominance, and inhibitory control, will be addressed, and their contribution to the reaction time will be assessed.

# 4 Chapter 4: Factors Influencing Lexical Selection during Picture Naming

## 4.1 Introduction

Bilingual lexical selection during picture naming depends on a host of factors that vary according to the experience of bilinguals, such as language proficiency, dominance, age of acquisition, usage, and cognitive ability (Kroll et al., 2006). For instance, cross-language activation and interaction in lexical processing are highly modulated by differences in L2 proficiency (Van Hell & Tanner, 2012). Previous research has shown that not only do L1 distractors influence L2 naming, but L2 distractors influence L1 naming once bilinguals are adequately proficient in L2 (Klaus et al., 2018; Kroll & Stewart, 1994). In addition, the asymmetry in L1 and L2 naming has been accounted for by individual differences in relative proficiency during lexical processing (Kroll et al., 2010). Specifically, previous studies that investigated L2 proficiency or language dominance as modulating factors of lexical selection in bilinguals have found mixed results, which they attribute to individual speaker differences (refer to Chapter 1, section 1.6.2 for more details).

Inhibitory control has also been identified as having an important role in bilingual speech production (section 1.5.1). For instance, Luk et al. (2011) found a smaller flanker cost (a commonly used inhibitory control measure) for early bilinguals compared to monolinguals and late bilinguals. All models of bilingual lexical access assume parallel activation of both languages, with the speaker exerting control at some point to select the intended language. The ICM (Green, 1998) proposes how this cross-language competition is managed and is thus compatible with language non-specific lexical selection accounts. The core assumption of the ICM is that the lexical nodes from the non-target language are suppressed to resolve the competition, thereby activating the target lexical nodes to greater levels (Rodriguez-Fornells et al., 2006; Sudarshan & Baum, 2019).

Evidence supporting inhibitory control as a modulating factor is provided in Chapter 1 (refer to section 1.6.1 for more details). Inhibitory control is assumed to be domain-general, which suggests that there is a common cognitive control (executive function) process in linguistic and non-linguistic domains. For instance, (Prior & Gollan, 2011) reported a correlation between the language switching task and a non-linguistic switching task, suggesting the same cognitive control was operating across the domains. Lifelong experience of bilingualism is presumed to enhance the executive functions of bilinguals (Green & Abutalebi, 2013; Miyake et al., 2000).

Zeng et al. (2019) investigated the relationship between linguistic and non-linguistic domains using the Simon inhibition task and verbal fluency as a linguistic measure in monolingual and bilinguals with three age groups: children, younger, and older adults. Bilingual children and older adults outperformed monolinguals in the Simon task, but not younger adults. On the other hand, in the verbal fluency task, bilingual children performed significantly better in letter fluency than the monolingual group. Still, there was no difference between the younger and older groups. Thus, bilingual advantage appears to be modulated by factors such as age and individual differences in linguistic experiences. However, other studies have demonstrated no such bilingual advantages (Paap & Greenberg, 2013; Paap & Sawi, 2014; Zeng et al., 2019), suggesting differences between monolingual and bilingual speakers are influenced by the interplay of multiple factors.

The inconsistency in the literature may be due to heterogeneity among bilinguals (exposure to languages, age of acquisition, learning environment, usage, etc.). Most previous research work has compared bilinguals with monolinguals, whereas the involvement of inhibitory control may vary depending on the degree of bilingualism or difference in bilingual groups. For example, some previous studies have shown a significant correlation between language proficiency and language use (communication) and their relationship with cognitive control (Timmer et al., 2019). Therefore, investigating multidimensional aspects of bilingualism and inhibitory control within the same bilingual speakers helps us to understand to what extent each of these parameters plays a role in bilingual lexical selection. This chapter takes this approach and investigates the relationship between bilingual and inhibitory control factors and their influence on lexical selection within the PWI paradigm.

## 4.2 Objectives:

This chapter focuses on measuring two main aspects: first, to investigate the relationship between the bilingual participant factors (proficiency and dominance) and inhibitory control measures (Stroop and Flanker costs). Second, to investigate whether the bilingual and inhibitory control factors modulate the lexical selection process. Language proficiency, dominance, and inhibitory measures (Stroop and Flanker) will be discussed separately before answering the research questions.

### 4.2.1 Research Questions:

1. Are the inhibitory control and bilingual factors (proficiency and dominance) related?

Prediction: There will be a positive relationship between proficiency and inhibitory control.

2. Do bilingual factors (proficiency and dominance) influence lexical retrieval in distant language bilinguals?

   Prediction: As bilinguals in the present study are more proficient and dominant in L1, we expect more interference from L1 while naming the pictures.

3. Does inhibitory control influence lexical retrieval in distant language bilinguals?

   Prediction: Bilinguals with better inhibitory control will show less cross-language interference when naming in a bilingual context.

## 4.3 Method

### 4.3.1 Ethical Statement

School of Psychology and Clinical Language Sciences, University of Reading (Ref: 2021-086-AA) approved this study. All participants provided informed consent before participating in the study.

### 4.3.2 Bilingual Participant Profile

The bilinguals in the present study are the same participants who participated in the previous PWI study and performed all the tasks in one session (1.5 hours). They are native speakers of Kannada who learnt English after the age of five years once introduced in school, and we consider them sequential bilinguals. A total of 32 participants (Males = 17, Females = 14) participated in the study with the age range of

19-34 (M = 27.62, *SD* = 3.98). The bilinguals in the present study are typologically distant, with Kannada being a Dravidian language and English an Indo-European language.

Various measures of proficiency, dominance, and lexical decision tasks were employed to profile the participant-related characteristics of bilingualism. All the questionnaires and inhibitory tasks were developed and presented using www.gorilla.sc.

### 4.3.3 Materials

The Modified Language Proficiency Questionnaire was used to measure subjective language proficiency, the Bilingual dominance scale (Dunn et al., 2009)(Dunn & Fox Tree, 2009) was used to measure language dominance and objective L2 proficiency using the LexTale lexical decision task (Lemhöfer & Broersma, 2012).

### 4.3.4 Procedure

***Subjective measures of Language Proficiency:*** To evaluate subjective language proficiency, each participant completed the Modified Language Proficiency Questionnaire (MLPQ; see Appendix B) presented online. The language questionnaire gathered demographic details, order of language acquisition, age at which language was learnt for usage, and proficiency for understanding, speaking, reading, and writing. Switching ability between languages, language use of one language over another based on situations (work/home/friends/TV/textbook/writing/listening to radio, etc.,); how frequently others identify you as a native speaker of language based on accent and hours of language use per day. The participants were asked to read the questions carefully, answer the following, or click their responses on the Likert scale. The maximum score that can be obtained per language is 100.

***Subjective measure of Language Dominance:*** Bilingual Dominance Scale, BDS (Dunn & Fox Tree, 2009) was programmed on Gorilla (Likert scale responses) to assess the information regarding participant use of language, which included the sections on the age of acquisition, language usage (L1, L2) and restructuring of language (See Appendix D). The participants were instructed to read the questions carefully and answer them by typing when required or by clicking on the Likert multiple-choice option. The BDS scale gives more information on the relative usage of one language over the other (Dunn & Fox Tree, 2009). The BDS scale ranges from -25 to 25. According to Dunn & Fox Tree (2009), a score between -5 to 5 represents equal use of both languages. The higher scores on one language over the other represent the dominance of that language.

***Objective measure of Language Proficiency:*** Language proficiency of L2 (English) was assessed objectively using a lexical decision task based on LexTale (Lemhöfer & Broersma, 2012). LexTale is a quick, valid, and standardized test of English vocabulary knowledge. Lexical decision task from LexTale has been widely used in studies of bilingual word processing (Boukadi et al., 2015; Primativo et al., 2013), as it has shown to provide reliable information on L2 (English) proficiency than self-rated measures. The lexical decision task is a visual word identification task where the participants had to decide whether the string of letters presented represents a real word in English. LexTale contains 60 items (40 real words and 20 nonwords) plus three items as practice trials. The procedure followed was the same as provided in LexTALE (Lemhöfer & Broersma, 2012). The participants were instructed to press "1" on the keyboard if they thought the string letters represented a real word and press "0" if they thought a string of letters presented was a nonword. Each item (a string of letters) was presented in a smaller case (colour: black, font: Arial, and font size: 72) and appeared on the centre of the screen with a white background for 5000ms one after the other or moved to next item as soon as participant responded whichever was the quicker. Averaged percentage correct (% Correct $_{avg}$) scores from accuracy were calculated for each participant, providing information on general (L2) language proficiency levels in bilinguals of our study. The formula for calculating % Correct $_{avg}$ is as follows: % Correct $_{avg}$ = ((number of the word correct responses/40*100) + (number of non-words correct response/20*100)) / 2 (Lemhöfer & Broersma, 2012). The scores can range from 0-100% and represent the proportion of words within that range known by the participant. The LexTale % Correct $_{average}$ scores indicate corresponding English proficiency levels in bilinguals. An average percentage correct score of 80-100% on LexTale indicates upper and lower advanced/proficient users; 60-80% indicates upper intermediate users; and below 59% represents lower intermediate to lower proficiency.

## 4.4 Results from the background measures

The mean, standard deviations, range values, and statistical tests for background language measures: subjective language proficiency, subjective dominance measures, and objective language proficiency are presented in Table 23. The Shapiro-Wilk test for normality revealed that only total proficiency scores from self-rated MLPQ for L1 and L2 had normal distribution ($p$ = .589, .137). Therefore, paired sample t-tests were performed. The subjective measures from subsections of MLPQ on L1 and L2 (rated proficiency for understanding and speaking and language use) and bilingual dominance score were not distributed normally ($p$ = < 0.01). Hence, Wilcoxon tests were performed to see if there were any differences within languages for rated sub-sections of language proficiency and dominance. The objective measure of L2 proficiency from the LexTale lexical decision task had a normal distribution ($p$ = .370).

**Table 22** Mean (M), Standard deviations (SD), Minimum (Min)-maximum (Max) values, and statistical results of the Kannada-English bilingual Language profile.

| **Subjective measures - Self-rated proficiency rating from MLPQ** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **L1(Kannada)** | | | **L2(English)** | | | |
| | **M** | **SD** | **Range** | **M** | **SD** | **range** | **L1 vs L2 scores** |
| Language proficiency scores (0-100) | 74.84 | 8.11 | 60-92 | 68.96 | 6.38 | 56-80 | $t$ (31) = 2.79, $p$=.009 |
| Understanding (1-4) | 3.93 | .24 | 3-4 | 3.18 | .39 | 3-4 | $Z$ = 4.53, $p$=<.001 |
| Speaking (1-4) | 3.79 | .29 | 3-4 | 3.06 | .50 | 2-4 | $Z$ = 4.54, $p$=<.001 |
| Language use (1-4) | 3.46 | 0.87 | 1-4 | 3.12 | 1.12 | 1-4 | $Z$ = 1.33, $p$=.183 |

Note: The scoring pattern explains higher mean scores represent greater proficiency in that language.

Total proficiency score (100 / language): Higher mean scores represent greater overall proficiency in that language.

Understanding: 1- low proficiency, 2- Fair proficiency, 3- Good proficiency, 4- Native like

Speaking: 1- low proficiency, 2- Fair proficiency, 3- Good proficiency, 4- Native like

Language use: 1- 2hrs/day, 2- 3hrs/day, 3- 4hrs/day, 4- 5+hrs/day

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Self-rated dominance scores- Bilingual Dominance Scale** | | | | | | | |
| Language dominance – BDS (-25 to 25) | 21.5 | 2.28 | 17-25 | 13.12 | 2.21 | 9-17 | $Z = 4.94$, $p = <.01$ |
| **An objective measure of L2 proficiency – Lexical decision** | | | | | | | |
| Lexical decision % Correct$_{avg}$ (0-60) | | | | 75.42 | 8.66 | 61.25-97.50 | |

The statistical results for the overall proficiency measures from self-rated MLPQ revealed that mean scores were significantly higher in the native language L1 (Kannada, M = 74.84) than in English (M = 68.96), and the difference was statistically significant (see Table 23). A paired sample t-test on MLQP subsections revealed significantly higher proficiency in Kannada for understanding (M = 3.93) and speaking (M = 3.79) than in English (M = 3.18, 3.06). Although the mean scores for language use were slightly higher for Kannada (M = 3.46) than English (M = 3.12), this did not yield any significant difference in usage hours between Kannada and English, suggesting that bilinguals in the present study use both languages equally in their day-to-day life.

The BDS scale suggests the relative usage of one language over the other. Accordingly, the self-rated bilingual dominance scale revealed that mean scores for Kannada (M = 21.5) were significantly higher than that of English (M = 13.12), suggesting bilinguals in this study are Kannada dominant.

The objective measure of L2 proficiency was obtained from the LexTale lexical decision task by calculating % $Correct_{avg}$ scores for each participant. This percentage was calculated from their performance (accuracy scores) on lexical decision tasks. The mean % $Correct_{avg}$ LexTale score of 75.42% (*SD* = 8.66, range = 61.25 – 97.5) falls between the scores of (60-80%) which correspond to general proficiency CEF level B2, suggesting that bilinguals in the present study have an upper intermediate level of L2 proficiency. CEF levels refer to general English language proficiency. Therefore, we can consider bilinguals in the present study as moderately proficient bilinguals with a vocabulary size greater than low proficiency in the lower frequency range and lesser vocabulary size relative to the highly proficient bilinguals.

The overall subjective measures of language proficiency and dominant scales revealed that participants are more proficient and dominant in their native language, Kannada, than English. The LexTale scores suggested moderate proficiency of L2 in our bilingual group.

## 4.5 Inhibitory Control Measures

In the present chapter, we are considering executive functioning, mainly inhibitory control, which measures the response inhibition or conflict resolution through the Stroop and flanker tasks (refer to Chapter 1, section 1.7 for more details). In these tasks, task-irrelevant stimuli are used to induce conflict. However, task-irrelevant information is presented along with the task-relevant information, either response-compatible (congruent) or can be response incompatible (incongruent). The difference in naming latency between the congruent and incongruent trials is called the conflict cost or Stroop cost, depending on the task.

### 4.5.1 Stroop Task:

This task was initially developed by Stroop (1935). The Stroop task assesses the ability to inhibit cognitive interference, which occurs when the processing of a stimulus feature (name of the colour) affects the simultaneous processing of another attribute of the same stimulus (the ink of the colour).

#### *4.5.1.1 Materials, presentation, and procedure:*

We used a Stroop task consisting of colour words printed in the same/different ink colours. Four colours were used: RED, BLUE, GREEN, and YELLOW. Forty colour word stimuli were congruent (RED), and forty other stimuli were prepared with incongruent colour word stimuli (**RED**). Additionally, six colour word stimuli were presented as practice trials.

The presentation of the Stroop experiment was pseudo-randomized and followed this way: Target pictures followed by the six practice trials were presented with the colour words at the centre of the screen with a font size of 72. Each experiment began with a fixation cross (+) for 250ms followed by a 500ms blank screen followed by a colour-word stimulus. The stimulus remained for 2000ms on screen, and naming responses were recorded through the microphone. The stimulus remained for 2000ms if there was no response or moved to next if there was a participant's naming response, which was quicker. The recording of naming responses from the participants started with the onset of the target picture presentation. A pause of 500ms was added before the next fixation mark for the beginning of the following target stimuli. Each trial lasted for about 3250ms. Figure 18 shows an example of the Stroop task presentation with congruent and incongruent conditions.

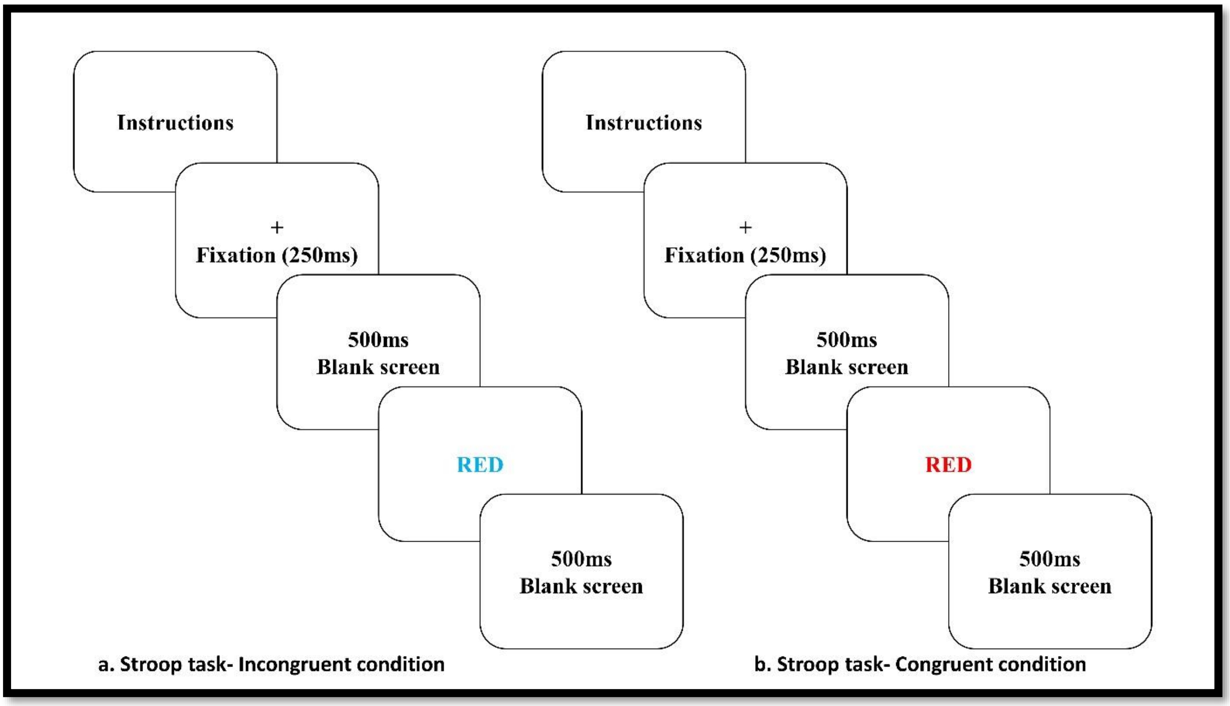


**Figure 18.** Display of Stroop task (a) Incongruent condition and (b) Congruent condition.

In this task, participants were instructed to be equipped with headphones with a microphone to respond. Kannada-English bilinguals were asked to name the ink colour of the word quickly and accurately in their L2 (English) and not read the word itself.

## 4.5.2 Flanker task:

The flanker task by Eriksen & Eriksen (1974) is a common task that taps into inhibition, more specifically, the interference suppression function.

### *4.5.2.1 Materials, presentation, and procedure:*

In the present study, we used an arrow-flanker variant (Eriksen & Eriksen, 1974), and Fig 19 displays the congruent and incongruent conditions of the flanker task. Forty congruent and forty incongruent stimuli were presented. Additionally, six flanker stimuli were presented as practice trials. The flanker stimuli can trigger the compatible response as the target (the congruent condition) and the incompatible response to the target (the incongruent condition).

The presentation of the Flanker experiment was pseudo-randomized and followed this way: Target pictures followed by the six practice trials were presented with multiple arrows with centre arrow pointing towards the same or different directions as other arrows. Each experiment began with a fixation cross (+) for 250ms followed by a 500ms blank screen followed by a multiple arrow. The picture remained on screen for 2000ms, and manual responses were recorded through the keyboard press. The arrows remained for 2000ms if there was no response or moved to next if there was a participant's response, which was quicker. The recording of manual key press responses from the participants started with the onset of the arrow picture presentation. A pause of 500ms was added before the next fixation mark for the beginning of the following target picture. Each trial lasted for about 3250ms. Figure 16 shows an example of the Flanker task presentation with congruent and incongruent conditions.

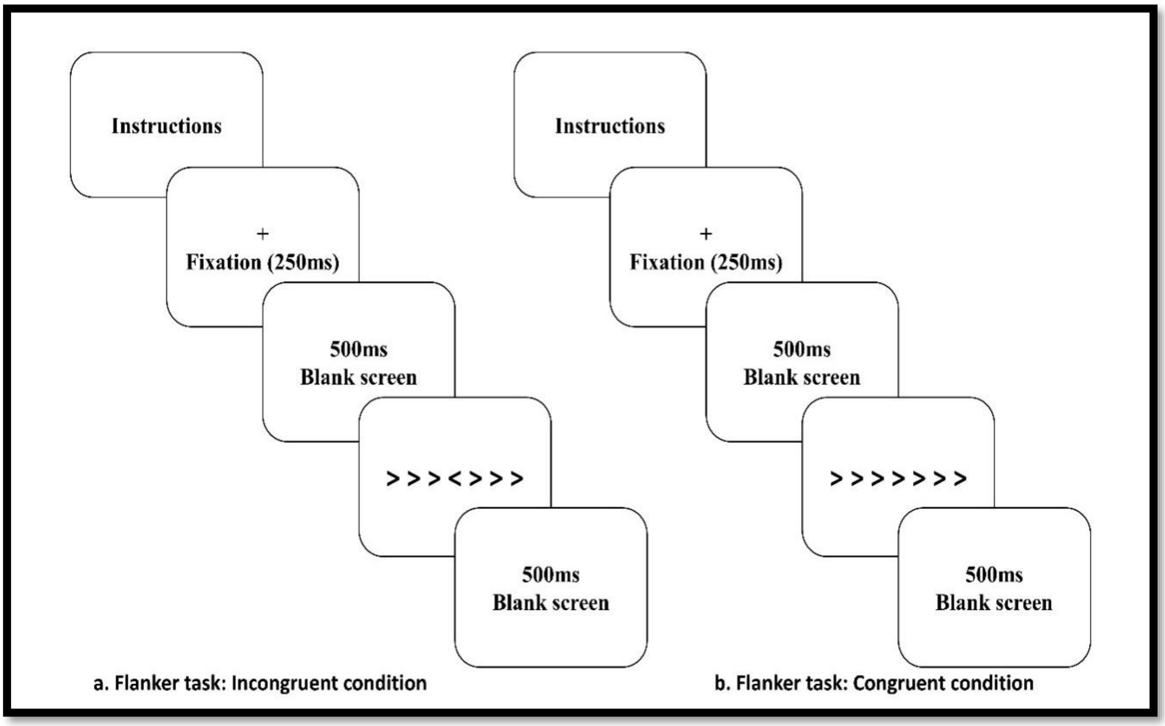


**Figure 19.** Display of Flanker task (a) Incongruent condition and (b) Congruent condition.

Participants were asked to identify and concentrate on the center arrow. They were asked to press the number "1" if the center arrow was in the same direction as the rest of the arrows and press "0" as quickly and accurately as possible if the centre arrow is in the opposite direction to the rest of the arrows.

### 4.5.3 Data Analysis

Verbal responses from the Stroop task were extracted from the Gorilla software. The recorded verbal response was analyzed using Check Vocal software to calculate the naming reaction time and accuracy of the congruent and incongruent conditions. Similarly, reaction times obtained from the Keypress response on the Flanker task were extracted from the Gorilla software and analysed for reaction time and accuracy of both conditions (congruent and incongruent). Later, the inhibitory cost was calculated for each participant for each task by subtracting the mean congruent reaction time from the mean incongruent reaction times.

## 4.6 Results of Stroop and Flanker tasks

The mean (*M*) reaction times and standard deviations (*SD*) for incongruent and congruent conditions. The paired-sample *t*-test was performed to compare the means between the incongruent and congruent conditions, along with inhibitory costs, which are presented in Table 24.

**Table 23** Mean, Standard deviations, and paired *t*-tests, conflict cost on Stroop and Flanker tasks

| **Variables** | **Incongruent** ***Mean (SD)*** | **Congruent** ***Mean (SD)*** | **Mean Difference Paired sample *t*-test** | **Inhibitory cost (Difference between incongruent - congruent)** ***Mean (SD)*** |
|---|---|---|---|---|
| **Stroop task** | 724.76 ms *(96)* | 572.39 ms *(101.3)* | $t\ (31) = 13.76$, $p < .001$ | 152.35 *(62.59)* |
| **Flanker task** | 561.11 ms *(228.96)* | 350.03 ms *(136.16)* | $t\ (31) = 7.96$, $p < .001$ | 211.08 *(149.97)* |

The mean reaction time for Stroop and Flanker tasks in Kannada-English bilinguals showed that there was a statistically significant difference between the conditions (incongruent and congruent) within each task. This numerical difference is known as the "Inhibitory cost" calculated for the Stroop and Flanker task, which will be used as predictor variables in subsequent analysis. The visual representation of reaction time for Stroop and Flanker tasks is presented as histograms in Figures 20 and 21.

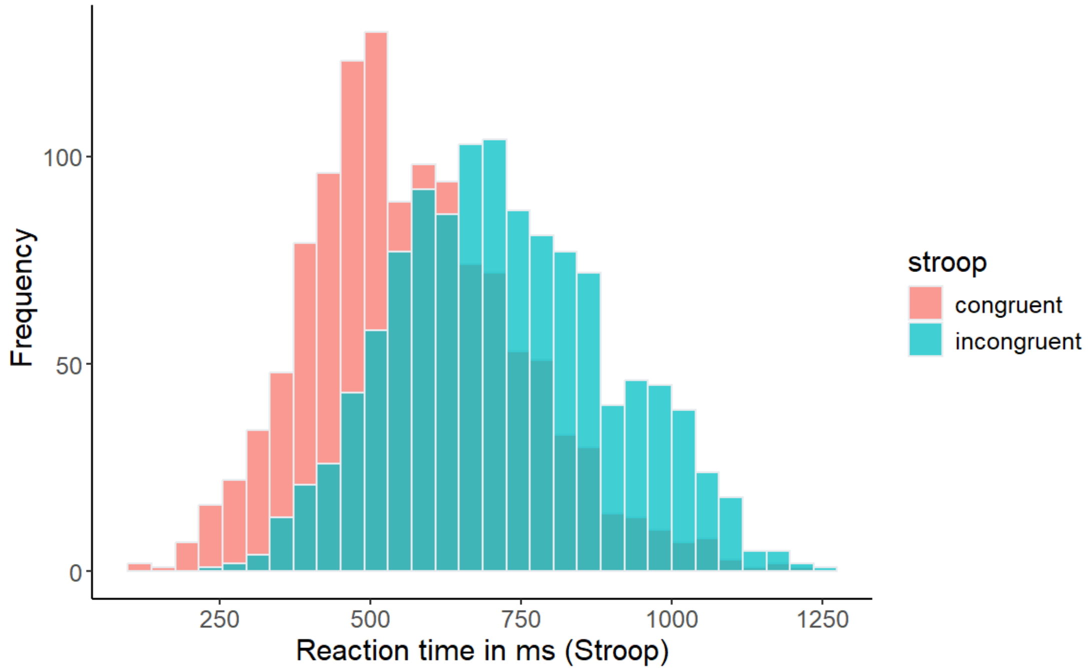


**Figure 20** Histogram representing Stroop task.

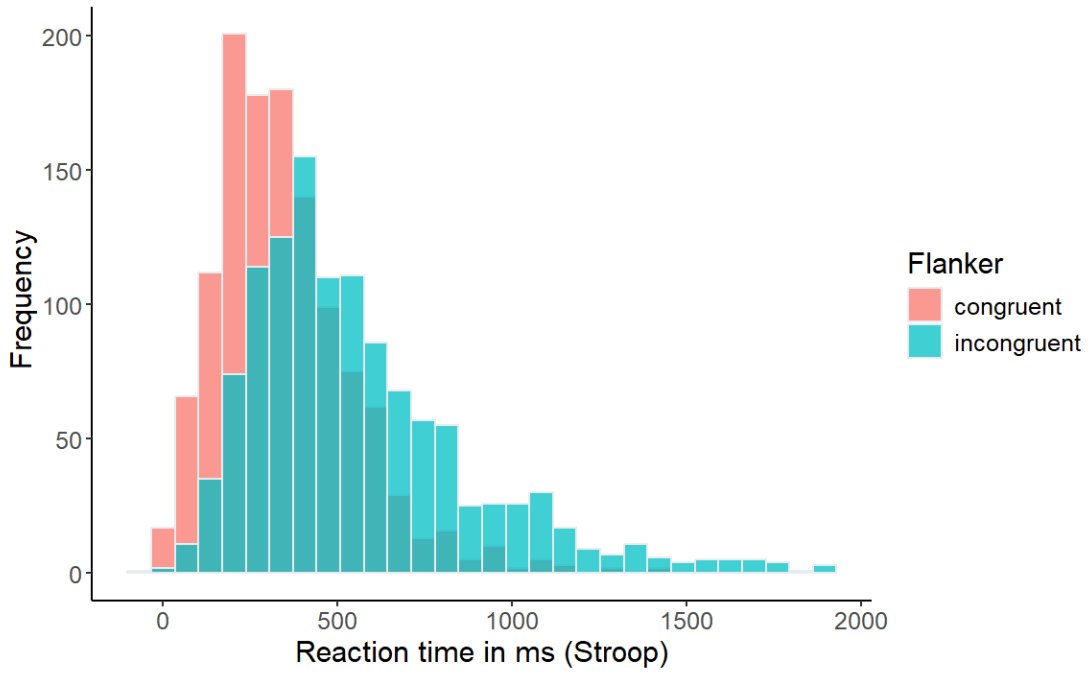


**Figure 21** Histogram representing Flanker task

The histogram represents normal distribution for the Stroop task and positively skewed for the Flanker task. However, the Shapiro-Wilk test of normality revealed both the tasks and conditions (incongruent, congruent) within each task were normally distributed ($p > .05$).

### 4.6.1 Research Q1. Correlation analysis between the bilingual factors (proficiency and dominance) and inhibitory measures (Stroop and Flanker tasks)

To address if there is correlation between the bilingual factors and inhibitory control, Pearsons correlations were performed for the following variables: Subjective proficiency measures included L1 and L2 total proficiency scores obtained from the MLPQ; Subjective dominance measures included L1 and L2 dominance scores obtained from Bilingual Dominance Scale (Dunn & Fox Tree, 2009); Objective L2

Proficiency, the percent correct scores were calculated from lexical decision tasks, and inhibitory costs were obtained from Stroop (Stroop cost) and Flanker tasks (flanker cost).

**Table 24** Correlation analysis representing the relationship between bilingual factors and inhibitory measures.

| Variables | L2 proficiency scores | L1 dominance scores | L2 dominance scores | Stroop cost | Flanker cost | L2 Objective proficiency |
|---|---|---|---|---|---|---|
| L1 proficiency scores | -. 331 | .284 | **-.450**** | -.061 | -.090 | -.223 |
| L2 proficiency scores | | -.089 | **.439*** | -.027 | -.157 | .032 |
| L1 dominance scores | | | **-.498**** | -.284 | .099 | -.199 |
| L2 dominance scores | | | | .137 | .114 | .022 |
| Stroop cost | | | | | .327 | .025 |
| Flanker cost | | | | | | .155 |

**. Correlation is significant at .001 level, *. Correlation is significant at a .05 level.

The correlation analysis varied between weak negative (*r* = -.027) to moderately positive relationships (*r* = .439). Among them, significant negative correlations were found between the L1 proficiency and L2 dominance measures (*r* = -.450), suggesting that bilinguals who rated themselves as more proficient in L1 also perceived themselves as least dominant in their L2. An expected significant moderate positive relationship between the L2 proficiency and L2 dominance (*r* = .439) scores was observed, indicating that bilinguals who rated themselves as more proficient in their L2 also rated themselves as more dominant in their second language (L2). Another moderately significant negative correlation was found between L1 dominance and L2 dominance scores (*r* = -.498), which shows that bilinguals who rated themselves as more dominant in their native language (L1) also rated themselves as less dominant in their L2. The other relationships between the variables did not yield any significance.

To sum up, correlation analysis showed that there was no significant relationship between the bilingual factors (proficiency and dominance) and inhibitory measures (Stroop and Flanker), indicating that bilingualism may not influence inhibitory control. In other words, higher proficiency may not lead to better inhibitory control or vice-versa. Although the participants in this study rated themselves as less proficient and less dominant in their second language, English, than Kannada and reflected moderate proficiency in objective measures of L2 proficiency (see Table 14), we did not find any significant correlation between the subjective and objective measures of L2 (see Table 25). However, significant correlations were present with in the subjective measures of proficiency and dominance within this study.

### 4.6.2 Principal Component Analysis (PCA) Results

The PCA was conducted to identify the bilingual and inhibitory factors explaining the variance in the data and to reduce the dimensions. The data included a total of seven variables related to five different aspects of bilingualism (L1 proficiency, L2 proficiency, L1 dominance, L2 dominance and objective L2 proficiency) and two inhibitory control factors (Stroop and flanker costs). Table 26 below represents the PCA for the bilingual and inhibitory factors.

**Table 25** Exploring bilingual and inhibitory factors through PCA.

| **Variables / Components** | **1** | **2** | **3** |
|---|---|---|---|
| L2 dominance | **.853** | .118 | -.027 |
| L1 dominance | **-.661** | -.265 | -.016 |
| L2 proficiency | **.656** | -.368 | -.003 |
| L1 proficiency | **-.654** | .025 | -.415 |
| Stroop cost | .214 | **.820** | -.161 |
| Flanker cost | -.096 | **.711** | .322 |
| Objective L2 proficiency | .066 | .065 | **.908** |

The PCA analysis extracted three components, which together explained 65.85% of the total variance in the data. Component 1 (L2 and L1 subjective proficiency and usage) explained 31.04 % of the variance, component 2 (Inhibitory control by Stroop and flanker scores) explained 20.06 %, and component 3 (L2 objective proficiency) explained 14.69 %. Based on the eigenvalues and cumulative variance explained, Components 1, 2, and 3 were considered important and were retained for further analysis.

**Component 1 (C1)** appears to capture factors related to subjective ratings of L2 and L1 proficiency and dominance, which are inversely related to each other. The values range from negative to positive. Participants with higher positive values likely perceive themselves as using and being proficient in L2 more, while those with negative values may feel more comfortable with their L1 usage and proficiency.

**Component 2 (C2)** represents inhibitory control, which refers to the ability to suppress irrelevant information or interference from non-target language. Participants with higher positive scores are likely to demonstrate larger cost values and, therefore, poorer inhibitory control.

**Component 3 (C3)** was associated with L2 objective proficiency. Participants with higher scores on English lexical decision tasks demonstrate a stronger aim of L2 proficiency.

For each of the components (C1, C2, and C3), the scores were extracted for each participant from the PCA, and these scores will be further used in the mixed model analysis to explore whether bilingual and inhibitory control factors interact and modulate the speed of lexical retrieval in Kannada English bilinguals. Accordingly, component 1 represents the subjective L2L1 proficiency and dominance measures; Component 2 indicates the inhibitory control and Component 3 represents the objective L2 proficiency. In the next section, these three components (L2L1 proficiency and dominance measures, inhibitory control, and objective L2 proficiency) will be run through mixed models as fixed factors to see if any or all these components/factors influenced the lexical selection (naming latency) from the PWI task.

### 4.6.3 Research Q2 & Q3. Results from mixed model analysis exploring bilingualism and inhibitory measures as modulating factors of lexical retrieval.

Statistical analyses were performed in R (R Core Team, 2022) with the lme4 package (Bates et al., 2015). Mixed effects models were fit with all the reaction time data from the four PWI paradigms from the previous Chapter 3. Reaction time was the dependent variable. As we did not find the main effect of distractor type in the previous Chapter 3, only the distractor language and language context were included, along with three factors extracted from PCA analysis. To address the research Q2 and Q3: Do bilingual and inhibitory control factors influence the speed of lexical retrieval? The mixed models were further split into two models, including **Model 1**. Interaction effects of distractor language and three components on naming latency; **Model 2**. Interaction effects of language context and three components on naming latency. These two models will allow us to explore whether the possible effects of distractor language/language context on naming latency were due to the influence of any or all these components (L2L1 proficiency and dominance measures, inhibitory control, and objective L2 proficiency) and if the main effects of these components are significant will further reveal as a direct modulating factor on naming latency.

Experimental variables: distractor language, language context, and three PCA components (L1L2 proficiency and dominance measures, inhibitory control, and objective L2 proficiency) were coded as fixed effects. Two mixed models were run separately, with three two-way interactions within each model (see Table 27 and Table 28). Fixed effects results are presented in contrast with the default factors: Kannada language and monolingual context. Participant and item intercepts were modelled as random effects. We present the random intercept structure model that could converge a two-way interaction of fixed effects with a random intercept that varied by participants and items.

**Table 26** Exploring Interactions between Distractor Language and PCA componentson Naming latency: A Mixed Model Approach".

| | ***Model 1**: lmer (Reaction time~ distractor language*C1 + distractor language*C2 + distractor language*C3 + (1\|participants) + (1\|Items)* | | |
|---|---|---|---|
| **Predictors** | **Estimates** | **Confidence Intervals (CI)** | ***p*** |
| (Intercept) | 1168.57 | 1117.33 – 1219.81 | **<.001** |
| Distractor language [English] | -33.47 | -43.47 – -23.47 | **< .001** |
| L2L1proficiency and dominance (C1) | 53.44 | 5.02 – 101.87 | **.031** |
| Inhibitory control (C2) | 42.65 | -5.77 – 91.08 | .084 |
| Objective L2 proficiency (C3) | -12.38 | -60.80 – 36.04 | .616 |
| Distractor language [English] × (C1) | -4.25 | -14.38 – 5.88 | .411 |
| Distractor language [English] × (C2) | -5.91 | -16.08 – 4.26 | .255 |
| Distractor language [English] × (C3) | -16.15 | -26.26 – -6.04 | **.002** |
| **Random Effects** | | | |
| Total variance | 58859.39 | | |
| Participants variance | 18499.55 $_{pid}$ | | |
| Item variance | 2390.03 $_{stim}$ | | |
| ICC | 0.26 | | |
| Number of participants | 32 $_{pid}$ | | |
| Number of items | 26 $_{stim}$ | | |

| | |
|---|---|
| Observations | 9056 |
| Marginal $R^2$ / Conditional $R^2$ | 0.057 / 0.304 |

#### 4.6.3.1 Main effects from Table 27:

The Table 27 model found the main effect of component 1 (L2L1 proficiency and usage) on naming latency (*b* = 53.44, *p*= .03), which indicates that for every unit, an increase in L2L1 proficiency and usage will increase the reaction time by 53ms respectively. As seen in the previous chapter of the PWI study, distractor language (*b* = -33.47, *p* <.01) significantly affected naming latency. However, neither inhibitory control (*b* = 42.65, *p* >.05) nor objective L2 proficiency (*b* = -12.38, *p* > .05) directly influenced naming latency.

#### 4.6.3.2 Interaction effects from Table 27

The mixed model from Table 27 revealed one significant two-way interaction between the Distractor language English and objective L2 proficiency (*b* = -16.15, *p* <.01). However, there was no significant interaction between distractor language, inhibitory control or L1L2proficiency and usage on naming latencies. Figure 22 represents the significant interaction between distractor language and Objective L2 proficiency.

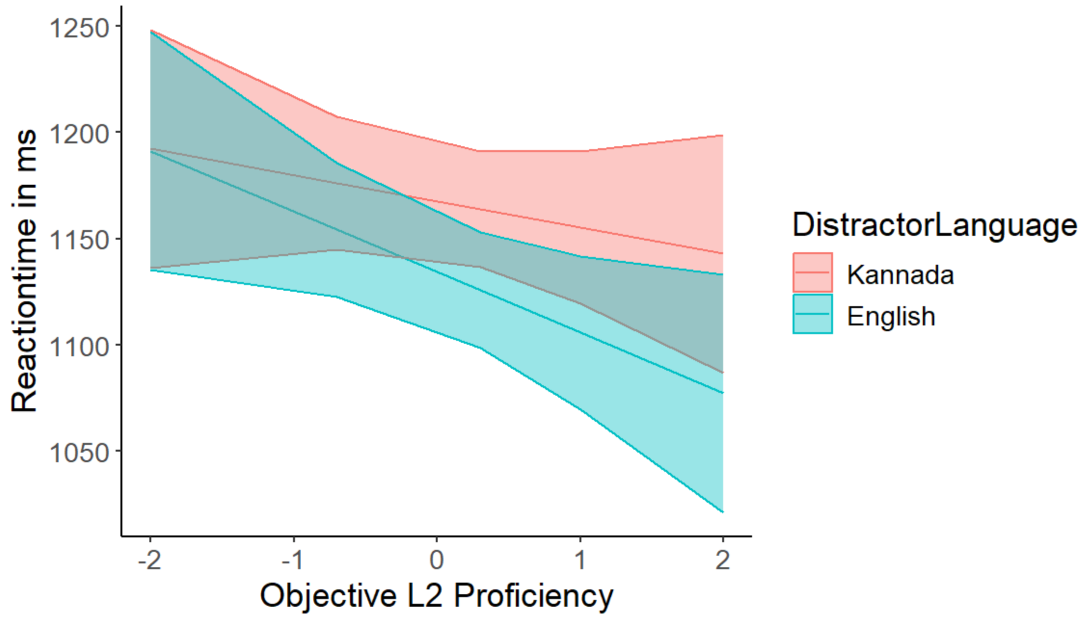


**Figure 22** Interaction between objective L2 proficiency and distractor language on naming latency

There is a significant two-way interaction between the distractor language English and objective L2 proficiency, which indicates that for every unit, an increase in objective L2 proficiency will result in naming the pictures faster by 16ms when accompanied by English distractors.

**Table 27** Exploring Interactions between Language Context and PCA Components on naming latency: A Mixed Model Approach".

| | ***Model 2:*** *lmer (Reaction time~ language context*C1 + language context*C2 + language context*C3 + (1\|participants) + (1\|Items)* | | |
|---|---|---|---|
| **Predictors** | **Estimates** | **CI** | ***p*** |
| (Intercept) | 1160.72 | 1109.48 – 1211.95 | **< .001** |
| Language context [Bilingual] | -18.13 | -28.14 – -8.13 | **< .001** |

| | | | |
|---|---|---|---|
| L2L1proficiency and dominance (C1) | 46.64 | -1.77 – 95.05 | **.059** |
| Inhibitory control (C2) | 34.34 | -14.07 – 82.76 | .164 |
| Objective L2 proficiency (C3) | -7.41 | -55.82 – 40.99 | .764 |
| Language context [Bilingual] × (C1) | 8.94 | -1.19 – 19.08 | .084 |
| Language context [Bilingual] × (C2) | 10.44 | 0.26 – 20.62 | **.044** |
| Language context [Bilingual] × (C3) | -26.27 | -36.39 – -16.15 | **< .001** |
| **Random effects** | | | |
| Total variance | | 58916.06 | |
| Participants variance | | 18490.36 pid | |
| Item variance | | 2396.98 stim | |
| ICC | | 0.26 | |
| Number of participants | | 32 pid | |
| Number of items | | 26 stim | |
| Observations | | 9056 | |
| Marginal $R^2$ / Conditional $R^2$ | | 0.056 / 0.303 | |

### *4.6.3.3 Main effects from Table 28*

The model found the main effect of component 1 (L2L1 proficiency and usage) on naming latency (*b* = 46.64, *p*= .05), which indicates that for every unit, an increase in L2L1 proficiency and usage will increase the reaction time by 47ms, respectively. As seen in the previous chapter of the PWI study, language context (*b* = -18.13, *p* <.01) significantly affected naming latency. However, neither inhibitory control (*b* = 42.65, *p* >.05) nor objective L2 proficiency (*b* = -12.38, *p* > .05) directly influenced naming latency.

#### *4.6.3.4 Interaction Effects from Table 28*

The mixed models revealed two significant two-way interactions: Language context (bilingual) and inhibitory control (*b* = 10.44, *p* < .04), Language context (bilingual), and objective L2 proficiency (*b* = -26.17, *p* < .01) were significant. Figures 23 and 24 present these significant interaction effects.

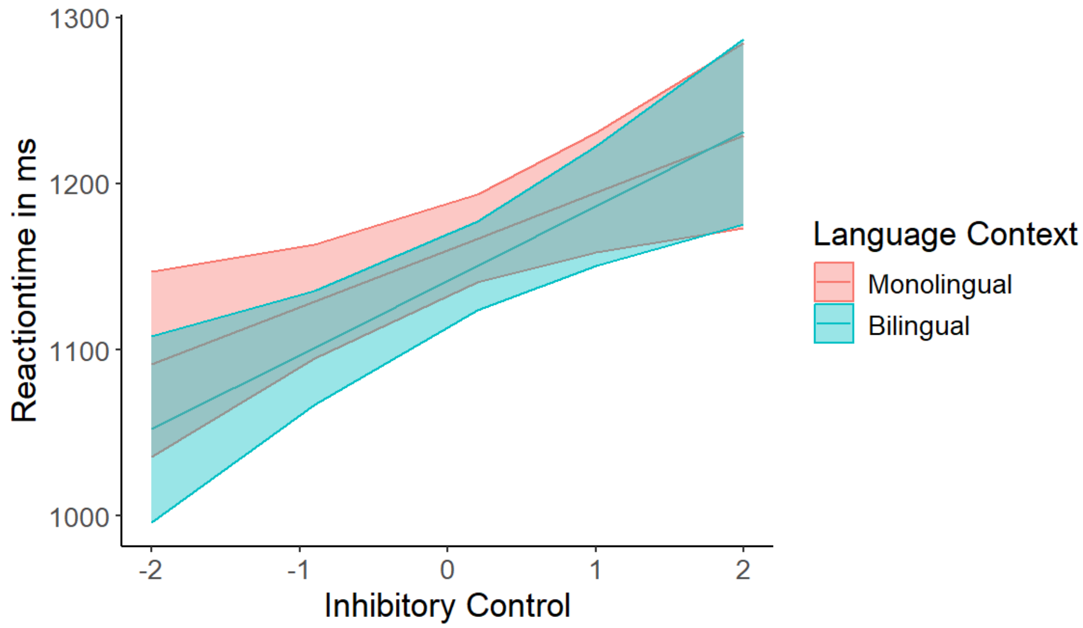


**Figure 23** Interaction effects between the inhibitory control and language context on naming latency

A significant interaction was observed between the language context (bilingual) and inhibitory control, suggesting that every unit increase in inhibitory cost increases naming latency by 10ms in a bilingual context.

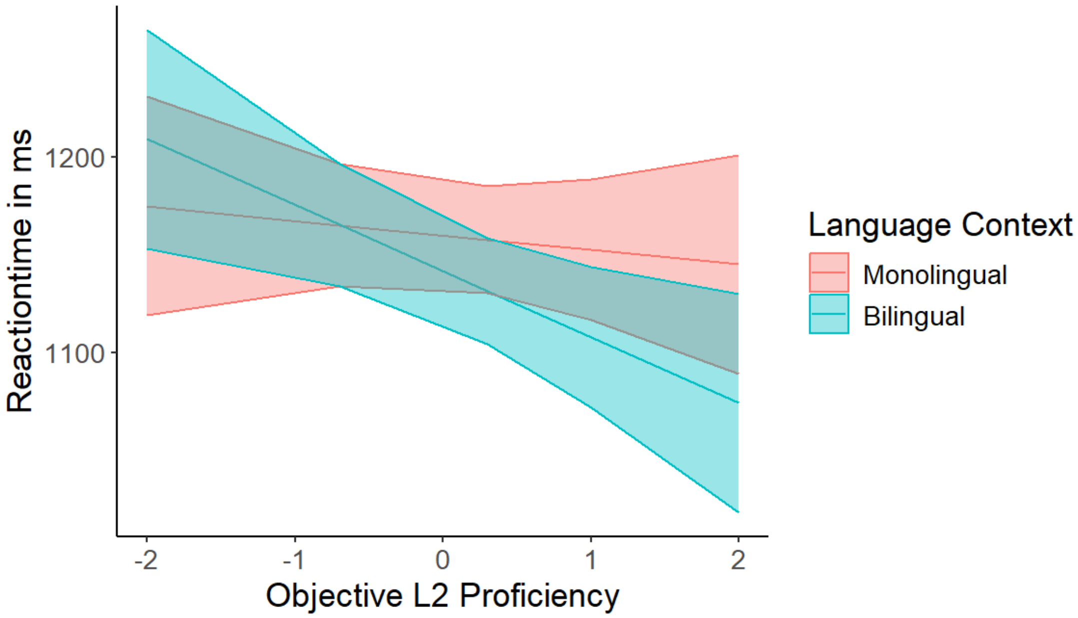


**Figure 24** Interaction effects between the objective L2 proficiency and language context on naming latency.

Significant two-way interactions were also present between the language context (bilingual) and objective L2 proficiency, indicating that for every unit increase in L2 objective proficiency, the naming response is faster by 26 ms in a bilingual context.

## 4.7 Discussion

The present chapter investigated the relationship between bilingual factors (proficiency and dominance) and inhibitory control and their influence on lexical selection. The bilinguals in the present study were sequential Kannada-English bilinguals who learnt their second language after the age of 5 years when introduced in school. Bilinguals in the present study were significantly more proficient and dominant in their native language based on the self-rated proficiency and dominance questionnaire. An objective measure of L2 proficiency was measured through lexical decision in English, displaying moderate proficiency levels. In addition, the bilinguals in the present study rated using both languages in their daily life approximately equally. The inhibitory control measures of the participants in this study were sensitive – significantly slower reaction times were produced in the incongruent than congruent conditions in both the Stroop and Flanker tasks.

### 4.7.1 Research Q1. Relationship between bilingual factors (proficiency and dominance) and inhibitory factors (Stroop and flanker cost)

Contrary to the hypothesis, no significant correlations between the bilingual participant and inhibitory factors were observed in this sample of Kannada-English bilinguals. The findings echo that of the study by Shell et al. (2015), which also found no relationship between the inhibitory control measured through the Simon task and L2 proficiency in a sample of 25 beginner Spanish students. Additionally, it may be that the bilingual cognitive advantage is less observable in young adults who are near the peak of their inhibitory abilities but can be detected in developmental and older adult populations with weaker abilities (Bialystok, 2005; Zeng et al., 2019).

Kannada English bilinguals showed a significant moderate relationship between subjective measures of proficiency and dominance ratings. The negative relationship between the L1 proficiency and L2 dominance measures showed that bilinguals who rated themselves as more proficient in L1 also perceived themselves as least dominant in their L2. The moderately positive relationship between the L2 proficiency and L2 dominance scores revealed that bilinguals who perceived themselves as more proficient in L2 were also using their L2 more often. Another straightforward negative relationship was found between L1 dominance and L2 dominance scores, suggesting that bilinguals who rated themselves as more dominant in their native language (Kannada) also rated themselves as less dominant in their L2 (English).

However, no significant relationship was observed between the self-rated L2 proficiency and objective L2 proficiency measures in the present thesis. These results partly support Gehebe et al. (2023) who reported correlations within subjective measures in the medium English proficient group. No significant correlation between subjective and objective L2 proficiency measures may reflect the type of task (rating vs lexical decision task). Each element of the subjective profile encompasses a variety of information, whereas the lexical decision isolates vocabulary knowledge.

### 4.7.2 Effects of distractor language and language context from PWI related to bilingual and inhibitory control factors

As stated in Chapter 3, there was no main effect of distractor type on naming latency, which indicated that Kannada-English bilinguals in the present study named the pictures with no difference in reaction time between the unrelated and related distractor conditions. However, there was a significant main effect of distractor language and language context, indicating that bilinguals were faster in naming the pictures with English distractors, and they were also faster while naming in a bilingual context compared to monolingual context (see Table 13 from Chapter 3 for more details).

Since there were no distractor effects on naming latency, it is not possible to explore links between semantic or phono-translation interference effects from the PWI task and inhibitory cost from the inhibitory control measures. Thus, it is not possible to examine predictions of bilingual lexical selection based on just inhibitory cost. However, since there were distractor language and language context effects in the PWI study, these could indicate that Kannada-English bilinguals showed a global competition effect. Specifically, by displaying longer reaction time with Kannada distractors and slower responses in monolingual context, which may be attributed to bilingual factors and/or inhibitory factors.

### 4.7.3 Research Q2. And Q3. Influence of bilingual factors (proficiency and dominance) and inhibitory control (Stroop and Flanker cost) on the speed of lexical retrieval.

Two measures were included to capture bilingual language proficiency using subjective and objective measures of L2 proficiency. The subjective and objective L2 proficiency did not correlate with each other, and they resulted in different directional effects on lexical retrieval. The overall relationship between these subjective and objective measures and the lexical retrieval data was paradoxical: an increase in the subjective measure of proficiency was associated with slower lexical retrieval in bilinguals, whereas the objective L2 proficiency was associated with faster responses (although this result was specific to interactions). One possibility is that these measures capture different characteristics of the task or participants.

The main effects of component 1 (L1L2 proficiency and dominance) on naming latency were significant. The one-unit increase in proficiency and dominance from both L1 and L2 leads to slower picture naming by 53ms; this may indicate that increased proficiency and/or dominance leads to more competition. The bilingual participants in this study were relatively more proficient and dominant in their native language, Kannada. A significantly slower naming response was observed in the monolingual Kannada PWI paradigm, consistent with increased competition effects. As people increase their L2 dominance and use naming slowed overall, this may indicate that information from both languages is more relevant to these individuals in daily life and, therefore, induces the processing of distracter items, which is hard to suppress and results in a global effect across the task.

The opposite direction of effect was observed with objective L2 data but within specific interactions, which may indicate that the measure is picking up on specific aspects of the efficiency of lexical retrieval. A significant interaction was observed between the objective L2 proficiency and distractor language. Bilinguals who scored better in L2 lexical decision tasks produced quicker responses in conditions with L2 distracters, indicating that this competition was easier to resolve. A second interaction was observed between objective L2 proficiency and language context. Those who had greater L2 objective proficiency were quicker in ignoring the distractors in a bilingual context, again indicating that cross-language interference was easier to resolve. These results suggest that the stronger the L2 network, the quicker it is to determine competition.

An alternative explanation is that the nature of the tasks induces these different patterns. The objective L2 measure used a lexical decision task, a psycholinguistic experimental paradigm, which is a qualitatively similar experience to the PWI task for participants. This may mean they approached the tasks in the same manner, e.g., using individualized strategies/approaches, which resulted in positive relationships between the tasks. However, interaction effects were found with the L2 objective measure, but the main effect is not entirely consistent with this interpretation.

Finally, a significant interaction was seen between the inhibitory control and the language context on naming latency. Greater inhibitory control was associated with faster lexical retrieval in a bilingual context. This indicates that bilinguals with better inhibitory control showed lesser cross-language interference in bilingual contexts. This view is in line with Grosjean's language mode hypothesis (Grosjean, 2001), suggesting that non-target language will be activated to greater levels in the bilingual context compared to that of the monolingual context and in line with Green's IC model, which suggests that inhibitory control is required to reduce cross-language interference. The fact that the effects of inhibitory control were specific to bilingual contexts is consistent with these hypotheses.

Consistent with previous research, bilingual and inhibitory factors impact lexical retrieval speed, which is further influenced by the context in which it occurs. This indicates complex and fluid relationships between these factors, which can induce paradoxical results depending on the measures used to capture them.

# 5 Chapter 5: General Discussion

This final chapter provides a summary and discussion of the main findings. The overall aim of this thesis was to investigate lexical selection in moderately proficient, sequential bilinguals speaking typologically distant languages, specifically Kannada and English, to address these three specific objectives:

1. Exploring lexical selection mechanism in moderately proficient distant language Kannada-English bilinguals through the effects of experimental manipulations.
2. Exploring the relationship between the bilingual (proficiency and dominance) and inhibitory control (Stroop and Flanker) factors.
3. Investigating how bilingual and inhibitory control factors influenced lexical retrieval in Kannada-English bilinguals.

## 5.1 Summary of studies

As a first step, in Chapter 2, a normative database in Kannada was developed by generating the naming responses for a subset of 180 items plus psycholinguistic parameters of these stimuli in Kannada, including a picture-name agreement, name agreement, familiarity, visual complexity, age of acquisition, and image agreement. Chapter 2 established a normative database in Kannada to control the stimuli selection for the PWI paradigm and investigate the lexical selection in bilinguals, as shown in Chapter 3. In the next chapter, Chapter 4, the relationship between the bilingual and inhibitory control factors and their influence on lexical retrieval was investigated.

## 5.2 Direct evidence of lexical selection mechanism in moderately proficient distant language Kannada-English bilinguals

One of the much-debated aspects in bilingual research is whether the simultaneous activation of lexical nodes in both languages compete for lexical selection or not. Based on the lexical competition between or restricted to within language during lexical selection, three lexical selection hypotheses have been formed: language-specific - within language competition only (Costa & Caramazza, 1999), language non-specific - between language competition (Green, 1998) and dynamic (Grosjean, 2001) - a combination of within and between language competitions. Study 3 aimed to test these three hypotheses directly. Four picture-word interference paradigms were produced, manipulating three experimental variables: (1) distractor type (semantic and phono-translation distractors and unrelated), (2) distractor language (Kannada and English), and (3) language context (Monolingual and Bilingual).

Our results suggest that lexical selection in Kannada English bilinguals is language-specific in both language directions (whether naming in L1 or L2) due to the absence of phono-translation interference effects in all four PWI paradigms in comparison to unrelated distracter effects.

The present study results are contradictory to previous research. Using the PWI paradigm (Boukadi et al., 2015) found an absence of phono-translation interference effects in the monolingual context and the presence of the phono-translation distractor effects in the bilingual context, indicating a dynamic lexical selection account in moderately proficient Tunisian-Arabic French bilinguals.  Hermans et al. (1998) found phonotranslation interference effects in monolingual and bilingual contexts, suggesting cross-language interference in highly proficient Dutch English bilinguals, indicating language non-specific account. On the other hand, the present results are in line with Hoshino et al. (2021) study, which supports language-specific lexical selection in distant language Japanese English bilinguals where an absence of interference effects was observed in comparison to closely related languages such as Spanish and English. However, Hoshino et al. (2021) study used visual distractors, and the authors assume that different script acts as perceptual cues at the early stages of processing the target picture naming. Moreover, previous studies using the PWI paradigm have investigated only L2 lexical selection, i.e., naming is always in L2 with either L2 or L1 distracters. The present study investigated the lexical selection in both language directions within the same bilingual participant with four PWI paradigms (naming in L1 with L1 and L2 distractors and naming in L2 with L2 and L1 distractors.

While the absence of phono-translation interference effects in the PWI paradigms implicates a language-specific lexical selection mechanism, caution should be taken due to the lack of semantic interference effect in all four paradigms. This raises questions as to whether the PWI paradigm is sensitive enough to capture the interference effects in this group of bilinguals. Although the presence of a semantic interference effect cannot be used to adjudicate between the lexical selection hypotheses, semantic distracters were included to evaluate the sensitivity of the paradigm in inducing lexical competition. The results reinforce the importance of methodological decisions that enable the evaluation of paradigm sensitivity, especially when hypothesis testing relies on a lack of change/effect, as was the case for the language-specific account in this work.

Semantic interference effects are common throughout the PWI literate (Aristei et al., 2012; Belke, Brysbaert, et al., 2005; Bloem & La Heij, 2003; Costa & Caramazza, 1999; Damian & Bowers, 2003; Navarrete & Costa, 2005; Vigliocco et al., 2004). Methodological decisions were taken to enhance the probability of obtaining these effects. For example, (Collina et al., 2013; Gauvin et al., 2018) demonstrated that familiarization induces interference effects in PWI tasks, and this phase was included in the current study. Second, the semantic distractors chosen were categorically related, which has been shown to yield semantic interference effects in previous studies (Costa et al., 1999; Hermans et al., 1998; Sudarshan & Baum, 2019). In addition, unrelated distractors were used along with related distractors, which reduced the possibility of participants developing a strategy forcing the relationship between the target and the distractor (Costa & Santesteban, 2004). Despite taking all these above measures, no semantic interference effects were observed. Interference effects may be reduced with multiple presentations. However, even with repetition, we can expect semantic interference to be evident in the first paradigm in which they named the pictures.

## 5.3 Lack of Semantic or Phonotranslation interference effects

The lack of either semantic or phono-translation effects is not readily interpretable. The presence of a semantic interference effect is consistently reported in highly proficient bilinguals (Chen et al., 2022; Costa & Caramazza, 1999; Hermans et al., 1998; Sudarshan & Baum, 2019). Therefore, one way to explain the absence of semantic interference effect could be related to moderate L2 proficiency in the present study, and L2 distractors may not be activated to greater levels, or by the time L2 distractors are processed, the target picture name may have reached the activation threshold, and distractors may not affect naming. However, the absence of a semantic interference effect even with L1 distractors contradicts the previous studies, as bilinguals were more proficient and dominant in their L1, which should have resulted in semantic interference effects. Therefore, it is hard to interpret the absence of semantic interference effects in these bilinguals.

The absence of phono-translation interference effects is in line with the previous study conducted on highly proficient French English bilinguals (Sudarshan & Baum, 2019), which they attributed to greater L2 proficiency leading to lesser cross-language activation during lexical selection. The absence of phono translation effects in the present study could be attributed to typological distance between the languages. In the present study, the Kannada language belongs to a Dravidian family, and English belongs to an Indo-European family. Kannada is alpha syllabary and phonemic. Therefore, each written symbol in the Kannada script corresponds with one syllable, as opposed to one phoneme in languages like English. Each sound has its unique letter, and therefore, every word is pronounced exactly as it is spelt. The perception, categorization, and recognition of speech sounds may vary across languages. Therefore, the phono-translation distractors may act as a cue to ignore the distractors efficiently and result in no interference effect, or they may not be strong enough to activate the target picture name in the non-target language to cause any interference effects because of the distance between the languages which could be weaker between languages in terms of linguistic factors (phonetics).

The absence of semantic interference effects raises the question of whether the PWI task is sensitive enough to detect the interference effects in moderately proficient bilinguals with typologically distant languages. The differences in the pattern of lexical selection mechanisms obtained concerning distant language bilinguals are consistent, e.g., Dynamic lexical selection in Tunisian Arabic-French bilinguals (Boukadi et al., 2015); Language non-specific lexical selection in Persian French bilinguals (Deravi, 2009) & Language-specific lexical selection in Chinese English bilinguals, (Chen et al., 2022); Japanese English, (Hoshino et al., 2021). Therefore, it might be possible that the typological distance may vary even within the so-called distant languages, resulting in different lexical selection patterns.

Alternatively, the absence of distractor effects may be due to the similar magnitude of effect from the unrelated distractors as the semantic and PWI distracters. Indeed, the effects of distracter language and language context suggest that this paradigm induced a degree of interference, but there was an insensitivity to the nature of the competition.

Overall, direct evidence in support of a lexical selection mechanism was not obtained through the interference manipulations (target-distractor relationship) in the PWI paradigm. However, this thesis found a range of other influences on lexical selection, which are consistent with the position that the bilingual experience and inhibitory factors are related to lexical selection processes and provide some indirect evidence for understanding the lexical selection mechanism in Kannada-English bilinguals.

## 5.4 Indirect evidence for lexical selection and the influence of wider factors

The two variables, distractor language and language context, significantly influenced the speed of lexical retrieval.

The PWI paradigm indicated that Kannada English bilinguals were significantly slower in naming the pictures when the naming and distractors were presented in their native language compared to all other paradigms. Native language effect suggests that Kannada distractors were harder to ignore in monolingual contexts. According to the RHM (Kroll & Stewart, 1994), the lexico-semantic network is stronger in L1 than L2 in unbalanced bilinguals, such as the moderately proficient bilinguals in this thesis. These participants were native Kannada speakers and reported being more proficient and dominant in their native language based on the self-rated proficiency and dominance questionnaires. Under the RHM, the connection between conceptual and lexical networks is stronger in L1 (Kannada), which might have led to the activation of a greater number of competitors at the lexical level and resulted in a distractor language effect. Consistent with the RHM, a relationship was observed between proficiency and dominance (inversely correlated between L1 and L2) and naming in a monolingual context. This suggests that the stronger the language representation, the more susceptible lexical selection is to competition in the PWI paradigm. Paradoxically, however, the inverse pattern was observed for L2. The objective proficiency lexical decision measure showed an inverse relationship with response speeds (i.e., better lexical decision = shorter/quicker response latencies). It may be that the PWI and lexical decision tasks were more related to their cognitive requirements, and, therefore, individual strategies such as speed-accuracy trade-off decisions may account for the relationship.

Another key finding from the PWI paradigm was the influence of language context on lexical retrieval, which was quicker in a bilingual context than in a monolingual context. Although both languages are thought to be active during any language task, Grosjean (2001) describes how the activity level of the target language is greater than that of the non-target language. Consistent with this, the language context effects in this thesis indicate that the effect of distractors was reduced when they were presented in the non-target language. The language context effects are also consistent with the Inhibitory Control model (Green, 1998), which states that bilinguals with better inhibitory control exhibit lesser cross-language interference effects. Interestingly, a relationship was found between inhibitory control and lexical retrieval, but only when naming in a bilingual context, indicating that this inhibitory mechanism is most relevant for cross-linguistic suppression, consistent with the Inhibitory Control model.

Overall, these results are most consistent with a dynamic view of lexical selection. To elaborate, the significant interaction between the inhibitory control and language context on naming latencies indicated that bilinguals with better inhibitory control could resolve the interference effects quickly in a bilingual context. If the lexical selection was purely language-specific, then we should not have observed the interaction between language context and inhibitory control factors and their influence on lexical retrieval. Therefore, a combination of language-specific and non-specific aspects are seen from direct and indirect evidence suggesting the dynamics within bilingual language production.

## 5.5 Theoretical implications of bilingual word production models

Alongside the main findings reported in Chapters 3 and 4, three additional observations were made, which have implications for models and frameworks of bilingual word production. These have been schematically represented in Figure 25 and explained in detail below.

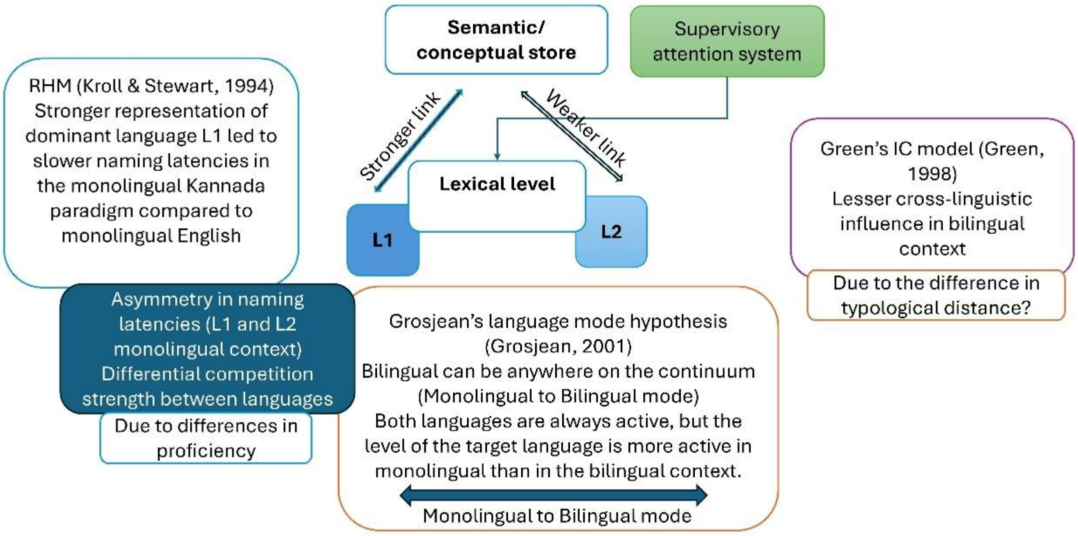


**Figure 25** Results depicting the theoretical implications of bilingual word production models.

***1)*** **Naming was slower and less accurate in monolingual Kannada than in both monolingual English and bilingual Kannada**

The RHM (Kroll & Stewart, 1994)(Kroll & Stewart, 1994) can explain this finding as this model states that the connection between the semantic lexical link is stronger in their dominant language (L1) than in their L2 while learning their second language or when they are low proficient in their L2. In this case, the low proficient bilinguals access the concepts via the indirect route through the L1 (L2-L1-concept).

Bilinguals in the present study were more dominant in their L1, which represents the stronger connection between the semantic store and the lexical representation within this language network, leading to more competition within the language, resulting in slower and less accurate naming in the monolingual Kannada. These Kannada-English bilinguals were faster in naming the pictures in monolingual English. Therefore, if bilinguals were slower in naming in monolingual Kannada than in monolingual English, then English naming cannot be a translation of the Kannada. Also, bilinguals in the present study were moderately proficient based on their objective L2 proficiency scores. Taken together, these results suggest a direct access route (L2 – semantic) for moderately proficient bilinguals. Moreover, RHM does not deny direct access between the semantic store and L2 lexicon in non-balanced bilinguals; rather, it suggests a weaker link relative to their dominant L1. If they had used an indirect route to access the concept (L2-L1-semantic route), we should have observed slower naming latencies due to cross-linguistic influences in monolingual English and bilingual contexts.

***2)* Why is monolingual English faster than the monolingual Kannada paradigm?**

If there is a direct naming route established between the semantic and lexical levels in both languages (L1 - semantic, L2 - semantic), it suggests that the differences between monolingual English and monolingual Kannada are caused by processing differences between the pathways. The RHM by Kroll & Stewart (1994) proposes a stronger representation of the dominant language based on proficiency. The current data are consistent with this position, as all conditions required name production in the presence of a distractor. The interference effect would be expected to be greater in L1 than L2, thus slowing naming – consistent with the data observed in the monolingual conditions. However, distracter-type effects would also be expected under this interpretation (or greater distracter-type effects in the monolingual Kannada condition). These were not observed, so this interpretation should be taken with caution.

### *3)* Bilinguals were faster in the bilingual context than in the monolingual context

This pattern indicates a more limited influence of distracters in the bilingual naming context than in the monolingual naming context (irrespective of naming/distractor language). These results are consistent with Green's IC model (Green, 1998), in which inhibitory control mechanisms are recruited to suppress the non-target language during word production. Inhibitory control may act to reduce the interference from distracters in the bilingual context to a greater extent than in the monolingual context. In support of this interpretation, inhibitory control was associated with naming latency in the bilingual but not monolingual context, which suggests that the finding cannot solely be accounted for by different degrees of cross- and within-language interference.

The impact of inhibition in the bilingual naming context was found despite the typological differences between the languages. Hoshino et al. (2021) suggest that cross-linguistic interference is suppressed in typologically different languages because orthographic or phonetic differences act as perceptual cues, enabling the target language to be activated to a greater extent. This concept parallels Grosjean's language mode hypothesis (Grosjean, 2001), in which the target language is activated to a greater extent in monolingual contexts. It may be that the capacity to restrict processing to a single language and/or the degree of cross-language interference is influenced by typological differences between the languages. Systematic future investigation may be able to test this hypothesis. If support were found, the typological difference could act as a moderating factor in Green's IC model, i.e. the degree of inhibition would be inversely proportional to the language similarity or integrated into the language mode hypothesis (Grosjean, 2001) in which the extent to which the target language requires greater activation would be influenced by the degree of difference between the additional language(s).

## 5.6 Future research / methodological considerations

The present study is the first to investigate the lexical selection in both language directions from the same bilinguals using the PWI paradigm. The current literature and the work from this thesis demonstrate a wide range of influences on lexical selection and question whether a single paradigm (in this case, the PWI task) is appropriate for comparing lexical selection mechanisms across different types of bilinguals. For example, the results from the Costa et al. (1999) study suggested that translation equivalents facilitate access to target language production rather than interference while retrieving. Consequently, one might conclude that bilingual language selection does not involve cross-language competition, which is suggestive of similarity to monolingual processing, i.e., language selection is competitive only within language. However, this has faced criticism regarding the facilitatory effects observed when the distractor word is the translation of the target word (strongest cross-language competitor). Alternatively, Abutalebi & Green (2007) argued that the design of PWI may not segregate different underlying mechanisms. For instance, whether the translation equivalent facilitation effects occur mainly at the lexical or conceptual level (Abutalebi & Green, 2007; Hermans, 2004). In recent years, the debate surrounding the PWI paradigm has shifted from examining how word distractors interfere with lexical selection to questioning the paradigm’s relevance for studying lexical selection in monolingual and bilingual word production. The PWI paradigm suggested more general response selection processes rather than constraining the lexical access process (Finkbeiner et al., 2006), which suggests that the observed interference effects may be more about how responses are chosen from candidates than about the retrieval of lexical items per se. Therefore, one should be cautious when interpreting the bilingual lexical selection when there are no interference effects from the PWI tasks.

It is important to acknowledge that this thesis has limitations. In the present thesis, phonological differences between the Kannada and English languages were considered markers for typological distance. The present thesis is the first attempt to develop stimuli for the PWI task, specifically the phono-translation distractors in Kannada and English. The absence of effects could be due to the inability of the phonemes to activate the lexicon in the non-target language for many reasons. For example, the phonological structure (syllabic structure) between Kannada and English are different (refer to section 1.5.1 from Chapter 1). The first phoneme or syllables were matched between the target lexicon and the phono-translation distractor. In addition, other parameters, such as syllable length or word length, were difficult to match between the target and phono-translation distractors. However, future studies can consider measuring the typological distance using multiple linguistic aspects (semantic/lexical/ phonological) along with script and writing systems for more accurate information while coining the term distant or similar. Future work should consider the interaction between language factors (e.g. phonetic and phonological features) and paradigm design and consider incorporating multiple measures of lexical selection (e.g. language switching) to unpick the effects of paradigm sensitivity and lexical-selection effects.

## 5.7 Conclusions

In summary, this thesis investigated bilingual lexical selection in moderately proficient distant language Kannada English bilinguals. After generating psycholinguistically controlled stimuli set, PWI paradigms and bilingual and inhibitory control measures were gathered to investigate lexical selection. The results from the current thesis suggest that lexical retrieval is dynamic in that distractor language and language context effects are observed, which interact with bilingual and inhibitory factors. The findings from this thesis offer new insights into the process of bilingual language production in Kannada-English bilinguals and highlight the importance of considering the impact of linguistic structure on experimental paradigms.

# 6 References

Abdel Rahman, R., & Aristei, S. (2010). Now you see it… and now again: Semantic interference reflects lexical competition in speech production with and without articulation. *Psychonomic Bulletin & Review*, *17*(5), 657–661.

Abutalebi, J., & Green, D. (2007). Bilingual language production: The neurocognition of language representation and control. In *Journal of Neurolinguistics* (Vol. 20, Issue 3). https://doi.org/10.1016/j.jneuroling.2006.10.003

Ahmed, W., Murthy, A. N., Gargeshwari, A., & Nikitha, M. (2013). Name Agreement Norms for a Set of 260 Pictures in Kannada for Children. *Language in India*, *13*(June), 320–344.

Alario, F.-X., & Ferrand, L. (1999). A set of 400 pictures standardized for French: Norms for name agreement, image agreement, familiarity, visual complexity, Image variability, and age of acquisition. In *Behavior Research Methods, Instruments, & Computers* (Vol. 31, Issue 3). http://www.nyspi.cpmc.columbia.

Alario, F.-X., Ferrand, L., Laganaro, M., New, B., Frauenfelder, U. H., & Segui, J. (2004). Predictors of picture naming speed. *Behavior Research Methods, Instruments, & Computers*, *36*(1), 140–155. https://doi.org/10.3758/BF03195559

Antón, E., Carreiras, M., & Duñabeitia, J. A. (2019). The impact of bilingualism on executive functions and working memory in young adults. *PLoS ONE*, *14*(2), 1–30. https://doi.org/10.1371/journal.pone.0206770

Aristei, S., Zwitserlood, P., & Rahman, R. A. (2012). Picture-induced semantic interference reflects lexical competition during object naming. *Frontiers in Psychology*, *3*, 28.

Bakhtiar, M., Nilipour, R., & Weekes, B. S. (2013). Predictors of timed picture naming in Persian. *Behavior Research Methods*, *45*(3), 834–841. https://doi.org/10.3758/s13428-012-0298-6

Bangalore, S., Robson, H., & Astell, A. J. (2022). Standardizing norms for 180 coloured Snodgrass and Vanderwart pictures in Kannada language. *PLoS ONE*, *17*(4 April), 1–16. https://doi.org/10.1371/journal.pone.0266359

Barry, C., Morrison, C. M., & Ellis, A. W. (1997). Naming the Snodgrass and Vanderwart Pictures: Effects of Age of Acquisition, Frequency, and Name Agreement. In *THE QUARTERLY JOURNAL OF EXPERIMENTAL PSYCHOLOGY* (Vol. 50, Issue 3).

Bates, D., Kliegl, R., Vasishth, S., & Baayen, H. (2015). Parsimonious mixed models. *ArXiv Preprint ArXiv:1506.04967*.

Belke, E., Brysbaert, M., Meyer, A. S., & Ghyselinck, M. (2005). Age of acquisition effects in picture naming: Evidence for a lexical-semantic competition hypothesis. *Cognition*, *96*(2). https://doi.org/10.1016/j.cognition.2004.11.006

Belke, E., Meyer, A. S., & Damian, M. F. (2005). Refractory effects in picture naming as assessed in a semantic blocking paradigm. *The Quarterly Journal of Experimental Psychology Section A*, *58*(4), 667–692.

Bi, Y., Xu, Y., & Caramazza, A. (2009). Orthographic and phonological effects in the picture–word interference paradigm: Evidence from a logographic language. *Applied Psycholinguistics*, *30*(4), 637–658.

Bialystok, E. (2005). Consequences of bilingualism for cognitive development.

*Handbook of Bilingualism: Psycholinguistic Approaches*, 417–432.
Bialystok, E. (2006). Effect of bilingualism and computer video game experience on the Simon task. *Canadian Journal of Experimental Psychology/Revue Canadienne de Psychologie Expérimentale*, *60*(1), 68.
Bialystok, E. (2009). Effects of bilingualism on cognitive and linguistic performance across the lifespan. *Streitfall Zweisprachigkeit–The Bilingualism Controversy*, 53–67.
Bialystok, E., & Craik, F. I. M. (2010). Cognitive and Linguistic Processing in the Bilingual Mind. *Current Directions in Psychological Science*, *19*(1), 19–23. https://doi.org/10.1177/0963721409358571
Bialystok, E., Craik, F. I. M., Klein, R., & Viswanathan, M. (2004). Bilingualism, Aging, and Cognitive Control: Evidence From the Simon Task. In *Psychology and Aging* (Vol. 19, pp. 290–303). American Psychological Association. https://doi.org/10.1037/0882-7974.19.2.290
Bloem, I., & La Heij, W. (2003). Semantic facilitation and semantic interference in word translation: Implications for models of lexical access in language production. *Journal of Memory and Language*, *48*(3), 468–488. https://doi.org/10.1016/S0749-596X(02)00503-X
Bonfieni, M., Branigan, H. P., Pickering, M. J., & Sorace, A. (2020). Cognitive control in bilinguals: Effects of language experience and individual variability. *Bilingualism: Language and Cognition*, *23*(1), 219–230.
Bonin, P., Peereman, R., Malardier, N., Méot, A., & Chalard, M. (2003). A new set of 299 pictures for psycholinguistic studies: French norms for name agreement, image agreement, conceptual familiarity, visual complexity, image variability, age of acquisition, and naming latencies. *Behavior Research Methods, Instruments, & Computers*, *35*(1), 158–167.
Bose, A., & Schafer, G. (2017). Name agreement in aphasia. *Aphasiology*, *31*(10), 1143–1165. https://doi.org/10.1080/02687038.2016.1254148
Bot, K. De. (1992). Applied linguistics. *Applied Linguistics*, *13*(1), 1–24. https://doi.org/10.1093/applin/13.1.1
Boukadi, M., Davies, R. A. I. I., & Wilson, M. A. (2015). Bilingual lexical selection as a dynamic process: Evidence from Arabic-French bilinguals. *Canadian Journal of Experimental Psychology/Revue Canadienne de Psychologie Expérimentale*, *69*(4), 297. https://doi.org/10.1037/cep0000063
Bürki, A., Elbuy, S., Madec, S., & Vasishth, S. (2020). What did we learn from forty years of research on semantic interference? A Bayesian meta-analysis. *Journal of Memory and Language*, *114*, 104125.
Caramazza, A., & Miozzo, M. (1997). The relation between syntactic and phonological knowledge in lexical access: Evidence from the “tip-of-the-tongue” phenomenon. *Cognition*, *64*(3), 309–343. https://doi.org/10.1016/S0010-0277(97)00031-0
Carroll, J. B., & White, M. N. (1973). Word frequency and age of acquisition as determiners of picture-naming latency. *The Quarterly Journal of Experimental Psychology*, *25*(1), 85–95. https://doi.org/10.1080/14640747308400325
Chen, S., Hou, R., Peng, Y., Xue, S., & Yang, L. (2022). Language dominance influences bilingual lexical selection quantitatively but not qualitatively in language production: Evidence from Chinese-English bilinguals. *Lingua*, *278*,

103418. https://doi.org/10.1016/j.lingua.2022.103418
Clare, L., Whitaker, C. J., Martyr, A., Martin-Forbes, P. A., Bastable, A. J. M., Pye, K. L., Quinn, C., Thomas, E. M., Mueller Gathercole, V. C., & Hindle, J. V. (2016). Executive control in older Welsh monolinguals and bilinguals. *Journal of Cognitive Psychology*, *28*(4), 412–426.
Clarke, A. J. B., & Ludington, J. D. (2018). Thai Norms for Name, Image, and Category Agreement, Object Familiarity, Visual Complexity, Manipulability, and Age of Acquisition for 480 Color Photographic Objects. *Journal of Psycholinguistic Research*, *47*(3), 607–626. https://doi.org/10.1007/s10936-017-9544-5
Collina, S., Tabossi, P., & De Simone, F. (2013). Word Production and the Picture-Word Interference Paradigm: The Role of Learning. *Journal of Psycholinguistic Research*, *42*(5), 461–473. https://doi.org/10.1007/s10936-012-9229-z
Colomé, À. (2001). Lexical activation in bilinguals' speech production: Language-specific or language-independent? *Journal of Memory and Language*, *45*(4), 721–736. https://doi.org/10.1006/jmla.2001.2793
Cortese, M. J., & Khanna, M. M. (2007). Age of acquisition predicts naming and lexical-decision performance above and beyond 22 other predictor variables: An analysis of 2,342 words. *Quarterly Journal of Experimental Psychology*, *60*(8), 1072–1082. https://doi.org/10.1080/17470210701315467
Costa, A., Alario, F.-X. X., & Caramazza, A. (2005). On the categorical nature of the semantic interference effect in the picture-word interference paradigm. *Psychonomic Bulletin & Review*, *12*(1), 125–131. https://doi.org/10.3758/BF03196357
Costa, A., & Caramazza, A. (1999). Is lexical selection in bilingual speech production language-specific? Further evidence from Spanish–English and English–Spanish bilinguals. *Bilingualism: Language and Cognition*, *2*(3), 231–244.
Costa, A., Caramazza, A., & Sebastian-Galles, N. (2000). The cognate facilitation effect: Implications for models of lexical access. In *Journal of Experimental Psychology: Learning, Memory, and Cognition* (Vol. 26, pp. 1283–1296). American Psychological Association. https://doi.org/10.1037/0278-7393.26.5.1283
Costa, A., Colome, À., Gomez, O., Sebastian-Galles, N., Colomé, À., Gómez, O., & Sebastián-Gallés, N. (2003). Another look at cross-language competition in bilingual speech production: Lexical and phonological factors. *Bilingualism: Language and Cognition*, *6*(3), 167–179. https://doi.org/10.1017/s1366728903001111
Costa, A., Hernández, M., & Sebastián-Gallés, N. (2008). Bilingualism aids conflict resolution: Evidence from the ANT task. *Cognition*, *106*(1), 59–86. https://doi.org/10.1016/j.cognition.2006.12.013
Costa, A., La Heij, W., & Navarrete, E. (2006). The dynamics of bilingual lexical access. *Bilingualism*, *9*(2), 137–151. https://doi.org/10.1017/S1366728906002495
Costa, A., Miozzo, M. M. M., & Caramazza, A. (1999). Lexical selection in bilinguals: Do words in the bilingual's two lexicons compete for selection? *Journal of Memory and Language*, *41*(3), 365–397. https://doi.org/10.1006/jmla.1999.2651

Costa, A., & Santesteban, M. (2004). Lexical access in bilingual speech production: Evidence from language switching in highly proficient bilinguals and L2 learners. *Journal of Memory and Language*, *50*(4), 491–511. https://doi.org/10.1016/j.jml.2004.02.002

Cox, S. R., Bak, T. H., Allerhand, M., Redmond, P., Starr, J. M., Deary, I. J., & MacPherson, S. E. (2016). Bilingualism, social cognition and executive functions: A tale of chickens and eggs. *Neuropsychologia*, *91*, 299–306.

Cuetos, F., Elus University Oj York, A. W., & Alvarez, B. (1999). Naming times für the Snodgrass and Vanderwart pictures in Spanish. In *Behavior Research Methods, Instruments. & Computers* (Vol. 31, Issue 4).

Damian, M. F., & Bowers, J. S. (2003). Locus of semantic interference in picture-word interference tasks. *Psychonomic Bulletin & Review*, *10*, 111–117.

de Zubicaray, G. I., Hansen, S., & McMahon, K. L. (2013). Differential processing of thematic and categorical conceptual relations in spoken word production. *Journal of Experimental Psychology: General*, *142*(1), 131.

De Zubicaray, G. I., McMahon, K. L., Eastburn, M. M., & Wilson, S. J. (2002). Orthographic/phonological facilitation of naming responses in the picture–word task: An event-related fMRI study using overt vocal responding. *Neuroimage*, *16*(4), 1084–1093.

Dell, G. S. (1986). A spreading-activation theory of retrieval in sentence production. In *Psychological Review* (Vol. 93, pp. 283–321). American Psychological Association. https://doi.org/10.1037/0033-295X.93.3.283

Dell, G. S., & O'Seaghdha, P. G. (1992). Stages of lexical access in language production. *Cognition*, *42*(1–3), 287–314.

Deravi, F. (2009). Language non-specific selection in highly proficient bilinguals. *Acquisition et Interaction En Langue Étrangère*, *Aile... Lia 2*, 131–163. https://doi.org/10.4000/aile.4542

Dimitropoulou, M., Duñabeitia, J. A., Blitsas, P., & Carreiras, M. (2009). A standardized set of 260 pictures for Modern Greek: Norms for name agreement, age of acquisition, and visual complexity. *Behavior Research Methods*, *41*(2), 584–589. https://doi.org/10.3758/BRM.41.2.584

Dunn, A. L., & Fox Tree, J. E. (2009). A quick, gradient Bilingual Dominance Scale. *Bilingualism*, *12*(3), 273–289. https://doi.org/10.1017/S1366728909990113

Dunn, A. L., Tree, J. E. F., & Fox Tree, J. E. (2009). A quick, gradient bilingual dominance scale. *Bilingualism: Language and Cognition*, *12*(3), 273–289. https://doi.org/10.1017/S1366728909990113

Dylman, A. S., & Barry, C. (2018). When having two names facilitates lexical selection: Similar results in the picture-word task from translation distractors in bilinguals and synonym distractors in monolinguals. *Cognition*, *171*, 151–171.

Eriksen, B. A., & Eriksen, C. W. (1974). Effects of noise letters upon the identification of a target letter in a nonsearch task. *Perception & Psychophysics*, *16*(1), 143–149.

Finkbeiner, M., Gollan, T. H., & Caramazza, A. (2006). Lexical access in bilingual speakers: What's the (hard) problem? *Bilingualism*, *9*(2), 153–166. https://doi.org/10.1017/S1366728906002501

Francis, W. N., Kucera, H., Kučera, H., & Mackie, A. W. (1982). *Frequency analysis of English usage: Lexicon and grammar*. Houghton Mifflin.

Gade, M., & Koch, I. (2005). Linking inhibition to activation in the control of task sequences. *Psychonomic Bulletin & Review*, *12*, 530–534.

Gauvin, H. S., Jonen, M. K., Choi, J., McMahon, K., & de Zubicaray, G. I. (2018). No lexical competition without priming: Evidence from the picture–word interference paradigm. *Quarterly Journal of Experimental Psychology*, *71*(12), 2562–2570. https://doi.org/10.1177/1747021817747266

Gehebe, T., Wadhera, D., & Marton, K. (2023). Interactions between bilingual language proficiency and exposure: comparing subjective and objective measures across modalities in bilingual young adults. *International Journal of Bilingual Education and Bilingualism*, *26*(7), 845–860.

George, A., & Mathuranath, P. S. (2007). Community-based naming agreement, familiarity, image agreement and visual complexity ratings among adult Indians. *Annals of Indian Academy of Neurology*, *10*(2), 92–99. https://doi.org/10.4103/0972-2327.33216

Gollan, T. H., Weissberger, G. H., Runnqvist, E., Montoya, R. I., & Cera, C. M. (2012). Self-ratings of spoken language dominance: A Multilingual Naming Test (MINT) and preliminary norms for young and aging Spanish–English bilinguals. *Bilingualism: Language and Cognition*, *15*(3), 594–615.

Green. (1998). Mental control of the bilingual lexico-semantic system. *Bilingualism: Language and Cognition*, *1*(2), 67–81. https://doi.org/10.1017/s1366728998000133

Green, D. W. (1986). Control, activation, and resource: A framework and a model for the control of speech in bilinguals. *Brain and Language*, *27*(2), 210–223.

Green, D. W., & Abutalebi, J. (2013). Language control in bilinguals: The adaptive control hypothesis. *Journal of Cognitive Psychology*, *25*(5), 515–530.

Grosjean, F. (2001). The Bilingual's Language Modes. In *One mind, two languages: Bilingual language processing.* (pp. 1–22). Blackwell Publishing.

Grosjean, F. (2012). Bilingual and Monolingual Language Modes. *The Encyclopedia of Applied Linguistics*. https://doi.org/10.1002/9781405198431.wbeal0090

Guo, T., Liu, H., Misra, M., & Kroll, J. F. (2011). Local and global inhibition in bilingual word production: fMRI evidence from Chinese–English bilinguals. *NeuroImage*, *56*(4), 2300–2309.

Hermans, D. (2004). Between-language identity effects in picture-word interference tasks: A challenge for language-nonspecific or language-specific models of lexical access? *International Journal of Bilingualism*, *8*(2), 115–125. https://doi.org/10.1177/13670069040080020101

Hermans, D., Bongaerts, T., De Bot, K., & Schreuder, R. (1998). Producing words in a foreign language: Can speakers prevent interference from their first language? *Bilingualism: Language and Cognition*, *1*(3), 213–229. https://doi.org/10.1017/s1366728998000364

Hernandez, A. E., Martinez, A., & Kohnert, K. (2000). In Search of the Language Switch: An fMRI Study of Picture Naming in Spanish–English Bilinguals. *Brain and Language*, *73*(3), 421–431. https://doi.org/https://doi.org/10.1006/brln.1999.2278

Hernández, M., Costa, A., Fuentes, L. J., Vivas, A. B., & Sebastián-Gallés, N. (2010). The impact of bilingualism on the executive control and orienting networks of attention. *Bilingualism: Language and Cognition*, *13*(3), 315–325.

Hoshino, N., Beatty-Martínez, A. L., Navarro-Torres, C. A., & Kroll, J. F. (2021). Do cross-language script differences enable bilinguals to function selectively when speaking in one language alone? *Frontiers in Communication*, *6*(June), 668381. https://doi.org/10.3389/fcomm.2021.668381

Hoshino, N., & Kroll, J. F. (2008). Cognate effects in picture naming: Does cross-language activation survive a change of script? *Cognition*, *106*(1), 501–511.

Hoshino, N., & Thierry, G. (2011). Language selection in bilingual word production: Electrophysiological evidence for cross-language competition. *Brain Research*, *1371*, 100–109. https://doi.org/10.1016/j.brainres.2010.11.053

Humphreys, G. W., Riddoch, M. J., & Quinlan, P. T. (1988). Cascade processes in picture identification. *Cognitive Neuropsychology*, *5*(1), 67–104. https://doi.org/10.1080/02643298808252927

Issa, S. H. M., Awadh, F. H. A., & Ahmed, H. R. (2022). The role of proficiency level in the speed of lexical activation. *Cogent Arts & Humanities*, *9*(1), 1999613.

Juhasz, B. J. (2005). Age-of-Acquisition Effects in Word and Picture Identification. In *Psychological Bulletin* (Vol. 131, Issue 5, pp. 684–712). American Psychological Association. https://doi.org/10.1037/0033-2909.131.5.684

Klaus, J., Lemhöfer, K., & Schriefers, H. (2018). The second language interferes with picture naming in the first language: evidence for L2 activation during L1 production. *Language, Cognition and Neuroscience*, *33*(7), 867–877. https://doi.org/10.1080/23273798.2018.1430837

Kroll, J. F., & Bialystok, E. (2013). Understanding the consequences of bilingualism for language processing and cognition. *Journal of Cognitive Psychology*, *25*(5), 497–514. https://doi.org/10.1080/20445911.2013.799170

Kroll, J. F., Bobb, S. C., Misra, M., & Guo, T. (2008). Language selection in bilingual speech: Evidence for inhibitory processes. *Acta Psychologica*, *128*(3), 416–430.

Kroll, J. F., Bobb, S. C., & Wodniecka, Z. (2006). Language selectivity is the exception, not the rule: Arguments against a fixed locus of language selection in bilingual speech. *Bilingualism: Language and Cognition*, *9*, 119–135. https://doi.org/10.1017/S1366728906002483

Kroll, J. F., Dussias, P. E., Bogulski, C. A., & Kroff, J. R. V. (2012). Juggling two languages in one mind: What bilinguals tell us about language processing and its consequences for cognition. In *Psychology of learning and motivation* (Vol. 56, pp. 229–262). Elsevier.

Kroll, J. F., & Stewart, E. (1994). Category interference in translation and picture naming: Evidence for asymmetric connections between bilingual memory representations. *Journal of Memory and Language*, *33*(2), 149–174.

Kroll, J. F., Van Hell, J. G., Tokowicz, N., & Green, D. W. (2010). The Revised Hierarchical Model: A critical review and assessment. *Bilingualism: Language and Cognition*, *13*(3), 373–381. https://doi.org/10.1017/S136672891000009X

La Heij, W. (2005). Selection Processes in Monolingual and Bilingual Lexical Access. In *Handbook of bilingualism: Psycholinguistic approaches.* (pp. 289–307). Oxford University Press.

Lee, M.-W., & Williams, J. N. (2001). Lexical access in spoken word production by bilinguals: Evidence from the semantic competitor priming paradigm. *Bilingualism: Language and Cognition*, *4*(3), 233–248.

Lemhöfer, K., & Broersma, M. (2012). Introducing LexTALE: A quick and valid lexical test for advanced learners of English. *Behavior Research Methods*, *44*(2), 325–343. https://doi.org/10.3758/s13428-011-0146-0

Lenth, R. (2024). *emmeans: Estimated marginal means, aka least-squares means. R package version 1.10. 5-0900003*.

Levelt, W. J. M., Roelofs, A., & Meyer, A. S. (1999). A theory of lexical access in speech production. *The Behavioral and Brain Sciences*, *22*(1), 1–75. https://doi.org/10.1017/s0140525x99001776

Linck, J. A., Schwieter, J. W., & Sunderman, G. (2012). Inhibitory control predicts language switching performance in trilingual speech production. In *Bilingualism: Language and Cognition* (Vol. 15, pp. 651–662). Cambridge University Press. https://doi.org/10.1017/S136672891100054X

Liu, H., Fan, N., Rossi, S., Yao, P., & Chen, B. (2016). The effect of cognitive flexibility on task switching and language switching. *International Journal of Bilingualism*, *20*(5), 563–579. https://doi.org/10.1177/1367006915572400

Liu, Y., Hao, M., Li, P., & Shu, H. (2011). Timed picture naming norms for Mandarin Chinese. *PLoS ONE*, *6*(1). https://doi.org/10.1371/journal.pone.0016505

Luk, G., & Bialystok, E. (2013). Bilingualism is not a categorical variable. *Cognitive Psychology*, *25*(5), 605–621. https://doi.org/10.1080/20445911.2013.795574.Bilingualism

Luk, G., De Sa, E., & Bialystok, E. (2011). Is there a relation between onset age of bilingualism and enhancement of cognitive control? *Bilingualism: Language and Cognition*, *14*(4), 588–595.

Lupker, S. J. (1979). The semantic nature of response competition in the picture-word interference task. *Memory & Cognition*, *7*(6), 485–495.

Marian, V., Blumenfeld, H. K., Mizrahi, E., Kania, U., & Cordes, A.-K. (2013). Multilingual Stroop performance: Effects of trilingualism and proficiency on inhibitory control. *International Journal of Multilingualism*, *10*(1), 82–104.

Martein, R. (1995). Norms for name and concept agreement, familiarity, visual complexity and image agreement on a set of 216 pictures. *Psychologica Belgica*, *35*(4), 205–225.

Martin-Rhee, M. M., & Bialystok, E. (2008). The development of two types of inhibitory control in monolingual and bilingual children. *Bilingualism*, *11*(1), 81–93. https://doi.org/10.1017/S1366728907003227

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex “frontal lobe” tasks: A latent variable analysis. *Cognitive Psychology*, *41*(1), 49–100.

Nag-Arulmani, S., Reddy, V., & Buckley, S. (2003). Targeting phonological representations can help in the early stages of reading in a non-dominant language. *Journal of Research in Reading*, *26*(1), 49–68.

Nasreddine, Z. S., Phillips, N. A., Bédirian, V., Charbonneau, S., Whitehead, V., Collin, I., Cummings, J. L., & Chertkow, H. (2005). The Montreal Cognitive Assessment, MoCA: A brief screening tool for mild cognitive impairment. *Journal of the American Geriatrics Society*, *53*(4), 695–699. https://doi.org/10.1111/j.1532-5415.2005.53221.x

Navarrete, E., Arcara, G., Mondini, S., & Penolazzi, B. (2019). Italian norms and naming latencies for 357 high quality color images. *PLoS ONE*, *14*(2).

https://doi.org/10.1371/journal.pone.0209524
Navarrete, E., & Costa, A. (2005). Phonological activation of ignored pictures: Further evidence for a cascade model of lexical access. *Journal of Memory and Language*, *53*(3), 359–377.
Nishimoto, T., Miyawaki, K., Ueda, T., Une, Y., & Takahashi, M. (2005). Japanese normative set of 359 pictures. *Behavior Research Methods*, *37*(3), 398–416. https://doi.org/10.3758/bf03192709
Nisi, M., Longoni, A. M., & Snodgrass, J. G. (2000). Misure italiane per l'accordo sul nome, familiarità ed età di acquisizione, per le 260 figure di Snodgrass e Vanderwart (1980). *Giornale Italiano Di Psicologia*, *27*(1), 205–220.
Oh, S., & Yoon, T. (2016). Similarities between Korean and Japanese. *International Journal of Languages, Literature and Linguistics*, *2*(1), 5–9.
Paap, K. R., & Greenberg, Z. I. (2013). There is no coherent evidence for a bilingual advantage in executive processing. *Cognitive Psychology*, *66*(2), 232–258.
Paap, K. R., Johnson, H. A., & Sawi, O. (2015). Bilingual advantages in executive functioning either do not exist or are restricted to very specific and undetermined circumstances. *Cortex*, *69*, 265–278.
Paap, K. R., & Sawi, O. (2014). Bilingual advantages in executive functioning: problems in convergent validity, discriminant validity, and the identification of the theoretical constructs. *Frontiers in Psychology*, *5*, 962.
Pae, H. K. (2018). Written languages, East-Asian scripts, and cross-linguistic influences. *Pae, HK (a Cura Di), Writing Systems, Reading Processes and Cross-Linguistic Influences. Reflections from the Chinese, Japanese and Korean Languages*, 1–22.
Peirce, J. W. (2009). Generating stimuli for neuroscience using PsychoPy. *Frontiers in Neuroinformatics*, *2*, 343.
Peleg, O., Degani, T., Raziq, M., & Taha, N. (2020). Cross-lingual phonological effects in different-script bilingual visual-word recognition. *Second Language Research*, *36*(4), 653–690.
Philipp, A. M., Gade, M., & Koch, I. (2007). Inhibitory processes in language switching: Evidence from switching language-defined response sets. *European Journal of Cognitive Psychology*, *19*(3), 395–416.
Pind, J., & Tryggvadóttir, H. B. (2002). Determinants of picture naming times in Icelandic. *Scandinavian Journal of Psychology*, *43*(3), 221–226.
Pompéia, S., Miranda, M. C., & Bueno, O. F. A. (2001). A set of 400 pictures standardised for Portuguese: norms for name agreement, familiarity and visual complexity for children and adults. *Arquivos de Neuro-Psiquiatria*, *59*, 330–337.
Prarthana, S. (2015). *Mental lexicon of nouns and verbs in adult speakers of Kannada*.
Primativo, S., Rinaldi, P., O'Brien, S., Paizi, D., Arduino, L. S., & Burani, C. (2013). Bilingual vocabulary size and lexical reading in Italian. *Acta Psychologica*, *144*(3), 554–562. https://doi.org/10.1016/j.actpsy.2013.09.011
Prior, A., & Gollan, T. H. (2011). Good language-switchers are good task-switchers: Evidence from Spanish–English and Mandarin–English bilinguals. *Journal of the International Neuropsychological Society*, *17*(4), 682–691.
Prior, A., & MacWhinney, B. (2010). A bilingual advantage in task switching. *Bilingualism: Language and Cognition*, *13*, 253–262.

https://doi.org/10.1017/S1366728909990526
Protopapas, A. (2007). Check Vocal: A program to facilitate checking the accuracy and response time of vocal responses from DMDX. *Behavior Research Methods*, *39*(4), 859–862.
Raman, I., Raman, E., & Mertan, B. (2014). A standardized set of 260 pictures for Turkish: Norms of name and image agreement, age of acquisition, visual complexity, and conceptual familiarity. *Behavior Research Methods*, *46*(2), 588–595. https://doi.org/10.3758/s13428-013-0376-4
Ramanujan, K., & Weekes, B. S. (2020). Predictors of lexical retrieval in Hindi–English bilingual speakers. *Bilingualism: Language and Cognition*, *23*(2), 265–273.
Ranganatha, M. R. (1982). Morphophonemic analysis of the Kannada language: Relative frequency of phonemes and morphemes in Kannada. *(No Title)*.
Roberts, L., & Meyer, A. S. (2012). Individual differences in second language learning: Introduction. *Language Learning*, *62*(Supplement S2), 1–4.
Rodriguez-Fornells, A., De Diego Balaguer, R., & Münte, T. F. (2006). Executive control in bilingual language processing. *Language Learning*, *56*(SUPPL. 1), 133–190. https://doi.org/10.1111/j.1467-9922.2006.00359.x
Roelofs, A. (2018). A unified computational account of cumulative semantic, semantic blocking, and semantic distractor effects in picture naming. *Cognition*, *172*, 59–72.
Roelofs, A., Piai, V., & Rodriguez, G. G. (2011). Attentional inhibition in bilingual naming performance: evidence from delta-plot analyses. *Frontiers in Psychology*, *2*, 184.
Rosinski, R. R., Golinkoff, R. M., & Kukish, K. S. (1975). Automatic semantic processing in a picture-word interference task. *Child Development*, 247–253.
Rossion, B., & Pourtois, G. (2004). Revisiting Snodgrass and Vanderwart's object pictorial set: The role of surface detail in basic-level object recognition. *Perception*, *33*(2), 217–236. https://doi.org/10.1068/p5117
Sanfeliu, M. C., & Fernandez, A. (1996). A set of 254 Snodgrass-Vanderwart pictures standardized for Spanish: Norms for name agreement, image agreement, familiarity, and visual complexity. *Behavior Research Methods, Instruments, and Computers*, *28*(4), 537–555. https://doi.org/10.3758/bf03200541
Schriefers, H., Meyer, A. S., & Levelt, W. J. M. (1990). Exploring the time course of lexical access in language production: Picture-word interference studies. *Journal of Memory and Language*, *29*(1), 86–102.
Shannon, C. E. (1948). A Mathematical Theory of Communication. *Bell System Technical Journal*, *27*(4), 623–656. https://doi.org/10.1002/j.1538-7305.1948.tb00917.x
Shell, A. R., Linck, J. A., & Slevc, L. R. (2015). Examining the role of inhibitory control in bilingual language switching. *Proceedings of the 37th Annual Conference of the Cognitive Science Society*, 2146–2151.
Simon, J. R., & Rudell, A. P. (1967). Auditory SR compatibility: the effect of an irrelevant cue on information processing. *Journal of Applied Psychology*, *51*(3), 300.
Singh, N., & Mishra, R. K. (2013). Second language proficiency modulates conflict-monitoring in an oculomotor Stroop task: Evidence from Hindi-English

bilinguals. *Frontiers in Psychology, 4*, 322.
Sirois, M., Kremin, H., & Cohen, H. (2006). Picture-naming norms for Canadian French: Name agreement, familiarity, visual complexity, and age of acquisition. *Behavior Research Methods, 38*(2), 300–306. https://doi.org/10.3758/BF03192781
Snodgrass, J. G., & Vanderwart, M. (1980). A Standardized Set of 260 Pictures: Norms for Name Agreement, Image Agreement, Familiarity, and Visual Complexity. In *Journal of Experimental Psychology: Human Learning and Memory* (Vol. 6, Issue 2).
Snodgrass, J. G., & Yuditsky, T. (1996). Naming times for the Snodgrass and Vanderwart pictures. In *Behavior Research Methods. Instruments. & Computers* (Vol. 28, Issue 4).
Spalek, K., Hoshino, N., Wu, Y. J., Damian, M., & Thierry, G. (2014). Speaking two languages at once: Unconscious native word form access in second language production. In *Cognition* (Vol. 133, pp. 226–231). Elsevier Science. https://doi.org/10.1016/j.cognition.2014.06.016
Steever, S. B. (2015). Gondi. In *The Dravidian languages* (pp. 288–316). Routledge.
Stocco, A., Yamasaki, B., Natalenko, R., & Prat, C. S. (2014). Bilingual brain training: A neurobiological framework of how bilingual experience improves executive function. *International Journal of Bilingualism*, *18*(1), 67–92.
Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology*, *18*(6), 643.
Sudarshan, A., & Baum, S. R. (2019). Bilingual lexical access: A dynamic operation modulated by word-status and individual differences in inhibitory control. *Bilingualism: Language and Cognition*, *22*(3), 537–554. https://doi.org/10.1017/S1366728918000111
Székely, A., D'amico, S., Devescovi, A., Federmeier, K., Herron, D., Iyer, G., Jacobsen, T., & Bates, E. (2003). Timed picture naming: Extended norms and validation against previous studies. *Behavior Research Methods, Instruments, & Computers*, *35*(4), 621–633.
Thierry, G., & Wu, Y. J. (2007). Brain potentials reveal unconscious translation during foreign-language comprehension. *Proceedings of the National Academy of Sciences*, *104*(30), 12530–12535.
Timmer, K., Christoffels, I. K., & Costa, A. (2019). On the flexibility of bilingual language control: The effect of language context. *Bilingualism*, *22*(3), 555–568. https://doi.org/10.1017/S1366728918000329
Tsaparina, D., Bonin, P., & Méot, A. (2011). Russian norms for name agreement, image agreement for the colorized version of the Snodgrass and Vanderwart pictures and age of acquisition, conceptual familiarity, and imageability scores for modal object names. *Behavior Research Methods*, *43*(4), 1085–1099. https://doi.org/10.3758/s13428-011-0121-9
Van der Wouden, T. (1990). Celex: Building a multifunctional polytheoretical lexical data base. *Proceedings of BudaLex, 88*, 363–373.
Van Hell, J. G., & Tanner, D. (2012). Second Language Proficiency and Cross-Language Lexical Activation. *Language Learning*, *62*(SUPPL. 2), 148–171. https://doi.org/10.1111/j.1467-9922.2012.00710.x
Verhoef, K., Roelofs, A., & Chwilla, D. J. (2009). Role of inhibition in language

switching: Evidence from event-related brain potentials in overt picture naming. *Cognition*, *110*(1), 84–99.

Vigliocco, G., Vinson, D. P., Lewis, W., & Garrett, M. F. (2004). Representing the meanings of object and action words: The featural and unitary semantic space hypothesis. *Cognitive Psychology*, *48*(4), 422–488.

Weekes, B. S., Shu, H., Hao, M., Liu, Y., & Tan, L. H. (2007). Predictors of timed picture naming in Chinese. *Behavior Research Methods*, *39*(2), 335–342. https://doi.org/10.3758/BF03193165

Wu, Y. J., Cristino, F., Leek, C., & Thierry, G. (2013). Non-selective lexical access in bilinguals is spontaneous and independent of input monitoring: Evidence from eye tracking. *Cognition*, *129*(2), 418–425.

Xavier Alario, F.-, Segui, J., & Ferrand, L. (2000). Semantic and associative priming in picture naming. *The Quarterly Journal of Experimental Psychology: Section A*, *53*(3), 741–764.

Yoon, C., Feinberg, F., Luo, T., Hedden, T., Gutchess, A. H., Chen, H.-Y. M., Mikels, J. A., Jiao, S., & Park, D. C. (2004). A cross-culturally standardized set of pictures for younger and older adults: American and Chinese norms for name agreement, concept agreement, and familiarity. *Behavior Research Methods, Instruments, & Computers*, *36*(4), 639–649.

Zeng, Z., Kalashnikova, M., & Antoniou, M. (2019). Integrating bilingualism, verbal fluency, and executive functioning across the lifespan. *Journal of Cognition and Development*, *20*(5), 656–679.

Zhang, Q., & Yang, Y. (2003). The determiners of picture-naming latency. *Acta Psychologica Sinica*, *35*(04), 447–454.

Zhou, H., Chen, B., Yang, M., & Dunlap, S. (2010). Language nonselective access to phonological representations: Evidence from Chinese–English bilinguals. *Quarterly Journal of Experimental Psychology*, *63*(10), 2051–2066.

Zied, K. M., Phillipe, A., Karine, P., Valerie, H.-T., Ghislaine, A., & Arnaud, R. (2004). Bilingualism and adult differences in inhibitory mechanisms: Evidence from a bilingual Stroop task. *Brain and Cognition*, *54*(3), 254–256.

# 7 Appendices

### Appendix A – Montreal Cognitive Assessment (MoCA)

## Appendix B –Modified Language Proficiency Questionnaire (MLPQ)

**MODIFIED LANGUAGE PROFICIENCY QUESTIONNAIRE**

**Developed by Yathiraj A., Jain S.N., and Amruthavarshini B. (2018)**

Name: Age:

Gender: Male / Female Education:

Occupation:

***Instructions:*** Please read the below given information carefully and choose the most appropriate choice. Respond to all eight points by either filling in blanks or ticking (✓) the most appropriate response. (***Note**:* L1 refers to the first language that you learnt; L2 refers to the second language that you learnt; L3 refers to the third language that you learnt)

****

1. Name all the languages you have learnt since your childhood in the order of acquisition of the language.

| **Order of Languages acquired** | **Language Name** |
|---|---|
| L1 | |
| L2 | |
| L3 | |

2. Since when have you been using your L1, L2 and L3 for understanding, speaking, reading and writing? *(**Note**. Please tick (✓) one duration per language for understanding, speaking, reading, & writing)*

| **Duration in years** | **Understanding** | | | **Speaking** | | | **Reading** | | | **Writing** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **L1** | **L2** | **L3** | **L1** | **L2** | **L3** | **L1** | **L2** | **L3** | **L1** | **L2** | **L3** |
| Less than 5 years | | | | | | | | | | | | |
| 5 to 10 years | | | | | | | | | | | | |
| 10.1 to 15 years | | | | | | | | | | | | |
| Greater than 15 years | | | | | | | | | | | | |

3. How would you mark your level of proficiency for understanding, speaking, reading, and writing? *(**Note**. Please tick (✓) one level proficiency per language for understanding, speaking, reading, & writing)*

| **Level of Proficiency** | **Understanding** | | | **Speaking** | | | **Reading** | | | **Writing** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **L1** | **L2** | **L3** | **L1** | **L2** | **L3** | **L1** | **L2** | **L3** | **L1** | **L2** | **L3** |
| Low proficiency | | | | | | | | | | | | |
| Fair proficiency | | | | | | | | | | | | |
| Good proficiency | | | | | | | | | | | | |
| Native like/perfect proficiency | | | | | | | | | | | | |

4. How would you rate your ability to switch between the languages? *(**Note**. Please tick (✓) one of the ratings)*

| **Rating Scale** | **Response (✓)** |
|---|---|
| Low Ability | |
| Fair Ability | |
| Good Ability | |
| Perfect Ability | |

5. Please tick (✓) which language you use maximum for the below mentioned situations: *(**Note**. Please tick (✓) one language per situation)*

| **Sl. No.** | **Situations** | **L1** | **L2** | **L3** |
|---|---|---|---|---|
| a | Interaction with family | | | |
| b | Education/ work | | | |
| c | Listening to instruction tapes at school | | | |
| d | Text books | | | |
| e | Dictionary | | | |
| f | Story books | | | |
| g | Newspapers | | | |
| h | Internet source | | | |
| i | Writing | | | |
| j | Interacting with friends | | | |
| k | Interacting with neighbours | | | |
| l | Watching TV/ YouTube | | | |
| m | Listening to the radio (music) | | | |
| n | Market places | | | |

6. On a scale of one to four, how often do you use the languages known to you in the following situations? *(Rating key: 1 = never; 2 = Sometimes; 3 = Most of the time; 4 = Always;* ***Note****. Please write the numbers 1, 2, 3, or 4, for each situation per language).*

| Sl. No. | Situations | L1 | L2 | L3 |
|---|---|---|---|---|
| A | Interaction with family | | | |
| B | Schooling/ work | | | |
| C | Listening to instruction tapes at school | | | |
| D | Text books | | | |
| E | Dictionary | | | |
| F | Story books | | | |
| G | Newspapers | | | |
| H | Internet source | | | |
| I | Writing | | | |
| J | Interacting with friends | | | |
| K | Interacting with neighbours | | | |
| L | Watching television/ YouTube | | | |
| M | Listening to the radio (music) | | | |
| N | Market places | | | |

7. How frequently do others identify you as a native speaker based on your accent or pronunciation in the language? *(****Note****. Please tick (✓) one rating per language)*

| Rating Scale | L1 | L2 | L3 |
|---|---|---|---|
| Never | | | |
| Sometimes | | | |
| Most of the time | | | |
| Always | | | |

8. For how many hours do you use the following languages? *(****Note****. Please tick (✓) one duration per language)*

| Duration | L1 | L2 | L3 |
|---|---|---|---|
| Greater than 2 hours | | | |
| Greater than 3 hours | | | |
| Greater than 4 hours | | | |
| Greater than 5 hours | | | |

***Note: Refer Scoring key for analysis***

**Appendix C – Normative data for rated psycholinguistic variables and confrontation naming can be found here** Appendix

## Appendix D – Bilingual Dominance Scale Questionnaire

**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 E – Target distractor word list of PWI paradigms

| Monolingual Kannada Paradigm | | | | |
|---|---|---|---|---|
| Kannada Target | kannada IPA transcription | Kannada Semantic | Kannada Unrelated | Kannada Phono-Translation |
| ರೈಲು | ra͜ɪl̥u | vɪmaːna | nakʃat̪ra | ţagarʊ |
| ಬೆಕ್ಕು | bekku | nayi | baːn̥a | kɛnɛ |
| ಹಸು | hasʊ | kʊrɪ | d̪ɪmbʊ | kal̂ʊ |
| ಕುದುರೆ | kʊd̪urɛ | d͡ʒɪnkɛ | mɛn̥asʊ | haːl̥ʊ |
| ಮೊಸಳೆ | mɔsal̥ɛ | kap̂ɛ | nɪl̥d̪aːn̥a | krɔːd̪ha |
| ಚಿರತೆ | t͡ʃɪrat̪ɛ | narɪ | t͡ʃɪːl̥a | l̥ɛk̂a |
| ಸಿಂಹ | sɪmha | hʊl̥ɪ | mɔːḍa | l̥ʌŋa |
| ಚಿಟ್ಟೆ | t͡ʃɪt̂ɛ | kaːgɛ | aːspat̪rɛ | banḍɛ |
| ಹದ್ದು | had̪̂ʊ | gɪn̥ɪ | nad̪ɪ | ɨːd͡ʒʊ |
| ಮೊಲ | mɔla | karaḍɪ | pɪtɪːl̥ʊ | raːkʃʌsa |
| ಸೇಬು | sæːbʊ | d̪aːl̥ɪmbɛ | hat̪̂ɪ | aːmɛ |
| ಅನಾನಸ್ | anaːnʌs | kɪt̪al̥ɛ | t͡ʃʌkra | pa͜ɪrʊ |
| ಘಂಟೆ | ghanţɛ | d̪ɛːvasţaːna | mara | ben̥̂ɛ |
| ಕುರ್ಚಿ | kʊrt͡ʃɪ | mant͡ʃa | t̪ɪmɪŋal̥a | t͡ʃæːl̥ʊ |
| ಬಾಚಣಿಗೆ | baːt͡ʃʌn̥ɪgɛ | kan̂aḍɪ | d̪ɔːn̥ɪ | kʊţʊmba |
| ಮನೆ | manɛ | kɪţakɪ | mʊt̪̂ʊ | han̥ɛ |
| ಬೀಗದ ಕೈ | bɪːgad̪ak͜aɪ | vaːhʌna | kɔl̥al̥ʊ | kɨrɪːţa |
| ಕೈಗಡಿಯಾರ | ka͜ɪgaḍɪɟaːra | d̪ʊːrad̪arʃana | maːt̪rɛ | vaːkɟa |
| ಚಮಚ | t͡ʃamat͡ʃa | l̥ɔːţa | mʊːl̥ɛ | sparʃa |
| ಬೀಗ | bɨːga | baːgɪl̥ʊ | ʊŋʊra | l̥aːga |
| ಕಿವಿ | kɪvɪ | hʊb̂ʊ | bɛːl̥ɪ | irʊvɛ |
| ಕಣ್ಣು | kan̥̂ʊ | kʊːd̪al̥ʊ | d͡ʒæːnʊ | a͜ɪd̪ʊ |
| ಕಾಲು | kaːl̥ʊ | hɒţ̂ɛ | man̥̂ʊ | l̥ækhanɪ |
| ಮೂಗು | mʊːgʊ | ţʊţɪ | t̪ʌnt̪ɪ | nɔrɛ |
| ಕೊಡಲಿ | kɔḍal̥ɪ | garagasa | t̪aːl̥a | aːkaːʃa |
| ಬಂದೂಕು | band̪ʊːkʊ | t͡ʃaːkʊ | ʊp̂ʊ | gaḍ̂a |
| ಸುತ್ತಿಗೆ | sʊt̪̂ɪgɛ | t̪ak̂aḍɪ | nɪmbɛ | haval̥a |
| ಮೊಳೆ | mɔl̥ɛ | kaţ̂arɪ | gaːl̥ɪ | nɛral̥ʊ |
| ಕುಂಬಳಕಾಯಿ | kʊmbal̥akaːɟɪ | bɛl̂ʊl̂ɪ | ak̂ɪ | parad̪ɛ |
| ಜೋಳ | d͡ʒɔːl̥a | ɨːrʊl̂ɪ | ʊɟ̂aːl̥ɛ | kaːgɛ |
| ಅಣಬೆ | an̥abɛ | ʃʊnţɪ | haĝa | maral̥ʊ |
| ಕಡಲೆಕಾಯಿ | kaḍal̥ɛkaːɟɪ | sak̂arɛ | mʊl̂ʊ | pɪːţʌh |

| Monolingual English Paradigm | | | |
|---|---|---|---|
| **English Target** | **English Semantic** | **English Unrelated** | **English Phono-Translation** |
| train | aeroplane | star | rider |
| cat | dog | arrow | belt |
| cow | sheep | pillow | hump |
| horse | deer | pepper | cooker |
| crocodile | frog | station | mosaic |
| leopard | fox | bag | chin |
| lion | tiger | cloud | signal |
| butterfly | crow | hospital | chimney |
| eagle | parrot | river | hunger |
| rabbit | bear | violin | moped |
| apple | pomogranate | cotton | sailor |
| pineapple | orange | wheel | animal |
| bell | temple | tree | gunman |
| chair | bed | whale | cooler |
| comb | mirror | boat | bathroom |
| house | window | pearl | monkey |
| key | vehicle | flute | beak |
| watch | television | tablet | kite |
| spoon | glass | bone | chunk |
| lock | door | ring | beer |
| ear | eyebrow | fence | king |
| eye | hair | honey | cover |
| leg | stomach | soil | corner |
| nose | lip | wire | moon |
| axe | saw | rhythm | court |
| gun | knife | salt | bundle |
| hammer | scale | lemon | soup |
| nail | scissors | air | mobile |
| pumpkin | garlic | rice | coupon |
| corn | onion | swing | joker |
| mushroom | ginger | rope | under |
| peanut | sugar | thorn | colour |

| Bilingual Kannada English Paradigm | | | | |
|---|---|---|---|---|
| Kannada Target | Kannada Target IPA transcription | English Semantic distractors | English Unrelated distractors | English Phono-Translation |
| ರೈಲು | raɪ͜lu | aeroplane | star | trial |
| ಬೆಕ್ಕು | bekku | dog | arrow | camp |
| ಹಸು | hasʊ | sheep | pillow | curve |
| ಕುದುರೆ | kʊd̪urɛ | deer | pepper | hot |
| ಮೊಸಳೆ | mɔsaḷɛ | frog | station | cross |
| ಚಿರತೆ | t͡ʃɪrat̪ɛ | fox | bag | level |
| ಸಿಂಹ | sɪmha | tiger | cloud | light |
| ಚಿಟ್ಟೆ | t͡ʃɪt̂ɛ | crow | hospital | bubble |
| ಹದ್ದು | had̪̂ʊ | parrot | river | eat |
| ಮೊಲ | mɔla | bear | violin | rubber |
| ಸೇಬು | sæ:bʊ | pomogranate | cotton | ankle |
| ಅನಾನಸ್ | ana:nʌs | orange | wheel | pilot |
| ಘಂಟೆ | ghanṭɛ | temple | tree | bench |
| ಕುರ್ಚಿ | kʊrt͡ʃɪ | bed | whale | chest |
| ಬಾಚಣಿಗೆ | ba:t͡ʃʌṇɪgɛ | mirror | boat | cool |
| ಮನೆ | manɛ | window | pearl | hunt |
| ಬೀಗದ ಕೈ | bɪ:gad̪ak͜aɪ | vehicle | flute | kitten |
| ಕೈಗಡಿಯಾರ | k͜aɪgaḍɪʝa:ra | television | tablet | wall |
| ಚಮಚ | t͡ʃamat͡ʃa | glass | bone | spot |
| ಬೀಗ | bɨ:ga | door | ring | lord |
| ಕಿವಿ | kɪvɪ | eyebrow | fence | ink |
| ಕಣ್ಣು | kaṇ̂ʊ | hair | honey | island |
| ಕಾಲು | ka:ḷʊ | stomach | soil | left |
| ಮೂಗು | mʊ:gʊ | lip | wire | note |
| ಕೊಡಲಿ | kɔḍalɪ | saw | rhythm | accident |
| ಬಂದೂಕು | band̪ʊ:kʊ | knife | salt | goat |
| ಸುತ್ತಿಗೆ | sʊt̪̂ɪgɛ | scale | lemon | heart |
| ಮೊಳೆ | mɔḷɛ | scissors | air | neck |
| ಕುಂಬಳಕಾಯಿ | kʊmbaḷaka:ʝɪ | garlic | rice | punch |
| ಜೋಳ | d͡ʒɔ:ḷa | onion | swing | coin |
| ಅಣಬೆ | aṇabɛ | ginger | rope | muscle |
| ಕಡಲೆಕಾಯಿ | kaḍaḷɛka:ʝɪ | sugar | thorn | peach |

| Bilingual English Kannada Paradigm | | | |
|---|---|---|---|
| English Target | Kannada Semantic distractor | Kannada Unrelated Distractor | Kannada Phono-Translation |
| train | vɪmaːna | nakʃat̪ra | rai͜t̪ʌ |
| cat | nayi | baːṇa | beṅki |
| cow | kʊrɪ | d̪ɪmbʊ | hat̪ʊ |
| horse | d͡ʒɪnkɛ | mɛṇasʊ | kusit̪a |
| crocodile | kap̂ɛ | nɪl̪d̪aːṇa | moṇakai͜ |
| leopard | narɪ | t͡ʃɪːl̪a | t͡ʃiɦ̂a |
| lion | hʊl̪ɪ | mɔːḍa | sihi |
| butterfly | kaːgɛ | aːspat̪rɛ | t͡ʃinte |
| eagle | gɪṇɪ | nad̪ɪ | haṇa |
| rabbit | karaḍɪ | pɪtɪːl̪ʊ | moːsa |
| apple | d̪aːl̪ɪmbɛ | hat̪̂ɪ | seːt̪ʊve |
| pineapple | kɪt̪al̪ɛ | t͡ʃʌkra | anātha |
| bell | d̪ɛːvast̪aːna | mara | gamana |
| chair | mant͡ʃa | t̪ɪmɪŋal̪a | kuruḍa |
| comb | kaɦ̂aḍɪ | d̪ɔːṇɪ | bālya |
| house | kɪṭakɪ | mʊt̪̂ʊ | mand͡ʒʊ |
| key | vaːhʌna | kɔl̪al̪ʊ | bil̪̂ʊ |
| watch | d̪ʊːrad̪arʃana | maːt̪rɛ | khaidi |
| spoon | l̪ɔːṭa | mʊːl̪ɛ | θʌt̪rɪ |
| lock | baːgɪl̪ʊ | ʊŋʊra | bīru |
| ear | hʊb̂ʊ | bɛːl̪ɪ | kiḍi |
| eye | kʊːd̪al̪ʊ | d͡ʒæːnʊ | kavi |
| leg | hɒṭ̂ɛ | maṇ̂ʊ | kaːḍʊ |
| nose | t̪ʊṭɪ | t̪ʌnt̪ɪ | mūṭe |
| axe | garagasa | t̪aːl̪a | Kōṇa |
| gun | t͡ʃaːkʊ | ʊp̂ʊ | baṇḍi |
| hammer | t̪ak̂aḍɪ | nɪmbɛ | sundara |
| nail | kat̪̂arɪ | gaːl̪ɪ | mot̪̂ɛ |
| pumpkin | bɛl̪̂ʊl̪̂ɪ | ak̂ɪ | kumbāra |
| corn | ɨːrʊl̪̂ɪ | ʊʝ̂aːl̪ɛ | jōḍɪ |
| mushroom | ʃʊnt̪ɪ | haĝa | aṇ̂a |
| peanut | sak̂arɛ | mʊl̪̂ʊ | kasa |