# Influence of interlocutor identity on bilingual language selection - An eye-tracking study

Thesis submitted in partial fulfillment
of the requirements for the degree of

*Master of Science*
*in*
*Neural and Cognitive Sciences*

by

Amit Singh
18MNMS02
amitcogsci@gmail.com

Center for Neural and Cognitive Sciences
School of Medical Sciences
University of Hyderabad
Hyderabad - 500 046, INDIA
June 2020

University of Hyderabad
Hyderabad, India

# CERTIFICATE

This is to certify that the thesis entitled "**Influence of interlocutor identity on bilingual language selection - An eye-tracking study**" submitted by **Amit Singh** bearing Reg. No 18MNMS02 in partial fulfillment of the requirements for the award of Master of Science in Neural and Cognitive Sciences is a bonafide work carried out by him under my supervision and guidance.

The thesis has not been submitted previously in part or in full to this or any other University or Institution for the award of any degree or diploma.

Signature of Student
**Amit Singh**

Signature of Supervisor
**Prof. Ramesh Kumar Mishra**

University of Hyderabad
Hyderabad, India

# DECLARATION

I, Amit Singh, hereby declare that the thesis entitled **"Influence of interlocutor identity on bilingual language selection - An eye-tracking study"** submitted by me under the guidance and supervision of Professor Ramesh Kumar Mishra. Is a bonafide work. I also declare that it has not been submitted previously in part or in full to this University or any other University or Institution for the award of any degree or diploma.

26-06-2020
Date

Signature of the Student

# Acknowledgments

I would like to extend my sincere gratitude to Prof. Ramesh Kumar Mishra for motivating me and shaping my interest in psycholinguistics and research. I want to thank him for allowing me to work under his guidance. I thank him for imparting the knowledge from the broad field of cognitive science and making me understand the essence of interdisciplinarity. The knowledge he imparted was not limited to the research topic but extends to the issues encountered in real life. His teachings will be instrumental to overcome future challenges. I am thankful to him for providing me with a strong foundation in cognitive science. His lectures from Philosophy of Mind helped me to expand my core interest in other domains of cognitive science. I also thank him for giving me the opportunity to meet some excellent researchers in this field.

I want to thank Seema for her consistent guidance and helping me with the experiment design. Without her comments and suggestions, I would not have gained insights into the theoretical issues of the experiment. I thank her for sharing reading suggestions pertinent to the topic and giving comments on the research design. I would also like to thank Vaishnavi for discussing the topic which always helped me to approach the idea from multiple perspectives. I also thank Keerthana for sharing ideas from her past research experience in bilingualism, it helped me to avoid a few mistakes in the design. I thank Ria for helping me with the stimulus creation and implementation. Special thanks to Sneha for clearing my doubt and always sharing insights from an alternate viewpoint.

Finally, I want to thank my family and friends for keeping me motivated throughout the research.

# Abstract

Bilinguals show robust adaptive behavior while selecting a language in a real-world interactional context (Green & Abutalebi, 2013). Both linguistic and non-linguistic (visual) cues subserve proactive language selection in bilinguals. Studies suggest that proficient bilinguals exploit visual cues apart from linguistic information to select target language in a context-dependent manner (Hartsuiker, 2015). Representations associated with interlocutor identity is a salient aspect of language processing in bilinguals (Molnar et al., 2014; Kapiley & Mishra, 2018). These representations are formed as a consequence of continuous interaction and experiential learning. Proficient bilinguals preferably choose a particular language based on the prior knowledge about an interlocutor. This prior knowledge can be cultural aspects associated with a context and interlocutor specific attributes like proficiency. Moreover, the bilingual language choice is not only contingent on the language background of the interlocutor (e.g., whether she/he can speak English or Hindi) but also on the level of proficiency (e.g., she/he can speak English better than Hindi). This thesis investigated whether bilingual adapts to a given context based on prior knowledge about the agent. More specifically, in an eye-tracking study, we examined whether the interlocutor specific attribute like proficiency influences the preferred language activation in high-proficient Hindi-English bilinguals in India. Eye-movement fixation results suggest that bilinguals use background knowledge about an interlocutor's L2 proficiency to activate either L1 (Hindi) or L2 (English) preferably. In other words, the interlocutor's degree of fluency in L2 serves as a cue to guide the language activation in high-proficient bilinguals, and mere awareness of such cues are sufficient to modulate this language activation. Moreover, the study suggests that the linguistic background of the interlocutor serves as a salient cue in guiding language selection to an extent that even in the absence of the addressee the participants tend to look to the blank space where the interlocutor was previously present, suggesting the active role of external environment in bilingual language processing. This effect is verified by the "Blank Screen Paradigm" (Altmann, 2004). In an audio-visual eye-tracking study participant fixation behavior was observed to a spoken word in either English or Hindi only after the familiar interlocutor (high L2 proficient or low L2 proficient) has been removed from the screen. The fixation patterns unveil the preferred tagging of space associated with the language and interlocutor type. The result is consistent with the previous findings in memory and support for the role of the external visual environment in addition to internal linguistic brain representations in modulating language selection (Spivey et al., 2004). The spatial indices to the environment do not only represent perceptual-motor processing but can also account for higher-order cognitive processes like interlocutor awareness in naturalistic conversation.



**Keywords:** *Bilingualism, Awareness, Interlocutor Identity, Language Selection, Blank Screen Paradigm.*

# Contents


Chapter Page

1 Introduction . . . 1
1.1 Bilingual lexical organisation . . . 3
1.1.1 Integrated and Independent lexicon . . . 4
1.2 Bilingual lexical processes . . . 5
1.2.1 Language selective and non-selective processing . . . 5
1.3 Models of bilingual processing . . . 6
1.3.1 Revised Hierarchical Model . . . 7
1.3.2 Bilingual Interactive Activation Model . . . 8
1.3.3 Bilingual Language Interaction Network for Comprehension of Speech 9
1.4 Zooming into the right language . . . 9
1.5 Cues guiding the language selection . . . 11
1.5.1 Linguistic and Non-linguistic cues . . . 11
1.6 Language cues in external environment . . . 12
1.6.1 Interlocutor identity affects language processing . . . 13
1.7 Proposed hypothesis for the current study . . . 13

2 Blank Screen Paradigm . . . 15
2.1 Introduction . . . 15
2.1.1 Blank Screen Paradigm in language processing . . . 16
2.1.2 Extending the idea to externalism . . . 16
2.1.3 External memory in language processing . . . 18

3 Eye-tracking study using blank screen paradigm . . . 20
3.1 Introduction . . . 20
3.2 Method . . . 21
3.2.1 Participants and Stimuli . . . 21
3.2.2 Procedure . . . 23
3.3 Data Analysis and Results . . . 25
3.4 Discussion and Conclusion . . . 27

Bibliography . . . 29

# List of Figures


| Figure | | Page |
|---|---|---|
| 1.1 | Three distinct bilingual representations configurations. (Adapted from Woutersen et al. 1994. Copyright 1994 by Cambridge University Press) . . . . . | 3 |
| 1.2 | The revised hierarchical model. (Adapted from Kroll and Stewart 1994. Copyright 1994 by Elsevier) . . . . . | 7 |
| 1.3 | The bilingual interactive activation(BIA+) model. (Adapted from Dijkstra and van Heuven 2002. Copyright 2002 by Cambridge University Press) . . . . . | 8 |
| 1.4 | The Bilingual Language Interaction Network for Comprehension of Speech (BLINCS). (Adapted from Anthony Shook and Viorica Marian, 2014) . . . . . | 10 |
| 2.1 | The 'Hollywood Squares' experiment", Richardson and Spivey (2000) . . . . . | 17 |
| 3.1 | Familiarised Interlocutors - Left: High L2 Proficient, Right: Low L2 Proficient | 23 |
| 3.2 | Trial Sequence for eye-tracking experiment . . . . . | 25 |
| 3.3 | Model parameter estimation from lmer function R, for conditions a) High-proficient L2; b) Low-proficient L2; c) Neutral Condition . . . . . | 26 |
| 3.4 | Interaction pattern in presence of familiar (left) and neutral interlocutor (right) . | 27 |

*Chapter 1*

# Introduction

People who acquire two or more languages early or later in their life develop multiple language systems in their mind/brain. They effectively use a specific language from this system based on the interactional context and environmental demands. For instance, a Hindi-English bilingual might prominently use Hindi at home and English at work, or chooses a language in a conversation based on familiarity with an interlocutor. Meaning, the language activation is guided by context, language experience and L2 proficiency of the interlocutor. Moreover, when a bilingual see a familiar face they decide which language to use based on their experience with that interlocutor. This process is achieved effortlessly and appears to be automatic in day to day life (Costa, Caramazza, & Sebastián-Gallés, 2000; Van Hell Dijkstra, 2002). How proficient bilinguals activate and select the task appropriate language as soon as they start a conversation or maybe way before speaking? And what are the perceptual and linguistic cues which modulate this language activation? Previous findings suggest that people extract linguistic and visual cues proactively during communication which guides language selection. Contextual information also plays a vital role to facilitate this process e.g., situatedness (Home or Office). To understand this fascinating characteristic of human communication system, it is important to investigate the organisation of the linguistic representations in bilingual mind and the underlying processes which operates on these representations. In bilingualism, the organisation of two languages and its access have been a topic of debate in the literature for a while. So far two different theories for the organisation and access to bilingual lexicons have been proposed; Integrated and Independent / Selective and Non-selective. Different bilingual models are built on

these ideas and capture some of the bilingual processes. Major theories support the integrated and non-selective access to the bilingual lexicon, suggesting that bilinguals simultaneously activate candidates belonging to two different mental lexicons at different hierarchical linguistic levels (Bialystok et al., 2009). An integrated lexicon organisation and non-selective access poses a challenge for the system to appropriately select one language without the interference of other. However, high proficient bilinguals overcome this challenge with ease and efficiently switch between different languages proactively. Such an adaptive behaviour has been highlighted in Adaptive Control Hypothesis (Green & Abutalebi, 2013). It proposes that bilinguals are sensitive to different interactional context (single language, dual-language and dense code-switching) and adapt to the task demands while selecting a language by using linguistic and non-linguistic cues. Furthermore, it has been established that the speaker will choose a particular language not only based upon the suitability to the interlocutor (whether he/she can speak it) but also the language in which the interlocutor is more fluent (e.g. he/she can speak English better than Hindi). The preference of a particular language while interaction is ascertained by past experiences or familiarity with an interlocutor. Meaning, speakers preferably tag a particular language with specific interlocutor (Hartsuiker & Declerk, 2009; Molnar et. al.,2015). A speaker uses all possible cues (linguistic and non-linguistic) present in the environment to achieve the conversational goal in the most parsimonious way. The visual cues are considered as non-linguistic in the sense that it is extrinsic to the internal linguistic system and any changes in it directly affect language processing via visual modality. On the other hand, the language system exploits the language extrinsic information optimally to achieve parsimonious processing. However, most models could not explain how, when and to what degree non-linguistic information (e.g. Interlocutor identity) might modulate activation patterns (Dijkstra, 2005; Dijkstra Van Heuven, 2002; Kroll et. al., 2010). The current study attempted to evaluate the degree to which language extrinsic cues (e.g. Interlocutor identity) are processed in a bilingual context. The study uses visual world eye-tracking to investigates the strength of non-linguistic cues which guides language selection in high proficient bilinguals in presence of interlocutors with different levels of L2 proficiency.

## 1.1 Bilingual lexical organisation

The core mechanism of bilingual lexical activation is not well understood till now. There has been a numerous attempts to investigate and model the organization of bilingual lexicons. One of the bilingual memory models was proposed by Weinreich (1953). This model worked as a foundation for later bilingual lexicon models which were theorised and empirically tested e.g., Revised Hierarchical Model (RHM). The Weinreich (1953) bilingual memory model is a simple yet robust theoretical proposal which is based on the hierarchical levels of linguistic representations. According to this model, the information is organized as hierarchical representations at conceptual and form level. For bilinguals the two possible configurations between meaning and form are compound and coordinate. In compound configuration, the concept is shared between two forms of different languages, and in the coordinate configuration, the two language systems are independent. For example, in compound configuration, the two forms of different language say German (das Buch) and English (Book) are connected to a shared mental lexicon (Buch=Book) whereas in coordinate structure two forms are connected to independent mental lexicons.

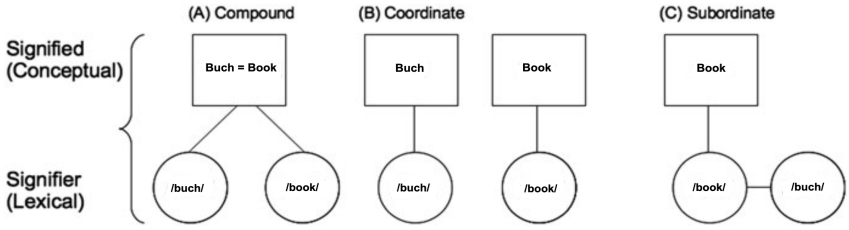


**Figure 1.1** Three distinct bilingual representations configurations. (Adapted from Woutersen et al. 1994. Copyright 1994 by Cambridge University Press)

The subordinate bilingual configuration assumes that a single concept is directly linked to the form of L1 and the second language (L2) is the translation of the L1 word. And during the early phase of L2 learning, the speakers associate every L2 word with the L1 word and the lexical access for L2 takes place via L1 route (Fig. 1.1). These theoretical models lay the foundation for bilingual lexical activation processes like switching, inhibition, or language selection. With

regard to language selection in bilinguals, it is unknown whether at what linguistic level the language switching takes place, conceptual or the form? The dynamic nature of the lexical configuration does not allow these questions to be answered directly. For example, the subordinate bilinguals may achieve a compound configuration with practice (McLaughlin 1990). However, later computational and cognitive models of bilingual memory which were developed based on these initial theoretical assumptions have attempted to understand bilingual organization and processing in more detailed manner.

### 1.1.1 Integrated and Independent lexicon

The majority of the bilingual memory models assume that the lexicons of two languages are integrated, and cross-linguistic activation of multiple candidates takes place via spreading activation. The integrated bilingual memory has an impact on the processing and access of a word from the target language. As a consequence, bilinguals have more candidates to chose from, and these words share conceptual representation and forms, e.g., homographs and homophones. Due to integrated configuration, the access to a lexicon belonging to a particular language requires either selection of target language (e.g., the Cohort and TRACE model) or inhibition of the other language. This organization has been implemented and empirically established in multiple bilingual models like BLINC, RHM, BIA+. It is also found that the selection of a particular language from an integrated lexicon is guided by linguistic and non-linguistic cues. Recent computational models based on connectionism have demonstrated this phenomenon with the network weights associated with the linguistic and non-linguistic nodes at the task schema level, e.g., BIA+. On the other hand, the independent lexicon hypothesis proposes that bilingual memory contains two different language-specific representations and the two systems are modular. According to this assumption, the lexical items are independently organized. Since most empirical studies support the co-activation of lexical candidates from both languages, the independent lexical organization has not been a powerful theory in bilingualism.

## 1.2 Bilingual lexical processes

The issue concerning bilingual processing is the way bilinguals gain access to their language system either from the integrated or independent lexical organization. As already described in the previous section, bilingual memory representations consist of integrated or independent lexicons. During comprehension, as soon as a word is encountered in either language, the bottom up information flows upwards and cognitive process operates on those representations following lexical access takes place. The top-down attentional processes operates at later processing stages to modulate the inhibition or selection. Current theories support the view that during comprehension, the initial graded activation takes place for every lexical candidates for selection, after which the weights of activation is adjusted by the top-down factors. The most activated candidate is selected finally after competing at multiple linguistic levels within and between languages, e.g., morpho-syntactic, phonological, orthographic, or semantics. The lexical processing mechanism needs to select the proper candidate and inhibit the irrelevant neighbors. The more neighborhood candidates are activated after the initial lexical encounter, the more work needs to be done by the top-down signal to select target candidates and inhibit irrelevant neighbors. This cost is reflected in many psycholinguistic tasks and following which it has been found that the consatant selection and inhibition in bilinguals leads to an efficient attentional network as opposed to monolingual of the same age (Bialystok et al., 2009). The processing of the bilingual lexicon follows two pathways either selective or non-selective. The issue is widely debated in the bilingual literature and is centered around two opposing views: a language selective view which assumes that a linguistic input must selectively activate only candidates from the target language; and a non-selective access view which assumes that the linguistic input in one language will activate lexical candidates from both the languages.

### 1.2.1 Language selective and non-selective processing

The selective-processing predicts that the processing happens within a single language system and there is no interference from the other language. Meaning, the two language system

operate modularly in bilinguals. On the other hand, non-selective access is the dominant theory, which predicts that the candidates from both languages will be activated when the linguistic input is encountered. However, the type of processing depends on the nature of the representation and how it is organised. The nature of lexical organization determines which pathway will be followed. For example, if the lexical organization is integrated the selective access cannot take place. And if the lexical candidates are independent then selective access seems a viable process. Few studies show that the two hierarchical representational levels (form and meaning) are organized distinctly. The study shows that forms are stored independently and semantics are shared between languages (see De Groot, 1998; Kroll & De Groot, 1997). Therefore the lexical access process can be distinct based upon the question asked and the representational level at which the study is conducted. Most of the prominent models are built upon the non-selective assumption and the activation pattern seems to be the function of the linguistic and non-linguistic cues provided during processing. The current study also assumes that bilingual processes are non-selective and follows an integrated lexicon configuration whose activation level is modulated by non-linguistic cues in addition to linguistic input.

## 1.3 Models of bilingual processing

In the last decade, the research in the bilingual literature has produced various models of bilingual lexical access. Some of these models have been tested empirically and provided greater insight into the organisation and mental processes of the bilingual lexicon. The language selection process is assumed to be different from the lexical selection. This distinction has been made with regard to the attentional processes which operates on these levels in BIA+ model. For example, BIA+ model implements distinct nodes at two levels for these different processes. Hence, models help in giving an insight about the nature of representations and the processes which run on that particular level. Several models have been developed to account for distinct bilingual processes. To understand the language selection in interactive context, models implementing those functionalities will help in conducting research and framing the hypothesis. Considering the hypothesis proposed in this study, models which implement rep-

resentations and processes at the global language nodes are pertinent. And these theoretical and computational models of bilingual lexical access can further aid the understanding of bilingual processes.

### 1.3.1 Revised Hierarchical Model

One of the prominent descriptive models in bilingual lexical access is the Revised Hierarchical Model (RHM) proposed by Kroll and Sholl (Kroll & Sholl, 1992). The model is based on the translational asymmetries observed in bilinguals. The observation that bilinguals translate from L2-L1 faster than L1- L2 has led to the development of this model. In terms of organisation, the model follows subordinate configuration in which L1 lexicon (first language lexicon) is assumed to have larger vocabulary as opposed to L2 (second language lexicon). The link between the concept and L1 is bidirectional and stronger than the link between L2 and concept which is the result of early L1 exposure as a child. However, when a person learns L2 later in life, the learning takes place via the L1 pathway whereby L1 serves as the basis of L2 acquisition and conceptual access takes place via L1 pathway. Hence, the direct link between L2 and concept is weak which necessitates the conceptual access via already established L1 pathway. However, Kroll and Scholl suggest that the link between L2 form and concept can be strengthened as bilingual become more proficient and fluent in their L2 later in life.

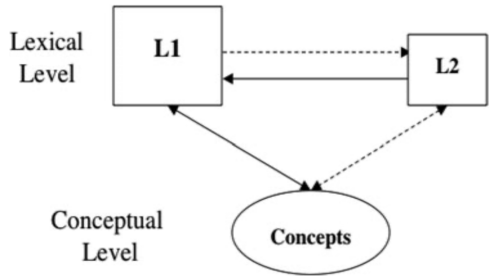


**Figure 1.2** The revised hierarchical model. (Adapted from Kroll and Stewart 1994. Copyright 1994 by Elsevier)

### 1.3.2 Bilingual Interactive Activation Model

Earlier work in the bilingual lexical access proposed that when bilingual use one language other language shuts down. In other words, in given time only one language will be activated and selected. However, many neuroimaging studies and behavioural studies in psycholinguistics have found that bilingual activate both their languages automatically while processing a candiadate from one language. This led to the theory of non-selctive activation in bilingualism and it assumes that both languages are activated during processing. The computational model, Bilingual Interactive Model (BIA, BIA+; see Dijkstra & van Heuven 1998, 2002) follows the non-selective activation. The initial model BIA was designed to account for the orthographic

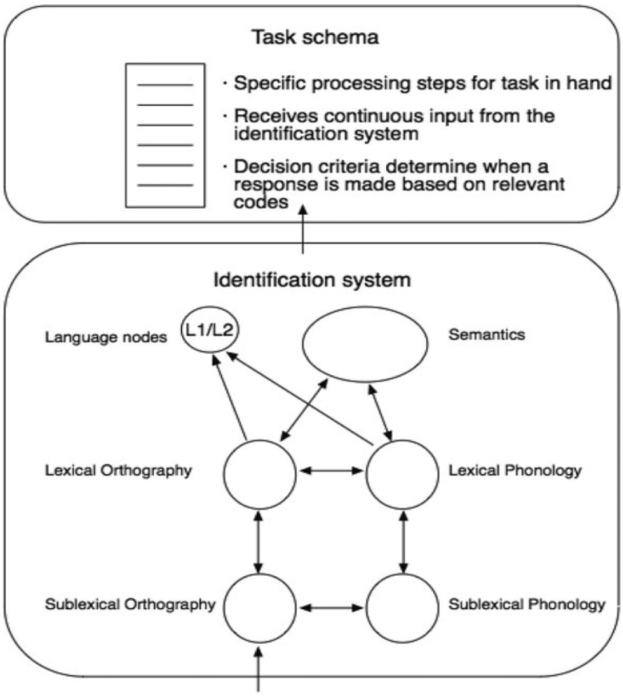


**Figure 1.3** The bilingual interactive activation(BIA+) model. (Adapted from Dijkstra and van Heuven 2002. Copyright 2002 by Cambridge University Press)

processing but later it was extended to phonological processing. When a word is presented to the model the features corresponding to the word are activated in a bottom-up manner, following which the top-down selection of relevant candidates and inhibition of distractors takes

place. During comprehension, the cross-linguistic spreading activation at the orthographic or phonological level takes place initially at the words sharing orthographies and phonemes from both L1 and L2, following which the information flows upward in hierarchical fashion from pre-lexical to lexical and then to conceptual level where the lexical access takes place. The core assumptions of the model is as follows: (1) The nodes are fully connected within the level and between levels. (2) The lexicon is integrated so that there is a formation of a competitive network within a level. (3) There is a language node associated with the lexicons which account for the degree of activation for the two languages and acts as a language filter.
The model suggests that the top-down (language nodes) and bottom-up (featural processing) processes influences word recognition. For the current study, the language node will be a crucial factor to decide the language selection in the interactional context. The crucial question is that, how and at what degree interlocutor identity modulates the weights of language nodes. The task schema embedded in the model is considered to be modulated by the goal which facilitates the language selection.

### 1.3.3 Bilingual Language Interaction Network for Comprehension of Speech

So far we have considered the models in bilingual processing which accounts for only linguistic information. However, it is already established that non-linguistic visual information affects the lexical processing in bilinguals concurrently. To account or these visual cues, the BLINC model integrates the visual module to the semantic at the perceptual level. This connectionist model is based on the competitive neural network model, Self Organising Map. The nodes in this models are fully connected within and between levels. The model does not implement global language identification nodes unlike BIA+ model but it serves as a potential model to give an insight into the organisation of bilingual lexicon.

## 1.4 Zooming into the right language

Given that the bilingual language processing follows the non-selective pathway, restricting the processing to minimum lexical candidates and target language would be very useful

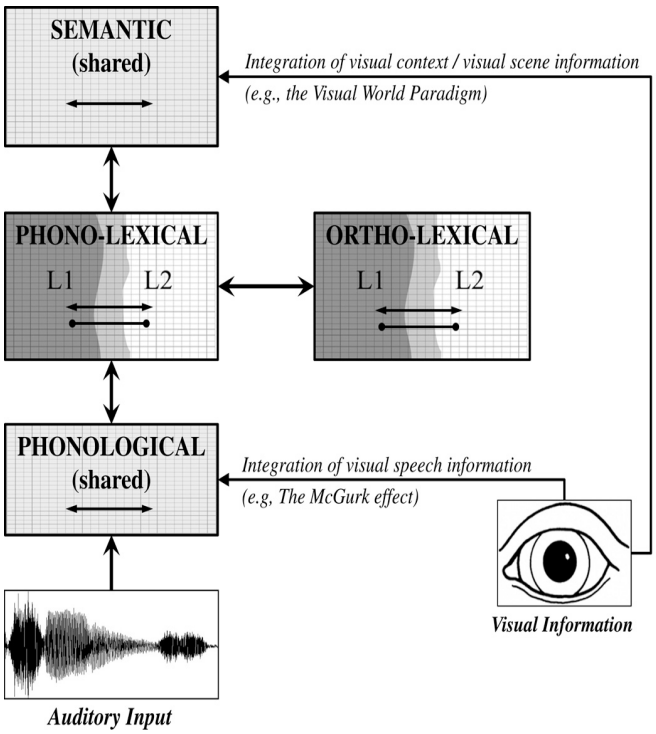


**Figure 1.4** The Bilingual Language Interaction Network for Comprehension of Speech (BLINCS). (Adapted from Anthony Shook and Viorica Marian, 2014)

for the processor. Since several studies have shown that the processor encounters difficulty when identical or similar words are encountered (e.g. cognates and interlingual homophones), restricting the processing to a limited number of neighbours will facilitate processing. For example, a study conducted by Ivanova Costa (Ivanova & Costa, 2008) suggest that monolingual speakers were faster in naming a picture of the common object as opposed to Spanish-Catalan bilinguals. Therefore it is parsimonious for the processor to restrict the processing to a particular language. Now, the central question arises that how bilingual efficiently achieve this in a complex interactional context. As Elston-Güttler, and Gunter & Kotz calls it ”Zooming into the right language” (Elston-Güttler; Gunter & Kotz, 2005) using the available linguistic and non-linguistic cues in a context. The context contains multiple cues which is language-intrinsic (linguistic cues) and language-extrinsic (non-linguistic cues e.g. visual appearance of people). The present study proposes that the language processor is proactively watchful for

both language-intrinsic and language-extrinsic cues in the context and it exploits even the weak cues present in the environment to select the target language.

## 1.5 Cues guiding the language selection

### 1.5.1 Linguistic and Non-linguistic cues

**Linguistic cues:** Linguistic cues affect the strength of language activation within a particular language and allow bilinguals to zoom into the target language. Various studies have highlighted that sentence context provides important cues about the language belonging of upcoming word to reduce the interference from the other language. It has also been shown in spoken word recognition literature that the speech signal contains the language-specific sub-phonemic component which helps to disambiguate the similar words towards the target language (Lagrou, Hartsuiker & Duyck, 2011). These studies suggest that syntactic and phonetic linguistic cues are used to zoom into the correct language associated with the target word. Moreover, a number of visual world studies show that semantic information does help in anticipating the language of the upcoming word. Given that the linguistic cues are strong enough to modulate language selection, the interplay between linguistic and non-linguistic cues in determining the target language needed to be explored more cautiously. These linguistic cues are subserved by visual non-linguistic cues which further facilitates the robust selection of the target language.

**Non-linguistic cues:** A growing body of research suggest that non-linguistic cues like visual information affect language activation (Hartsuiker & Declerck, 2009; Jared et al., 2013; Li et al., 2013; Martin et al., 2011; Zhang et al., 2013). Moreover, these visual cues are directly linked to the linguistic processes since interlocutor identity does modulate language selection. People visual appearance tells us about their cultural identity and the likelihood of the language they are going to use based on the past experience. For example, if you interact with a person daily in English, the mere presence of him/her will automatically lead to the selection of English out of possible languages you know. Moreover, if the person appears to be

Asian, one will probably expect him to use an Asian language. In other words, that features corresponding to a familiar face generate an expectation about the language selection. Several studies have suggested that language associated with a particular face induces the bias towards a certain language (Gollan, Schotter, Gomez, Murillo & Rayner, 2013). In other words, the language associated with a particular face activates that particular language more than the non-target language. This effect is so robust that a short conversation with a person is sufficient to induce this effect (Martin, Vandenbulcke, Navarra, Schoonbaert, Hartsuiker & Costa, 2011). Apart from the faces, which is too salient to bias the language choice, cultural icons can also modulate language selection which suggests that the cultural cues also plays an important role in zooming to the target language. These cues are considered to be language-extrinsic (Green, 1986; Van Heuven, Dijkstra & Grainger, 1998) and directly affect the activation of the global language node which restrict the processing to the target language.

## 1.6 Language cues in external environment

Research suggests that the holistic visual experience is not only achieved with the help of internal representations but the external visual environment also plays a vital role. In the context of language processing, the internal representations are linguistic and external visual experiences are non-linguistic. The external physical environment contains information which can be accessed quickly to update the concurrent information, and influence the agent present in the environment. The visual information combined with the linguistic information serves to disambiguate the ambiguous signal perceptually (e.g. McGurk effect; McGurk & MacDonald, 1976). The visual information are limited in both space and time for the agents at a particular instance. How the synchronicity is achieved between external and internal representation is a core question in language and vision interface since language also unfolds with temporal constraints. To optimally exploit a region in a space the high acuity fovea must be directed towards a location in the space which contains relevant information. In the case of conversational context, the primary external cues are the facial features and interlocutor identity apart from verbal cues associated with lip movements and gestures. And these features guide language selection

from the external environment. How strongly and at what extent these external cues affect the language processing is the question which remains to be addressed.

### 1.6.1 Interlocutor identity affects language processing

In a natural conversational setting, the interlocutors are part of the external environment. The features or identity of interlocutors are said to influence the lexical activation patterns in bilinguals. It can be assumed that the interlocutors are embedded in the external environment and guide our linguistic behaviour. For example, many studies have found that interlocutors identity affects language choice in bilinguals. Moreover, the cultural and ethnic information associated with a particular person helps us to choose the appropriate language. Socio-cultural identity which is a part of overall appearance is also found to modulate the language selection. One study has also investigated that such cues influences other agent's actions on voluntary switching during object naming task (Bhatia, Prasad, Sake, & Mishra, 2017). Moreover, familiarity with the language background of interlocutor modulates the language choice as well.

## 1.7 Proposed hypothesis for the current study

The current study investigates the effect of non-linguistic information on language choice in high proficient Hindi-English bilinguals. Unlike the previous studies which focused on the linguistic tasks (e.g. lexical decision) to observe this phenomenon, the current eye-tracking study taps directly on the selectional mechanism in high proficient bilinguals in an automatic way which generally occurs in the interactional context. Based on the previous idea that speakers choose a language based on the suitability and background knowledge about the interlocutor the study takes a step further to investigate the strength of such non-linguistic external cues. The degree to which the interlocutor identity influences the language choice is remained to be investigated. Which further raises the question whether these external cues are salient enough to induce changes for a long time. Past studies have shown that a short conversation is sufficient to induce language bias based upon the interaction. The present study follows the same path and divides the study into two different phases, familiarity and testing. Two different interlocu-

tors are introduced as high and low L2 proficient speakers (L2 English). It is hypothesised that if this interactional experience is strong enough then it would not only replicate the previous findings and guides eye-movement behaviour based upon the interlocutor identity in presence of the interlocutor but also in absence of it. It is further hypothesised that the cues generated in the external environment in the form of abstract identity remain even after the interlocutor is not present in the space. Because visual processing is limited to space and time even though the bottom-up information is not present in the environment the language processor tries to extract the cues to restrict the activation to a single language, considering that the bilingual activation follows non-selective activation. The blank screen paradigm further extends to the idea that these external representations are not solely retrieved from linguistic system inside rather from directly outside which is automatically extracted as soon as the necessity arises. Moreover, the results extend to an idea of externalist philosophy of mind in which the mental content is not solely defined by the internal neural representations but also by the active role of the external environment (Clark & Chalmers, 1998).

*Chapter 2*

# Blank Screen Paradigm

## 2.1 Introduction

A collection of eye tracking experiments suggests the active role of the external visual environment in linguistic processes and naturalistic conversation. Moreover, in the visual world paradigms, the eye movements are not only depended on the concurrent visual scene but are also depended upon the mental record which is independent of the visual scene still present (Altmann, 2004). Studies suggest that the spatial pattern of absent stimuli can influence eye movement pattern when features associated with it is recalled or imagined (Spivey, Richardson & Fitneva, 2004). For example, Richardson and Spivey (2000) have shown that the eyes will, under certain circumstances, move to where information had previously been introduced. This idea is closely linked to visual imagery as proposed by Neisser (1967), who suggested that imagining activates a ”top-down” process of perceptual representation which influences the eye movement. This is also true for linguistic processes since several studies have observed that same fixation patterns in blank screen paradigm and visual world study in presence and absence of the objects in the scene. It suggests that in visual world paradigm the fixations on visual object which is concurrent to a linguistic expression, might not refer to the actual location of that item within the scene, but the location of that item represented as a mental object in mind.

### 2.1.1 Blank Screen Paradigm in language processing

In the visual world study conducted by Altmann (Altmann, 2004) instead of presenting the visual scene and target word concurrently the visual world items were presented first and then followed by the target sentence. The anticipatory eye movements were consistent with the previous findings of Altman and Kamide (1999) which suggested that anticipatory eye moments to the objects in the scene in presence of linguistic input is independent of the physical presence of the object but it is contingent upon the mental representations of the spatial indexes of the objects in the scene. Moreover, the fixations followed the temporal pattern as the linguistic information unfolds in the absence of the visual stimulus. How the blank screen was able to constrain the fixation? One possibility is that the visual system follows a strict spatial and temporal constraints and very little information are maintained internally when eyes move to different areas on the screen. One prominent theory by Richardson and Spivey (2000) which is based upon the idea of O'Regan (1992) is that the external visual environment itself acts as an external memory which can be accessed using the oculomotor coordinates as pointers towards the cues within the scene (Ballard, Hayhoe, Pook & Rao, 1997). This suggests that the blank screen paradigm is a robust method to evaluate the effect of visual internal and external representations on language. The paradigm is suitable to understand the interplay between the visual representations which are inside the brain and the visual information which is extracted only in the presence of the bottom-up stimulus.

### 2.1.2 Extending the idea to externalism

Now, since it has been established that eye movements that are triggered during linguistic expressions are not contingent on an item being co-present with that expression, understanding these phenomena require the investigation into the memory system. As already suggested by O'Regan (1992) that the external environment acts as a memory system, how and when the information present in this storage is accessed needed to be evaluated. It is further suggested that the visual environment can be treated as a memory database and eye-movements can extract the relevant information from it. Meaning, the eyes can scan through this external memory and

organise high-level cognitive processes. The idea is consistent with the externalist philosophy of mind, in which the mental content is not solely defined by the internal neural representations but also by the active role of the external environment (Clark Chalmers, 1998). And the information from the external environment can be access as quickly as from the internal memory. Recent ideas from externalism argue that the mental experience is constructed through the immediate participatory role of the environment, this is known as active externalism (Clark & Chalmers, 1998). Moreover, O'Regan and Noë (2001) claim that "activity in internal representations does not generate the experience of seeing. The outside world serves as its own, external, representation." The pointers in the external world are the only way to access the external memory and cognitive system uses those labels to access those content. One of the most famous studies called "Hollywood Squares" (Richardson & Spivey, 2000), in which four characters appeared in either of the four quadrants of the screen and recited some arbitrary facts then disappeared. The participants were asked some questions regarding the uttered facts, crucially, participants looked on the quadrant where the character was present previously while producing the information related to that character.

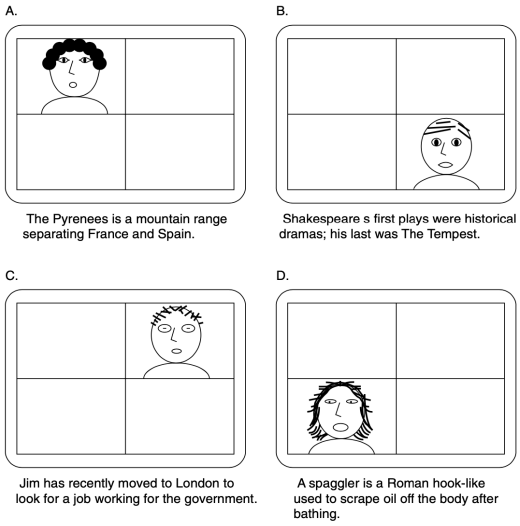


**Figure 2.1** The 'Hollywood Squares' experiment", Richardson and Spivey (2000)

It was argued following the findings that the visual system looks for the deictic pointers in the external environment in absence of the characters because it helps to offload the working memory and the information from the outer world itself acts as the deictic pointers to facilitate recall. Thus, when the label of one of the pointers is called to access the relevant information in a context, the information is extracted from all the possible cues, i.e., external environment, pointer's address in the external environment and from internal working memory. This can also be assumed for linguistic processes since linguistic system also relies heavily on working memory.

### 2.1.3 External memory in language processing

The organisation of sensory input by using space is helpful in language processing as well. As mentioned earlier, space acts as an external memory onto which the information is organised and accessed when required. Moreover, access to information from this external space is considered to be automatic and fast. This property for the memory aligns well with the language processing module in humans because most linguistic phenomena appear to be automatic and fast. The previous study in memory, attention and action suggest that by using the external memory one offloads the working memory, since linguistic processes use working memory as a core cognitive component. Hence, using the external memory simultaneously with internal representation while language processing can have two prominent effects on the overall linguistic processes. (1) Relying partially on external memory will automatise the processing task. (2) The cues present for disambiguation at the perceptual or decisional level will make the linguistic system more efficient. Maintenance of multiple indices in space helps in naturalistic conversation (e.g. Gestures). Also, studies on American Sign Language (ASL) studies suggested that the assigning the particular space for an action verb helps in extracting the meaning at the discourse level. The concept of external memory is exploited mostly in the naturalistic conversational setting. And the language processor uses these indexical cues in the environment to aid the understanding. Moreover, the spatial indexing within the linguistic system is constantly looking for the potential information in the external physical environment

even if the object goes off the environment, and it treats these indexes as a potential source of information. These cues are used as a concurrent source of information while processing as if the object is still there and it is waiting for its content to be addressed. For the present study the interlocutor identity serves as a potential source of similar information and this idea is being investigated in context of bilingual processing.

*Chapter 3*

# Eye-tracking study using blank screen paradigm

## 3.1 Introduction

Non-selective parallel activation of linguistic information has been widely studied in Bilingualism. And this activation pattern is found in both directions from L2 to L1 and vice-versa at multiple levels of linguistic representations (e.g. Orthography, conceptual and phonological form). Visual world studies have also shown that participants activate information in both their languages with audio-visual input. Interactional context plays a key role in constraining the activation of target language from two lexical systems in bilinguals. Consistent with this idea many studies have found that non-linguistic visual cues associated with an interlocutor (e.g. face, ethnicity and proficiency) constraint language selection. However, very few studies have investigated the effect of interlocutor proficiency on cross-linguistic parallel activation in bilinguals. Language is a social phenomenon where every interlocutor is tagged with certain prior language proficiency either in L1 or L2. The awareness about interlocutor's proficiency appears more natural and perceived unconsciously in daily life without much effort. Bilinguals choose their language based on the context and the interlocutor they are interacting with. The two languages are in close proximity for selection and which language is used consequently depends upon both linguistic and non-linguistic cues present in the environment. Past studies suggest that speakers evaluate the proficiency of the interlocutor and selects the language in which the interlocutor is more proficient. The theory is adopted in the Adaptive Control Hypothesis (Green & Abutalebi, 2013). The non-selective activation pattern necessitates the

optimal use of cues present in the environment to weight the language selection. Such a mechanism has been implemented in a computational model like BIA+. This model incorporates two global nodes for language selection at the task schema level and based on the maximum weight of the nodes a particular language will be selected. Crucially, the model assumes that linguistic and non-linguistic cues are the most important factors in guiding the activation level of the global language nodes and selection. In this study, we try to evaluate the effect of a non-linguistic cue like interlocutor proficiency this global selection nodes in high proficient Hindi-English bilinguals. Using eye-tracking the effect of interlocutor proficiency on language choice is evaluated. Unlike the past studies where the selection mechanism is evaluated based on production or comprehension task, the present study uses a popular paradigm known as Blank Screen Paradigm to investigate the extent to which the non-linguistic cues (like interlocutor proficiency) affects language choice in high proficient Hindi-English bilinguals. The result suggests that speakers tend to fixate more on the high proficient L2 interlocutor when a word in L2 is presented after the offset of interlocutor from the screen. Crucially, this effect is even found in the absence of the interlocutor i.e., on the blank screen. The study connects the findings to the popular theory in philosophy of mind called Externalism (Clark & Chalmers, 1998).

## 3.2 Method

### 3.2.1 Participants and Stimuli

#### Participants

Sixteen Hindi (L1) – English (L2) bilinguals from the University of Hyderabad community (8 male, 8 female, Mean-age = 23.5 years, SD = 2.6 years) participated in the main experiment. All the participants were students at the University of Hyderabad and voluntarily participated in the study by providing their written consent. The study was approved by the institutional ethics committee (IEC) at the University of Hyderabad.

**Language environment in the university**

The lingua-franca of the university is English (L2) of all participants. Since the University of Hyderabad is a big research university of national importance, most students who come here are fluent in English (L2) apart from their mother tongues. However, we selected only speakers who had Hindi (L1) as their first language. All the teaching and instruction at the university is in English, which also influences the choice of language during conversations.

**Control task**

The participants were tested on the Lextale (Lemhöfer & Broersma, 2012). Lextale is an online vocabulary test. The task was done to measure the L2 proficiency (English) of the participants. Participants' mean score on the Lextale test was 49.43 percent, (SD = 9.73 percent). The lextale task followed a semantic fluency task to evaluate the language fluency in L1 (Hindi) and English (L2). In this task, speakers were asked to produce as many words as they could in two different categories. For word generation in Hindi (L1) the categories "vegetables" and "birds", and for English (L2) "fruits" and "animals". Categories were counter-balanced between languages. We calculated the number of words produced per minute in each language for each category and the scores was averaged out for two categories for each language. The semantic fluency score in English (L2) (M = 15.32, SD = 3.14) was significantly higher than Hindi (L1) (M = 10.09, SD = 2.3), $t(1, 30) = 5.3748$, $p < 0.001$. To administer, the demographic details and language used by participants in both L1 and L2 a language questionnaire were used. The questionnaire was based on the scores on language proficiency, current use of language and age of language acquisition (see LSBQ, Anderson, Mak, Chahi & Bialystok, 2017). The factor score of English (L2) (M = 0.02, SD = 1.09) was significantly higher than Hindi (L1), (M = -0.23, SD = 0.8), $t(1, 30) = 7.03$, $p < 0.001$. It suggests that participants were more likely to use English efficiently than Hindi.

**Stimuli**

Using an animator software 6 cartoon avatars were created with varied L2 proficiency (2 High

and 2 Low proficient, 2 neutral) to act as an interlocutor in the study. Hindi-English speech samples were recorded by Early and Late Hindi-English Bilinguals in University of Hyderabad. We generated overall 20 video clips by superimposing recorded speech samples over the animated cartoon, that made lip movement and eye-blink. The bilingual characters code-switched when it was natural to do so. And High-proficient bilingual code-switched frequently than low L2 proficient character. In addition to this, 160 words (80 English, 80 Hindi) were recorded to be used in Eye-Tracking Experiment. The videos were made realistic by adding lip movement and eye blink. Crucially, each of the cartoons from the different language condition was lip-synced with high proficient voice or low proficient voice. The cartoons asked question in both languages English (L1) and Hindi (L2). However, the distribution of languages between cartoons were made uneven to make a some cartoon appear more proficient in L2 than others. For example, low proficient L2 cartoon asked more questions in L1 than in L2. And since the L2 voice sample was recorded by a low proficient English speaker there were occasional grammatical mistakes as well. Two of the six interlocutors are shown in figure (3.1).

**Figure 3.1** Familiarised Interlocutors - Left: High L2 Proficient, Right: Low L2 Proficient

### 3.2.2 Procedure

The experiment was divided into two phases Familiarization and Testing. The participant was seated on the chair in a quiet room with a headset. In the familiarization phase, the two cartoons were presented and given a brief introduction. Then, participants interacted with each interlocutor in a question-answer session. The interlocutors asked day to day life questions (about hobbies, family, work etc.). Participants answered all the questions freely in any

language. The session was self-paced where each video appeared after a key-press and the answers were recorded using microphone. The order of the presentation of the cartoons was counterbalanced between the participants. The total number of video clips in each condition was 10 making altogether 20 questions to be answered. The cartoons remained on the screen until the participant pressed the button to change the clip. The familiarisation session lasted for 20 minutes.

After the familiarisation phase, the eye-tracking study was conducted in the same room. Participants were seated on the chair in a quiet room. Eye movement data were recorded using a desktop mounted Eyelink 1000 eye-tracker (SR research, Ontario) with a sampling rate of 1000 Hz under binocular viewing. Participants rested their head on a chin rest for stable viewing. A 9-point calibration was used for each participant. Stimuli were presented on a 19 inch LCD monitor with a refresh rate of 60 Hz placed at a distance of 60 cm from the participant. Participants first saw a fixation 1000 ms on each trial. Then two interlocutors one high proficient and one low proficient was presented in two half of the screens for 3000 ms. (Adopted from Kapiley & Mishra, 2019) in language conditioned trial. Two neutral cartoons were presented in the neutral condition in both quadrants. After the offset of the cartoons, the auditory word was presented in either Hindi (L1) or English (L2). In some trials, participants were given a word on the screen which either matches or does not matches with the spoken word. The task was to press the spacebar on the keyboard if the written word was similar to the spoken word. There was no time constraint for this task and the task was just to ensure that the participant pays attention to the screen.

The eye movement data were recorded in the blank screen interval. A total of 160 trials equally divided between experimental and neutral condition. The participants were presented with a total of 4 blocks of trials blocked across condition and language (Hindi or English). The block was randomised across participants. The order of presentation of the blocks was randomised at each level of blocking such that participants first encountered all trials with L1 spoken word or all trials with L2 spoken word. Within each language direction, the order of presentation of language conditioned and neutral blocks was then randomised. Eye movement data were extracted using DataViewer (SR Research, Ontario) for analysis. The screen size

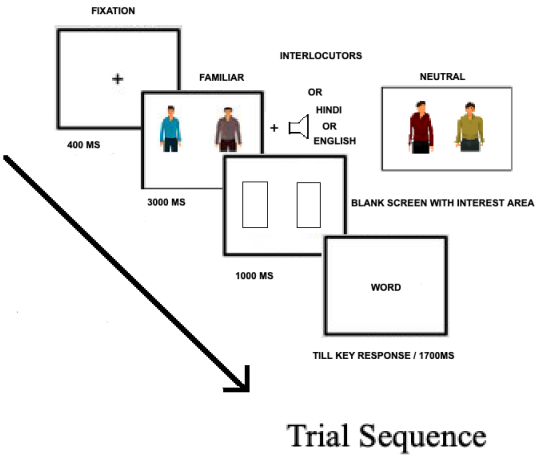


**Figure 3.2** Trial Sequence for eye-tracking experiment

was divided into two equal quadrants (based on the analysis procedure of Mishra & Singh, 2014, 2016).

**Prediction**

1. If participants have learned the abstract features associated with an interlocutor, it will affect their language activation pattern. Such that, a participant will preferably activate L2 (English) first in presence of high L2-proficient bilingual and L1 (Hindi) in presence of low L2-proficient bilingual.

2. An unknown interlocutor should elicit equal activation to both the languages.

## 3.3 Data Analysis and Results

**Eye-Tracking data analysis**

The interest period was taken from the offset of the cartoon until the onset of the word for 3500 ms. Fixations were counted only during the blank screen period. The proportion of fixation was calculated to each quadrant by counting the number of fixation in each interest region and dividing it by the total number of fixations the fixations having a duration less than 200 ms was not included in the analysis since, the lower limit of 200 ms was chosen as that is the minimum time required to program and launch a saccade (Saslow, 1967) based on previous visual

world studies (e.g. Altmann & Kamide, 2004; Mercier et al., 2014). Looks to the regions were analysed by considering the log transforms of fixation proportion as the dependent variable and language type, Interlocutor Type and condition (Neutral vs Bilingual) as the predictor variables. The neutral condition was taken as the baseline. A linear mixed model was fit for each Area of Interest (AOI) with varying intercepts and slope (the maximal model), with sum contrast coding (Spoken language, Hindi +1, English –1,) The dependent variable (proportion of fixation) was log-transformed. The Chi-Square model comparison was done for each interest region. The model parameter estimation are provided for each condition in fig (3.1).

a)
```
Fixed effects:
             Estimate Std. Error t value
(Intercept)    0.90516    0.09522   9.506
so_spokenlang -0.09199    0.01753  -5.249
```

b)
```
Fixed effects:
             Estimate Std. Error t value
(Intercept)    0.89458    0.09669   9.252
so_spokenlang -0.07177    0.01759  -4.081
```

c)
```
Fixed effects:
             Estimate Std. Error t value
(Intercept)    0.92760    0.11013   8.423
so_spokenlang -0.03528    0.04834  -0.730
```

**Figure 3.3** Model parameter estimation from lmer function R, for conditions a) High-proficient L2; b) Low-proficient L2; c) Neutral Condition

**Results**

The statistical analysis was done using lme4 package R (Bates et. al., 2015). Results as presented for Familiar Interlocutor Condition fig (3.4.1) and Neutral interlocutor Condition fig (3.4.2). In familiar interlocutor condition, the comparison between simpler model and complex model with language type as a fixed effect shows that the model fit was better as suggested by Chi-Sq test. Meaning, the proportion of fixation to the high L2 proficient bilingual was significantly higher compared to the low proficient interlocutor when spoken word was English ($\chi^2$= 27.28, p-value = 1.76e-07***). Similarly, the fixation to the low-proficient L2 bilingual was higher when spoken word was Hindi ($\chi^2$= 16.56, p-value = 4.69e-05***). However, in neutral condition the model fit was not improved when language type was added as a fixed effect to the simpler model ($\chi^2$= 0.1818, p-value = 0.663), suggesting that in presence of neutral interlocutor the language type did not modulate the fixation proportion to the interlocutor and

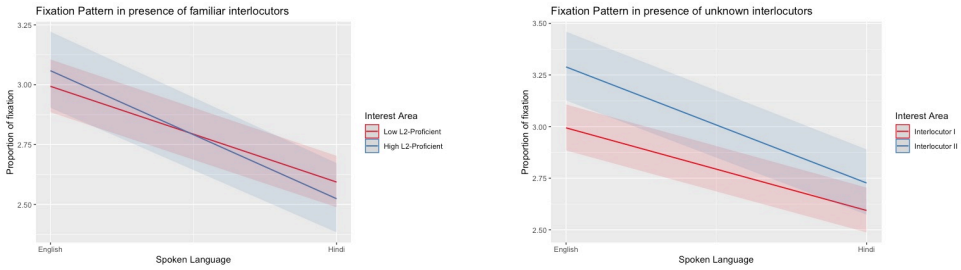


**Figure 3.4** Interaction pattern in presence of familiar (left) and neutral interlocutor (right)

the preference was not guided by the spoken language type. In other words, the identity of the interlocutor formed during the familiarisation phase was sufficient to modulate the language preference in a given context. Later, we also evaluated the perceived identity of the interlocutor by analysing the rating scale and Reaction Time (RT). The post-hoc analysis of the self rating to the interlocutors after the experiment suggested that participants were able to distinguish between low and high proficient interlocutors during interaction, which was evident in the fixation pattern during eye-tracking testing phase.

## 3.4 Discussion and Conclusion

In this experiment, we examined whether non-linguistic cues (interlocutor proficiency in L2) modulate language selection in high-proficient Hindi-English bilinguals. Crucially, the fixation was analysed in the period when there was nothing on the screen. The data suggest that bilingual's language choice is affected by the L2 proficiency of the interlocutor. When presented with English word participants are more likely to fixate on the location where high L2 proficient bilingual was present previously. The data also suggest that the location tagged with particular interlocutor acts as a salient cue which can guide language selection. Importantly, in both condition, there were overall more fixations on the bilingual interlocutor which suggest that the participants fixated on high proficient bilingual more number of times. The result is consistent with the past studies, but the current study extends the previous idea to the blank screen paradigm. Previous study suggest that participant tag certain language with particular

interlocutor (Molnar et al., 2015). The current study takes a step forward to illustrate that this preferential tagging of a language with an interlocutor can also take place when the interlocutor is not present on the screen. The bilinguals established a strong association between language and interlocutor and this association is robust to the extent that even after the interlocutor disappear from the screen the cues can guide fixation behaviour. The present study suggests that non-linguistic cues present in the visual environment affect the language representations. Studies in bilingualism literature uses cognate effects and homographs to investigate the effect of these cues on non-selective processing and few studies use non-linguistic cues to evaluate the selection mechanism. This study adds to the previous results of non-selective activation with a more weightage to non-linguistic cues in modulating the language selection. Crucially, the present study only accounts for the results obtained in the absence of the bottom-up stimulus. Hence, it further supports the idea that surrounding environment potentially serves as a memory which holds the current object and also the object which was previously present there. And fixations are used to access those external data. Following this process the system external information complements the linguistic internal information. One theoretical proposal with this external information is that it is quickly accessed, sometimes faster than the internal information. This idea seems intuitive in an interactional context where as soon as one meets a person the language selection happens automatic. However, most non-selective activation model suggests that language selection requires inhibition and selection simultaneously which is a resource-demanding task. These two different views can be understood in terms of internal and external representations. As suggested by the current study non-linguistic cue like interlocutor awareness is not a part of internal linguistic representation hence it is accessed fast without any competitions however on the other hand linguistic representation are internal and it needs conscious evaluation before selecting a candidate from the possible lexical candidates. The interplay between both internal and external representations give rise to a holistic conversation in an interactional environment. However, the time-course of this phenomenon is yet to be explored. And future studies should aim to understand how and when the visual and auditory signals from two modalities integrate at perceptual level to influence the later decisional level processes.

# Bibliography


[1] Bates, D., Mächler, M., Bolker, B., & Walker, S., "Fitting Linear Mixed-Effects Models Using lme4," *Journal of Statistical Software*, 67(1), 1–48. doi: 10.18637/jss.v067.i01, 2015.

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

[3] Hartsuiker, R. J., "Visual Cues for Language Selection in Bilinguals," *Attention and Vision in Language Processing*, pp. 129-145, 2015.

[4] Jared, D., Poh, R. P. Y., & Paivio, A., "L1 and L2 picture naming in Mandarin-English bilinguals: A test of bilingual dual coding theory," *Bilingualism: Language and Cognition*, 16, pp. 383–396, 2013.

[5] Li, Y., Yang, J., Scherf,K. S., & Li, P., "Two faces, two languages: An fMRI study of bilingual picture naming," *Brain and Language*, pp. 515-530, 2013.

[6] Martin, C., VandenBulcke, C., Navarra, E., Schoonbaert, S., Hartsuiker, R.J., Costa, A., "Please, Catalan or Spanish, but not both! Are bilinguals fully in control of their language selection during word production? Paper presented at the Workshop on Bilingualism," *Neurolinguistic and Psycholinguistic Perspectives, Aix-en-Provence, France.*, 2011.

[7] Zhang, S., Morris, M. W., Cheng, C-Y., & Yap, A. J. , "Heritage-culture images disrupt immigrants' second-language processing through triggering first- language interfer-

ence," *Proceedings of the National Academy of Sciences of the United States of America*, 110, pp. 11272-11277, 25(5), 2013.

[8] Molnar, M., Martin, C., & Carreiras, M., "Interlocutor Identity Affects Proficient Bilinguals' Language Activation," *PsycEXTRA Dataset*, 25(5), 2014.

[9] Kapiley, K., & Mishra, R. K. "What do I choose? Influence of interlocutor awareness on bilingual language choice during voluntary object naming," *Bilingualism: Language and Cognition*, 22(5), 1029-1051, 2018.

[10] Altmann, G. T., "Language-mediated eye movements in the absence of a visual world: The 'blank screen paradigm'," *Cognition*, 93(2), 2004.

[11] Spivey, M. J., Richardson, D. C., Fitneva, S. A., "Thinking outside the brain: Spatial indices to visual and linguistic information," *The interface of language, vision, and action: Eye movements and the visual world. New York: Psychology Press.*, 2004.

[12] Clark, A., Chalmers, D., "The extended mind," *Analysis*, 58, 7-19, 1998.

[13] Costa, A., Caramazza, A., Sebastián-Gallés, N., "The cognate facilitation effect: Implications for models of lexical access," *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 26, 1283–1296, 2000.

[14] Van Hell, J. G., Dijkstra, T., "Foreign language knowl- edge can influence native language performance in exclu- sively native contexts," *Psychonomic Bulletin & Review*, 9, 780–789, 2002.

[15] Bialystok, E., Craik, F. I. M., Green, D. W., Gollan, T. H., "Bilingual minds," *Psychological Science in the Public Interest*, 10, 89129, 2009.

[16] Green, D. W., Abutalebi, J., "Language control in bilinguals: The adaptive control hypothesis," *Journal of Cognitive Psychology*, 25, 515–530, 2013.

[17] Kroll, J. F., Van Hell, J. G., Tokowicz, N., Green, D. W., "The revised hierarchical model: A critical review and assessment," *Bilingualism*, 13, 373–381, 2010.

[18] Dijkstra, T., van Heuven, W. J. B., "The architecture of the bilingual word recognition system: From identification to decision," *Bilingualism: Language and Cognition*, 5, 175–197, 2002.

[19] Dijkstra, T., "Bilingual word recognition and lexical access," *Handbook of bilingualism: Psycholinguistic approaches*, pp. 179–201, New York: Oxford University Press, 2005.

[20] Weinreich, U., "Languages in contact," *New York: The Linguistic Circle of New York.*, 1953.

[21] McLaughlin, J., Osterhout, L., Kim, A., "Neural correlates of second-language word learning: Minimal instruction produces rapid change," *Nature Neuroscience*, 7, 703–704, 2004.

[22] Marslen-Wilson, W., "Functional parallelism in spoken word recognition," *Cognition*, 25, 71-102, 1987.

[23] Van Hell, J. G., De Groot, A. M. B., "Conceptual representation in bilingual memory: Effects of concreteness and cognate status in word association," *Bilingualism: Language and Cognition*, 1(3), 193–211, 1998.

[24] McLaughlin, J., Osterhout, L., Kim, A., "Neural correlates of second-language word learning: Minimal instruction produces rapid change," *Nature Neuroscience*, 7, 703–704, 2004.

[25] Kroll, J. F., de Groot, A. M. B., "Lexical and conceptual memory in the bilingual: Mapping form to meaning in two languages," *Tutorials in bilingualism: Psycholinguistic perspectives* , p. 169–199, 1997.

[26] McLaughlin, J., Osterhout, L., Kim, A., "Neural correlates of second-language word learning: Minimal instruction produces rapid change," *Nature Neuroscience*, 7, 703–704, 2004.

[27] Kroll, J. F., Sholl, A. , "Lexical and conceptual memory in fluent and nonfluent bilinguals," *Cognitive processing in bilinguals*, pp. 191–204, 1992.

[28] Dijkstra, T., van Heuven, W., "The BIA-model and bilingual word recognition," *Localist connectionist approaches to human cognition*, pp. 189–225, 1998.

[29] Ivanova, I., Costa, A., "Does bilingualism hamper lexical access in speech production?," *Acta Psychologica*, 127, 277-288, 2008.

[30] Elston-Güttler, K. E., Gunter, T. C., & Kotz, S. A., "Zooming into L2: global language context and adjustment affect processing of interlingual homographs in sentences," *Cognitive. Brain Research*, 25, 57–70, 2005.

[31] Lagrou, E., Hartsuiker, R. J., and Duyck, W., "Knowledge of a second language influences auditory word recognition in the native language," *Journal of Experimental Psychology: Learning Memory and Cognition*, 37, 952–965, 2011.

[32] Hartsuiker, R. J. De Clerck, M., "Language attraction in bilingual language production," *Paper presented at the AMLaP 2009 conference, Barcelona, Spain*, 2009.

[33] Jared, D., Pei Jun Poh, R., Pavio, A., "L1 and L2 picture naming in Mandarin-English bilinguals: a test of bilingual dual coding theory," *Bilingualism: Language and Cognition*, 16, 383-396, 2013.

[34] Zhang, S., Morris, M. W., Cheng, C-Y., Yap, A. J., "Heritage-culture images disrupt immigrants' second-language processing through triggering first- language interference," *Proceedings of the National Academy of Sciences of the United States of America*, 110, 11272-11277, 2013.

[35] Gollan, T. H., Schotter, E. R., Gomez, J., Murillo, M., Rayner, K., "Multiple levels of bilingual language control: Evidence from language intrusions in reading aloud," *Psychological Science*, 2013.

[36] McGurk H., MacDonald J., "Hearing lips and seeing voices," *Nature*, 264, 746–748, 1976.

[37] Bhatia, D., Prasad, S. G., Sake, K., amp; Mishra, R. K., "Task Irrelevant External Cues Can Influence Language Selection in Voluntary Object Naming: Evidence from Hindi-English Bilinguals," *Plos One*, 2(1), 2017.

[38] Altmann, G. T. M., Kamide, Y., "Incremental interpretation at verbs: Restricting the domain of subsequent reference," *Cognition*, 73(3), 247–264, 1999.

[39] Richardson, D. C., Spivey, M. J., "Representation, space and Hollywood squares: Looking at things that aren't there anymore," *Cognition*, 76, 269–295, 2000.

[40] O'Regan, J. K., "Solving the real mysteries of visual perception: The world as an outside memory," *Canadian Journal of Psychology*, 46, 461–488, 1992.

[41] Ballard, D. H., Hayhoe, M. H., Pook, P. K., Rao, R. P. N., "Deictic codes for the embodiment of cognition," *Behavioral and Brain Sciences*, 320, 723-767, 1997.

[42] Richardson, D. C. Spivey, M. J., "Representation, space and Hollywood Squares: looking at things that aren't there anymore," *Cognition*, 76, 269-295, 2000.

[43] Saslow, M. G., "Latency for Saccadic Eye Movement," *Journal of the Optical Society of America*, 57(8), 1030, 1967.

[44] Seabold, Skipper, and Josef Perktold, "statsmodels: Econometric and statistical modeling with python," *Proceedings of the 9th Python in Science Conference*, 2010.