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Neurocognitive Mechanisms of Language Switching in Bilinguals: Insights from the Dynamic Restructuring Model

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Abstract

Code switching refers to the speakers' ability to switch between languages proficiently. Many internally generated and external factors are responsible for processes of code switching. The current study aims to find out the neurocognitive mechanisms involved in the process of code switching in bilinguals. The study is based on qualitative and quantitative data. A small sample size of only 6 participants aging between 20 to 25 years is selected purposively. The data is collected with the help of recording conversations of the participants in different conversation contexts i.e. formal and informal contexts for processes of code switching. Similarly, Quantitative data are collected through Frequency Magnetic Resonance Imaging **(fMRI)** in order to record which parts of the brain are involved in the process of code-switching. The data are analyzed with the help of Dynamic Reconstruction Model and Diffusion Tensor Imaging (DFI) technique. The findings have shown that the proficiency of languages, contexts of conversation and cognitive load are responsible for smooth code switching.

Keywords: code switching, Neurocognitive, mechanisms, Dynamic reconstruction model, Magnetic Resonance Imaging, cognitive

Introduction

Language is a ubiquitous phenomenon. It is a medium to express thoughts, emotions and messages for communication. According to Jacobson (1960) one of the six functions of language is emotive: expressing emotions. Similarly, dwelling upon the proper functions of language, Unnsteinsson (2022) puts forward that the proper function a language performs is nothing but communication. It is matter of fact that the world is thronged with multiple ethnic, geographic and cultural groups. All of these groups speak different languages. As the world is crammed with a variety of people, in the same vein, the languages they speak are not limited. There are over 7000 languages spoken across the world. However, it is pertinent to note

that none of these languages are identical to one another. Simons & Fennig, (2017) have rightly noted that there are more than 7000 languages in the world. They further note that these languages contain quirk of lexicology, structures, phoneme systems and even sometimes the systems of writing. Yet the only shared feature in all these languages is the facilitation for communication.

Definition and Effectiveness of Bilingualism

Bilingualism can be defined as the speaker's ability to speak more than one language at the same time. L.S. & Schmitt. E, (2010) also believe that bilingualism is the speakers' ability to speak two languages with complete grip and fluency at the same time for communication in social settings. Bloomfield (1933) presented a more specific definition of bilingualism. He believed that ability is to have a native like control over two languages. Thierry (1978) defines bilingual to be two monolinguals in one person. In the same vein, Grosjean (2010) also demonstrates that it is the ability of a speaker to switch to two languages simultaneously. However, the use of bilingualism is not just limited to communicative settings, but it can also be very useful and effective mode of communication in the academic settings as well. Abella (2024) also talks about the effectiveness of bilingualism in academic settings.

Bilingual and multilingual culture in the world

Previously, it was not a tradition but an exception to being able to speak more than one language. It many countries like the United States, it was not common for people to speak more than one language. Helsinki (2018) has aptly noted that using bilingual and multilingual mechanisms for communication has developed over the course of time in many countries of the world because of its utility in terms of compunction in all practical aspects of life.

Code-Switching (CS)

Code-switching refers to an individual's ability to switch between languages at the same time without facing any difficulty. Daller et.al (2021) note that it is unique ability of the bilinguals to switch between languages and within utterances. This uniqueness is known as code-switching. The researchers in the past and in the present have been keenly interested in finding out the answer that how these languages are stored and administered in the brain of the bilinguals.

Neurocognition Mechanism

These are processes and structures within the brain. Both the process and structures are responsible for enabling the cognitive factions like decision making, problem-solving, attention, memory and language etc. These mechanisms are not so simple. These mechanisms entail a very complex relationship between different regions of the brain, neurons and neurotransmitters. It is very important to understand Neurocognitive mechanisms in order to study neurological and psychological issues and factors.

Role of Neurocognitive Mechanism in Code switching

The role of neurocognitive mechanisms has been very crucial in the process of code switching. This process engages many brain-regions which are responsible for code switching. During the process of code-switching, the bilingual brain makes a rapid selection of the language based on the context of the language. The brain very actively restrains one language and activates the other language through a process called execution control system. Keeping the same in view, the current study aims to find out the cognitive mechanism in code switching. It further tends to investigate which cognitive functions are responsible for code switching. The study intends to achieve this by using Dynamic Reconstructing Model.

Research Objectives

(i) To explicate the neurocognitive mechanisms involved in the process of code switching through the use of Dynamic Reconstructing Model.

Research questions

How does the neurocognitive mechanism help the process of code switching in the bilinguals through Dynamic Reconstructive Model?

Hypotheses

(1) The Dynamic Reconstruction Model implies that it is convenient for the bilinguals to switch between languages. This is the result of dynamic interaction that exists between the Neurocognitive Mechanism of both the languages. These mechanisms include those parts of the brain which are responsible for bringing efficiency in linguistic systems by managing language processing, working memory and cognitive control.

Literature Review

This section will comprise of an overview of the studies conducted in the past on code switching in bilingual users of language. The section will further comprise two sub-sections, i.e. studies on code switching and neurocognitive mechanisms.

Code switching

Code switching has been one of the favorite topics among the researchers in the present and in the past, especially psycholinguists and psychologists. Ramzan et.al (2021) have conducted a concurrent study on code switching and code mixing on a population of 100 children ranging from age 2-5 years. The participants of the study came both from educated and uneducated backgrounds. The study utilized Rasul (2006) and found out that code switching and code mixing are a common practice in the speakers of Urdu and Punjabi languages. Similarly, Beatty Martinez et al. (2020) have also conducted and mixed method study based on English Spanish Code switching. The study has utilized theoretical models of bilingual speech production and language control of Green, 2011, 2018, 2019; Green and Abutalebi, 2013;

Green and Wei, 2014. Their findings have suggested that both languages provide a great contribution in the production of language under the corporate control state. Moreover, their findings have shown that code switching may help fluency as both languages remain active during the process of code switching providing other methods to convey meanings. They conclude their findings that speakers use code switching to alleviate production difficulties. In the same vein, Helsinki (2018) has conducted mixed method research on 127 participants at three different levels: study I, study II and study III using various research methods i.e. Magneto encephalography (MEG) and encephalography (EEG), as well as behavioral methods and extensive language background questionnaires. The findings of this study reveal that language control depends on the strength of language network. Further, the findings indicate that there is no cost when switching is carried out from native language. However, switching is costly when it is done with later-learned language. The study has further revealed that when two languages are acquired at an early age, it does not have any noticeable effect on the accuracy or speed with accuracy of lexical processing. However, monolingually raised native speakers showed the worst performance in switching.

Beatty Martinez et al. (2018) have conducted experimental research using corpus-cognition approach on English Spanish bilinguals. Their findings have revealed that inter-language code switching is cognitively costlier than intra-lingual code switching. Their finding further suggests that despite this cost of inter-lingual code switching, it is very common in certain communities and doesn't seem to affect the linguistic understanding of those communities.

The above review of the literature suggests, as far as the researcher has seen, that despite their large sample sizes, no study has been conducted by using the Dynamic Reconstruction Model. Similarly, based on the small review of the existing literature, it is insinuated that no research has been conducted before involving English-Urdu bilinguals. Hence, this study will seem to fill the gap of sample size, methodology and data structures.

Methodology

This is a concurrent study consisting of both quantitative and qualitative data. The results of the quantitative data will provide foundation for qualitative analysis of the data.

Sample size

Only a small sample size of 6 participants both male and female in equal proportion is taken aging 20 to 25 years old. All the participants are healthy adolescents without any mental illness or depression or anxiety etc. All the participants have completed their graduation in various subjects in the English medium of instruction. The participants are fluent in English and Urdu is their native language.

Variables of Data

The following variables will be kept in view for carrying out the data analysis.

ID of the Participants:
Each participant is allotted a unique ID. This identifies each individual participant.

Age:
All the participants range from 20 to 25 years.

Gender:
The participants are both male and female. It is done in order to avoid any impression of gender bias.

Language proficiency
Each participant has reported their proficiency in both languages on a scale of 1-10. It is done to make sure that the participants feel rest assured about their proficiency in both languages.

Contexts
All the participants are involved in both informal and formal contexts for conversation. This has provided the participants with equal opportunity to converse in both types of contexts.

Relationship with Interlocutor
The participants are made to interact with their family members, colleagues and friends. This is done in order to make them remain more natural without any external pressure to continue conversing unilingually.

Code Switching Mechanism
The participants are judged for two aspects of code switching i.e. frequency with which have the participants have code switched, Event-related potential (ERP) and the time taken to switch between languages. Their time of code switching is recorded/ ms of switching.

Self-reported Cognitive Load
The last variable for which the participants are judged is cognitive load. This load is recorded from the participants on their personal reporting form scale 1-10.

Methods of Data Collection
Data is collected with the help of recording. With prior permission Performa dully signed by is each participant is collected. Their conversation is recorded with the help of an electric recorder when each participant is involved in conversation with their interlocutor over the course of 3 days to record them in both formal and informal contexts. Their conversations are transcribed afterwards and with the help of a stopwatch the time gap of code switching is recorded and written afterwards. Quantitative data are collected through Frequency Magnetic Resonance Imaging **(fMRI)** in order to record which parts of the brain i.e. Left Inferior Frontal Gyyrus (LIFG) Superior Temporal Gyrus (STG) and Caudate are involved during the process

of switching. Also, Diffusion Tensor Imaging **(DTI)** is used to check the structural connectivity of the brain regions involved during the switching process.

Conceptual Framework

The data are analyzed with the help of Dynamic Reconstruction Model. This model insinuates that brains of the bilinguals keep facilitating them without any break during the process of code switching. The framework also elaborates the flexibility of the neurons of the brain that help facilitate speakers during switching.

Data analysis and discussion

Table 1: The Data-Variables and analysis

Participant ID	Gender	Age	English Proficiency	Urdu Proficiency	Topic of Conversation	Interlocutor Relationship	Switching Frequency/ minute	Latency of Switching	ERP	fMRI Activation (Regions)	Load on Cognition
A	Male	21	08	09	Technical	Colleague	14	239	7.5	ACC, STG, LIFG	8
B	Male	20	09	08	Formal	Colleague	10	311	5.8	CAUDATE, STG	7
C	Female	22	09	08	Informal	Friend	10	278	6.7	LIFG, CAUDARE	4
D	Male	25	07	10	Informal	Brother	12	204	3.9	STG	5
E	Male	24	08	09	Informal	Sister	13	206	5.5	CAUDATE	4
F	Female	23	09	10	Formal	Colleague	16	243	5.8	ACC LIFG	7

Table 1 describes the variables of the data. Each participant is allotted a unique identification from A-F. The participants of the data are proportionally men and women. The English proficiency of the participants ranges from minimum 7 and maximum 9 whereas Urdu proficiency ranges from minimum 8 to maximum 10. Minimum switching frequency is recorded from participant C while she is involved in conversation with a friend. However, the maximum frequency of 16 is recorded from participant F when she is conversing on a formal topic with a colleague. Maximum latency is recorded from participant B when he is found conversing with a colleague on a formal topic. The minimum latency is recorded as participant D when he is having a conversation with his brother on an informal topic. Where the participants are frequently switching it suggests more proficiency and conversely when the participants are found switching less or slower, it indicates low proficiency. The EPR values are of great significance. The higher EPR values are an indication of more effort and vice versa. There is a clear indication that the EPR is higher in

technical contexts. It means there is an involvement of labyrinth mental operations. Activation regions of is also found active. Various regions of the brain are found involved during switching. ACC, the region of the brain responsible for resolving conflicts during switching, is found active in formal and technical settings. Similarly, LIFG and STG,

The regions of the brain which are responsible for the management of language processing of language are found active throughout the course of conversation. The data shows that whenever the participants are indulged in formal or technical conversation, their cognitive load increases by far. The highest cognitive load is recorded in technical contexts from participant A. Lower cognitive load is observed when the participants are involved in informal conversation. This may be the result of the comfortable nature of conversation and nadir need for language appraisal.

Conclusion

The study began with an aim to find out the role of Dynamic Reconstruction Model in neurocognitive mechanism of code switching in bilinguals. The current study intended to find the answer of How does the neurocognitive mechanism help the process of code switching in the bilinguals through Dynamic Reconstructive Model? The study has rightly found the answer that this model provides an insight into the fact that the regions of the brain which are responsible for the processing of language during switching facilitate the process of switching by resolving conflicts and proving facilitation during code switching. The study also began with a hypothesis that it is convenient for the bilinguals to switch between them because of dynamic interaction that exists between two languages. The data has shown that it is true that more proficiency of both languages and convenient conversation has resulted in less cognitive load and more frequent code switching.

Across the course of data analysis, it has been found that the Dynamic Reconstruction Model gives a thorough and useful model to understand the process of code switching. Further, this method is useful in order to understand the fundamental Neurocognitive mechanisms which are responsible for code switching are bilingual. In addition to this, based on the small sets of the data, it has been discovered that Dynamic Reconstruction Model also indicates that smooth code switching is the result of many factors such as high level of proficiency of both languages, low cognitive load and contexts of the conversation.

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