Cognitive Language Processing through Positron Emission Tomography

Natasha Parkins-Maliko

UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

A thesis submitted to the Wits School of Language, Literature and Media, Faculty of Humanities, University of the Witwatersrand in fulfilment of the requirements for the degree of Doctor of Philosophy

Johannesburg

2021

Declaration

I, Natasha Parkins-Maliko, declare that this thesis is my own, unaided work. It is being submitted for the Degree of Doctor of Philosophy at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

30th day of April 2021 in Johannesburg.

Dedication

To my late father, Neville, how I wish you were here to support me and witness this journey.

Acknowledgements

I thank Jehovah for blessing me to see this project to fruition. I wish to thank all the people whose assistance was a milestone in the completion of this project.

- I wish to express my gratitude to my supervisors, Professors Judith Inggs and Mboyo-Di-Tamba Vangu, for their efforts in guiding me. To Prof. Vangu thank you for embracing me and taking a humanities student under your experienced neuroscience wing.
- To Prof. Hervais-Adelman thank you for providing solid feedback on the data analysis chapter to ensure the presentation of sound empirical evidence.
- To my family, Mummy, thank you for filling my shoes when I had to be an absent mom. To my daughters Anastacia, Jael and Joie, thank you for your understanding and patience throughout my journey on this project.
- Sincere appreciation goes to the contributors of the SASL video. To the respondents in the experiment, thank you for sacrificing your time to make my data collection materialise, sacrificing the early mornings and enduring the experiment in a medical environment. The staff at CM Hospital, Department of Nuclear Medicine, thank you for your technical assistance and accepting the extra workload.
- To those people on whose doors I knocked, called, email boxes I bombarded, social media inboxes I flooded, who offered an ear and guidance, thank you. In particular thank you to Professors Mhlambi, Kadenge and Makalela for being my mentors, sounding boards and my go to persons to clear my head.
- To the Deaf community, who graciously accepted me as an outsider and gifted me sign language, thank you. To Desmond, Tefo, Harry, Xoli, Emily and Jackson thank you for being my first teachers of SASL.
- Lastly, to a man who has made a great impact on my career as a practisearcher, Mzee Dr. Akach, you planted the seed; thank you.

Abstract

This thesis investigates the cognitive language processing of South African Sign Language (SASL) interpreters using positron emission tomography (PET). The study is pertinent concerning cognitive language processing during simultaneous interpreting and grapples with a specific question: "What happens in the plurilingual black box during interpreting from SASL to spoken language/s?" The concept of translanguaging is fundamental to this study as it elucidates the intersection of ubuntu translanguaging and interpreting praxis in plurilingual interpreting settings. Interpreting in a plurilingual context is discussed concerning cognition, drawing on the theoretical framework of Motor Resonance and Adaptive Control theories. This investigation aims to understand cognitive language processing by plurilingual interpreters using neurological examination and accessing the idiosyncrasy of interpreting from sign language (visual-gestural mode) into a spoken language/s (vocal-auditory mode). The research questions cover prominent cognitive areas of activation during simultaneous interpreting and its relevance to language and simultaneous interpreting. Twenty subjects took part in the study. They interpreted an SASL text into various South African spoken languages while PET brain imaging, as well as baseline and activation imaging were recorded. Data were collected using a questionnaire, interpreted voice notes, and PET brain imaging. A triangulation approach was used to analyse the data by thematic analysis of the questionnaire, ELAN transcription and annotations of the recorded interpretation and NeuroQ^{TM} analysis of the PET brain imaging. The findings present evidence of ubuntu translanguaging strategies during interpreting, mainly by code-blending and lexical borrowing. For the cognitive part of the experiment, significant differences were seen in brain metabolism in the right Primary Visual Cortex (rPVC), left Primary Visual Cortex (lPVC), right inferior lateral anterior Temporal Cortex (riLAT), left anterior Medial Temporal Cortex (lMAT) and the right inferior lateral posterior Temporal Cortex (riLPT) across all respondents. Significant changes in the primary visual cortices, left and right anterior medial temporal cortex and right inferior lateral posterior temporal cortex of experienced interpreters were recorded. These changes highlight the role of visual cortices for visual inputs and processing and the temporal regions in language processing during interpreting. This study pinpoints the defined anatomical part of the temporal lobe that demonstrates changes during activation. The inferior or superior and lateral or medial and anterior or posterior region of the temporal lobe is involved when respondents interpret in the directionality SASL to spoken languages.

Keywords:

Interpreting, Sign Language, Translanguaging, Cognitive Processes, Positron Emission Tomography (PET)

Table of Contents **Page**

CHAPTER 2: Literature Review

Section I Cognitive Language Processing

CHAPTER 2: Literature Review

Section II Interpreting

List of Figures

List of Tables

List of Graphs

List of Acronyms

18F-FDG	Fluorine-18-Fluorodeoxyglucose
AC	Anterior Culmen
ACC	Anterior Cingulate Cortex
ACT	Adaptive Control Theory
ADNI	Alzheimer's Disease Neuroimaging Initiative
AI	Artificial Intelligence
AIIC	International Association of Conference Interpreters
APC	Action Perception Circuit
ASSESSTI	Assessment Tools for the Training of Interpreters
AU	African Union
BA	Brodmann Area
BL	Brandt Line
BOLD	Blood-Oxygen-Level-Dependent
BRICS	Brazil, Russia, India, China and South Africa
BSAE	Black South African English
CFS	Cultural Frame Switching
CG	Cingulate Gyrus

CG	Cingulated Gyrus
CLT	Cognitive Load Theory
CODA	Children of Deaf Adults
CPL	Cerebellum Posterior Lobe
CT	Computed Tomography
DeafSA	Deaf Federation of South Africa
DIVA	Directions into Velocities of Articulators
DLC	Dominant Language Constellation
DM	Declarative Model
DRC	Democratic Republic of Congo
EAF	ELAN Annotation Format
ELAN	EUDICO Linguistic Annotator
ERC	European Community for Research
ERP	Event Related Potential
EU	European Union
FG	Fusiform Gyrus
fMRI	Functional Magnetic Resonance Imaging
FO	Fusiform Occipital
FP	Frontal Precentral
GREIP	Research Centre for Plurilingual Teaching and Interaction

HE	Higher Education
HREC	Human Research Ethics Committee
IFG	Inferior Frontal Gyrus
ILO	International Labor Organization
IPL	Inferior Parietal Lobe
IS	International Sign
L1	First Language
L2	Second Language
LEDC	Less Economic Developed Country
LGBTIQA+	Lesbian, Gay, Bisexual, Transgender, Intersex, Queer, Asexual and other Non-binary Identities
LoLT	Language of Learning and Teaching
MBq	Megabecquerel
MCT	Motor Cognition Theory
MEDC	More Economic Developed Country
MFG	Medial Frontal Gyrus
MP	Minimalist Program
MTG	Middle Temporal Gyrus
OC	Optic Chiasm
OLON	One-Language-Only
PAC	Perception-Action Cycle

PCA	Principal Component Analysis
PET	Positron Emission Tomography
PhD	Doctor of Philosophy
PIS	Participant Information Sheet
PLT	Perceptual Loop Theory
PMOD	Biomedical Image Quantification
SALPCA	South African Language Practitioners Council Act
SASL	South African Sign Language
SASLinc	South African Sign Language Interpreting National Centre
SATI	South African Translators Institute
SDG	Sustainable Development Goal
SG	Supramarginal Gyrus
SIM	Sankofa Interpreting Model
SL	Source Language
SSL	Swedish Sign Language
ST	Source Text
STG	Superior Temporal Gyrus
STG	Superior Temporal Gyrus
TA	Tolerance Ambiguity
TL	Target Language

TMD	Thalamus Medial Dorsal
TT	Target Text
UFS	University of the Free State
UN	United Nations
UNDESA	United Nations Department of Economic and Social Affairs
UNHCR	United Nations High Commissioner for Refugees
UNIOM	United Nations International Office of Migration
UNW	University of the North West
US	University of Stellenbosch
VOI	Volume of Interest
Wits	University of the Witwatersrand

CHAPTER 1

Overview of the Study

1.1 Introduction

Interpreting is a remarkably high-level task, although the immediacy of interpreting makes it a fleeting activity. The implausible characteristics of interpreting compared to translation result in interpreting being viewed as a step-sibling to translation. This view is rapidly evolving, given the cross-disciplinary research in translation and interpreting studies. Current narratives in interpreting circles, both in academia and among practitioners, aim to subvert the general, familiar descriptions of the fragmented view of a separatist language practice stream. There has, therefore, been a rapid increase in the number of publications in translation and interpreting journals, specifically those linked to interpreting sign language. These publications reflect collaboration between sign and spoken language and translation scholars.

A common thread, and a prominent scholarly discussion in sign language interpreting studies, is the quality of interpreting from sign to spoken language/s, also known as voicing[1] (Napier 2003). A discrepancy in quality is evident as documented by studies investigating the perspectives of users on interpreting quality by Napier and Barker (2004), De Wit and Sluis (2014), and De Meulder and Haualand (2019). These studies were conducted in a European context, but in the African context, specifically in South Africa, the quality of interpreting from a users' perpective is only shared anecdotally. Deaf users are not entirely confident of the interpreters' voicing in various settings ranging from liaison to conference interpreting including high-level meetings. In addition, most South African Deaf users do not have insight into the directionality requirements of voicing, such as the metalinguistic and cultural navigation skills required of the interpreter. Given this situation, it is beneficial for various role players in South African Sign Language (SASL) interpreting, such as educators, researchers and practitioners, to gain insight into a

[1] Voicing refers to retour interpreting where the sign language interpreter works from a sign language as the input language and expresses the interpreting product in spoken language, also referred to as the target language (Napier, 2003).

particular aspect that contributes to effective interpreting namely cognitive processes during interpreting. Understanding cognition can aid in understanding the perceived challenges with voicing, at least from the view of language processing in the cognitive domain. It is particulary beneficial to understand the cognition of plurilingual interpreters during simultaneous interpreting, where more than two languages operate simultaneously in the brain. Based on cognition, this window could provide insight into the decision of word choice or communication choice, when working from sign to voice. This window could further guide our understanding of the challenges experienced, albeit regarding a singular variable, the brain, and its intricate operations of language. This study is relevant to cognitive language processing during simultaneous interpreting in a plurulingual context. It grapples with a specific question: "What happens in the multilanguaging black box during interpreting from SASL to spoken language/s?" This question has its origins in the work of Moser-Mercer, a conference interpreter-researcher who stated the following in an interview: "I got very intrigued with what was going on in my brain while I was interpreting, I thought there has to be a way to find out" (Watts, 2016). Makalela (2018) refers to the borderless complexity of language overlap, where the production of one language does not per se imply that other language/s are cognitively 'switched off'.

My interest in cognition and simultaneous interpreting was fuelled by a statement made by Tymoczko (2012:8) concerning cognition and interpreting: "The neurological mechanisms involved in translating and interpreting are one of the chief known unknowns in translation studies". Tymoczko (2012:11) also points to the unknown exploration of cognition and translation/interpreting by stating:

> Much of this terra incognita will be explored and illuminated by neuroscience in the coming quarter-century, and significant discoveries about language processing in translation will be made during the coming decade, linking observable behaviours at the macro-level, with knowledge of what happens in the production and reception of translation at the micro-level of the neuron and the neuronal pathways of the brain.

Linking to discoveries in neuroscience and interpreting, Moser-Mercer (2010) unequivocally state that, for interpreting to develop as a science, the third stage of a scientific discipline must be pursued by cognitive neuroscience this study seeks to contribute. She also states that cognitive analysis enables analysis on a granular level so as to assist in the scientific validation of interpreting theory and models (Moser-Mercer, 2010).

Thus far, understanding the intense cognitive conceptual and physical blending processes of interpreting has been based on theory and stimulus experiments, rather than on rigorous empirical testing using cognitive imaging scans, fMRI or PET, specifically in the Global South.The analysis is based on modelling processed and imaging data to develop cognitive models of interpreting. The exception is premier investigations conducted in Geneva by Moser-Mercer (2000), Hervais-Adelman, Moser-mercer and Golestani (2011), Hervais-Adelman et al. (2015), Hervais-Adelman and Babcock (2019). These studies have extended our knowledge of the neural pathways that link cognition with action for bilingual, simultaneous spoken language interpreters. However, no similar research has been conducted on plurilingual, simultaneous sign language interpreters with a view towards translanguaging in plurilingual settings. This study seeks to fill this gap.

Cognition studies have been pursued mainly in the medical and neuropsychology fields without the contributing, collaborative view of language practisearchers,[2] such as interpreters. The added value of practisearchers brings with it the ontological knowledge of interpreting practice. The study is rooted in cross-disciplinary scholarship between the Humanities and Neuroscience. It proceeds from a critical perspective, which is an approach to the past that produces disturbances to the interpreting studies field to invert familiar narratives of stasis. The project advances rival perspectives for surveying developments. It proposes alternative trajectories in traditional interpreting models related to language processing in plurilingual interpreting settings, as seen in the ubuntu translanguaging contexts in the Global South.

[2] Practisearcher refers to a language practitioner (interpreter) who also wears the hat of a researcher, and thus inhabits a dual role (Gile, 1995 and Pöchhacker, 1995). Napier (2009: 129), defines a practisearcher as: “A [interpreting] practitioner [who] can work with a practisearcher or academic who is more experienced in research, whereby the practitioner become a practisearcher and embark on his own journey of research and publication.”

1.2 Definition of Key Concepts

Although these critical concepts are discussed in more detail in the appropriate sections of this thesis, definitions are included here to benefit the reader. The definitions below are provided to ensure uniformity and understanding of these terms throughout the study, both for the researcher and reader. In each of the following chapters, footnotes are provided for the technical terms applicable to the specific chapter.

- Plurilingualism

In this study, I make reference to plurilingualism and not multilingualism. Canagarajah & Liyanage (2012) distinguish the two concepts as: "The difference between multilingualism and plurilingualism is largely theoretical. These are not different practices. The terms connote different ways of perceiving the relationship between languages in society and individual repertoire" (Canagarajah and Liyanage, 2012:49). Beacco (2005) defines plurilingualism as "This set of skills constitutes the complex but unique competence, in social communication, to use different languages for different purposes with different levels of command" (Beacco, 2005:19).

- Translanguaging

Makalela (2018: 34) defines translanguaging as: "Instead of language use, speakers are languaging and between many names languages, they are translanguaging. Translanguaging is meaning oriented and speaker oriented. What people do with languages (they are languaging) rather than what languages look like (language codes)." According to Kusters et al. (2017:225), within the Deaf community, "Translanguaging is the way we view language as processes of meaning-making rather than as enclosed systems". Code-switching and translanguaging have different epistemological orientations. According to Garcia and Wei (2014:6): "Translanguaging shares some components of code-switching but, in addition, presents the use of additional language resources and meta-linguistic awareness based on the context and communicative event". It is in this distinction between the two concepts that translanguaging is used in this study.

- Plurilinguistic repertoires

The linguistic repertoire refers to the sum of the linguistic resources available to a plurilingual individual (Busch, 2012). Backus (2000:25) explains the linguistic repertoire thus, "A repertoire is composed of a myriad of different communicative tools, with different degrees of functional specialization [sic]. No single resource is a communicative panacea; none is useless." Makalela (2018) refers to the blend of language features used strategically and simultaneously by a multilingual speaker in the context of language repertoire.

- Cognitive language processing

Cognitive language processing refers to an interpreter's holistic mental operations to access the source language (SASL) and render it in a functionally equivalent coherent message in the target language (spoken language/s). The cognitive areas are defined according to the Brodmann classification presented in Chapter 2: Section I. Cognitive language processing is considered a central part of interpreting operations because failure at this level has a significant adverse effect on the interpreter's language production. The inability to understand cognitively, decode a message and render output in a different mode, for example, from SASL (visual-gestural mode) to spoken languages such as isiZulu, Sesotho and so on (vocal-auditory mode), presents a situation where the interpreter cannot fulfil his or her role and communicative purpose.

- Sankofa Interpreting Model

Various interpreting models reflect the interpreting profession's historical evolution and understanding of the interpreter's role in the communication event. Of relevance to this study are the cognitive processing models that describe what occurs in the interpreter's brain when decoding the source language into the target language/s. Notable interpreting models posited are the following: Seleskovitch's triangular model (Seleskovitch and Lederer, (1984), Colonomos processing model (Wilcox and Shaffer, 2005), Gile's effort model (File, 1995, 2018b), Cokely's model (Cokely, 1992), Mizuno's processing model (Mizuno, 2005), Kohn and Kalina's comprehension and production model (Kohn and Kalina, 1996), Setton's cognitive pragmatic model (Setton, 1995), and Wilcox and Shaffer's cognitive model (Wilcox and Shaffer, 2005).

This study proposes a novel interpreting model based on ubuntu translanguaging strategies. The model is named the Sankofa Interpreting Model. *Sankofa* (*Se wo were fi na wosankofa a yenkyiis*), is an African word from the Akan tribe of Ghana, which means: "it is not taboo to fetch what is at risk of being left behind" (Talpade & Talpade, 2014 and Felder, 2019). The *sankofa* symbolises the Akan people's quest for knowledge, based on critical examination, as well as intelligent and patient investigation. This model is embedded in the reflective, ethical multilanguaging practice of interpreters in plurilingual, translanguaging speech and sign communities. In this model, the communicative exchange between the interlocutors is located in real-life ubuntu translanguaging phenomena where the interpreter is considered a part of the communicative exchange. In bridging the gap between the speech and sign communities, the model reflects the interpreter mediating between L1, L2 and L3 and employing their holistic linguistic repertoire to ensure the communicative aim is achieved. This model is proposed in Chapter 6 as part of the recommendations forwarded by this study.

1.3 Background to the Study

By the 1950s, the cognitive revolution, brought new disciplinary perspectives in linguistics, neuroscience, and computer science (Miller, 2003). Psycholinguistics flourished thanks to the cognitive revolution in the 1950s, when the first studies on interpreters were carried out by Paneth, Kurz, Oléron and Nanpon and Barik and Gerver. The migration from behaviorism to cognitivism is not best represented in terms of a Kuhnian "paradigm shift" according to Greenwood (1999). In this regard, Greenwood (1999: 7) states:

> theoretical definitions of the sensory register, attention, long- and short-term memory, depth grammar, cognitive heuristics, visual perception, propositional and imagery coding, episodic and semantic memory, template-matching, procedural networks, inference, induction and the like have abounded in the cognitive psychological literature, operational

definitions as opposed to specified operational measures of these phenomena have been non-exisitent. Cognitive psychological theories from the 1950s onward generally did.

Focusing specifically on interpreting studies and cognition, cognitive science became a significant reference for psycholinguistic research concepts and theories, according to Moser-Mercer (2000). Fabbro et al. (1990) produced scrientific results on cerebral lateralisation, which found right-hand interference in simultaneous interpretation from Ll to L2, where L2 showed weak left-hemisphere lateralisation.This finding confirmed the overall activation of the left and right hemispheres in simultaneous interpretation.

Interpreting scholars developed initial theory-based explanations of interpreting that have not yet been tested to a sufficient extent to either corroborate or falsify them with evidence from cognition experiments. Martin (2020: 173) states: “Translatology should include cognitive approaches to account for translation and interpreting”. Of significance in this context of translatology is the interdisciplinary collaboration between cognitive neuro-science and interpreting studies, where Moser-Mercer (2010) under the auspices of the University of Geneva, embarked on conducting cognition studies on human information processing aspects linked to interpreting. Researchers at the University of Geneva Neuroscience Laboratory, Hervais-Adelman et al. (2011), Hervais-Adelman et al. (2015) and Hervais-Adelman and Babcock (2019), proposed fMRI imaging evidence of two regions significantly active in executive management tasks namely, the caudate nucleus and putamen. fMRI brain imaging has revealed that the caudate is prominent in networks that regulate cognition and action. Given the advances and findings of cognitive investigations in simultaneous spoken language interpreters using fMRI, researchers focused on understanding how the various cognitive areas identified interact. The current project replicates the University of Geneva experiments by refocusing the cognition experiment on plurilingual SASL interpreters during simultaneous interpreting, from SASL to spoken languages. The replicated experiment focuses on cognitive areas prominent in modality differences, which are visual-gestural versus vocal-auditory.

In creating new knowledge and alternative lenses, it is critical for Global South scholars to posit empirical evidence that contributes to academic progress, something this thesis seeks to address.

Makalela (2018), states that the Global South presents unique disruptions to the orthodoxy of a monolingual/bilingual frame of thinking found in the Global North. Makalela (2018) refers to "ubuntu translanguaging", which explitcitly conveys multilingualism in the light of co-existence of language and their interdependencies. Dated European monolingual dogmas are now confronted with transformation, focusing on synthesising local epistemologies, ontologies, and indigenous knowledge systems, such as Sankofa. Such is the case and current reality of SASL interpreting. Formally and informally trained SASL interpreters are products of an education system that was, and still is, partially epistemologically embedded in the European content, theory, and models. This disjuncture presents a scenario where theory and practice are disconnected in plurilingual, ubuntu translanguaging communities, where South African sign language interpreters practice.

In addition, the interpreters are neither native English speakers (Heap and Morgans, 2006) nor native SASL signers, except Children of Deaf Adults (CODA).[3] Furthermore, most interpreters were educated in the South African primary and secondary education system, which is not English-medium based. However, the tertiary education system follows an English medium of instruction and requires written academic English ability. However, the language policy of progressive tertiary institutions is changing, where policy is being amended to reflect language use in the province in which the university is situated. The change in language policy has come about mainly to rid the institutions of implicit systemic exclusion based on language. Inclusive language policy is achieved by first creating a multilingual environment for developing all languages. Second, to create increased access to learning by ensuring that the language of learning and teaching (LOLT) does not exclude the advancement of students in the education system. The academic space as Makalela (2018: 9) states should be a platform for translanguaging: "Because intellectualisation is essentially about use, that is, a language becomes intellectualised at the moment of use in an academic environment, translanguaging is a pedagogical strategy that offers this natural use of languages fluidly and presents opportunities for both intellectualisation and decolonisation of academic discourses that have to date favoured english monolingual tendencies." This context corroborates the dynamic of a colonised linguistic repertoire of most SASL interpreters. Due to

[3] Children of Deaf Adults (CODA) are referred to as L1 sign language users according to Heap and Morgans (2006.) A distinction is made in this study between CODA and heritage interpreter practitioner (HIP), where the latter refers to a CODA who is professionally trained as an interpreter with L1 sign language.

the changing landscape of language practice and its operational relevance in the language practice framework, there is a pressing need for research. The South African market dictates a need for market-ready interpreters, who can render professional interpreting sevices for a plurilingual community. However, the current education and training practices and praxis do not feed into to the market reality.

In the language practice field, it becomes even more beneficial in understanding the acts of language practice (specifically sign language interpreting) when research is presented from the 'other end'. This other end has its beginning rooted in the language practitioners themselves. By acknowledging the aspect of self-representation and diverse linguistic repertoires of the practisearcher and respondents, it reflects an approach rooted in respect for the fundamental human and linguistic rights of minority groups, such as the Deaf community. In the African context, this approach in the research is rooted in the principles of ubuntu.[4] As a researcher, it is imperative to contextualise a community project by constant reference to the aporia "*umntu ngumntu ngabantu*" (a person is a person through other people). [5] As stated by Eze (2010:12): "'A person is a person through other people' strikes an affirmation of one's humanity through recognition of an 'other' in his or her uniqueness and difference. The 'I am' is not a rigid subject, but a dynamic self-constitution dependent on this otherness creation of relation and distance."

Underpinning the background of this research project is Martin's view of a translatology in that research must provide a theoretical framework for a systematic and coherent description of old and well-grounded intuitions. He states: "Theories can only be improved or disproved through experimental research, so it is high time to agree on sorne common, basic procedures to re-establish the normal relationship between them" (Martin, 2020: 183).

---

[4] "*Ubuntu*" is a Nguni Bantu term that defines humanness as contingent on respect for humanity (Lundin, 2012).
[5] "*Umntu ngumntu ngabantu*" is an isiXhosa phrase that translates "I am because we are" (Lundin, 2012).

1.4 Rationale

Cross-disciplinary research presents a unique opportunity for scholars from different study fields to present integrative, novel perspectives that contribute to the transformation of disciplines. This study explores cognitive language processing and draws on scholarly works primarily in translation and interpreting studies and neuroscience. This study adds to the scholarly works in translation and interpreting studies and neuroscience and is, therefore, timely.

Perspectives on translanguaging theory are incorporated from a critical analysis perspective to produce disturbances to the pedagogy of interpreting studies and interpreting practices in plurilingual speech and sign communities. The effects of translanguaging in a plurilingual environment such as South Africa and cognitive language processing are central to this study to provide insight into the mental operations of simultaneous interpreters using PET brain imaging. According to my knowledge, previous research in interpreting studies, specifically sign language interpreting studies, has not introduced the concept of translanguaging related to the process of interpreting. In addition, to my knowledge, none of the interpreting models project the idea of translanguaging and its function in the communicative event. Furthermore, the literature on interpreting models is silent on interpreters' and interlocutors' pluralistic repertoires in the interpreted event. Another aspect related to the studies enumerated above is the geographical reach and context. Studies conducted in the Global North contribute to the operational definitions of interpreting and its associated dynamics, but lack investigation in cognition with specific reference to language processing as it appears in plurilingual SASL interpreting. It can be surmised that aspects of plurilingualism, translanguaging, and cognition during simultaneous interpreting from a visual-gestural to a vocal-auditory mode remain an under-researched aspect. Sign language interpreting studies present a perplexing reticence regarding aspects of cognitive investigation during simultaneous interpreting.

In the context of plurilingualism, this project seeks to understand cognitive functioning and the interface with linguistics when interpreting from SASL to spoken language/s, and how translanguaging unfolds in the final interpreting product in the target language. This study is timely in proposing an alternative lens by means of which to interpreting practice in plurilingual communities. This study is progressive in recognising the holistic professional, linguistic, and social profile of SASL interpreters. This study acknowledges the interpreters' idiolect and their role as communication agents. Most importantly, this study acknowledges the interpreters' role in restorative justice for minority language/s and linguistic minority communities by working in multimodal and multisensory modes (audio- and visual-gestural mode) to construct communicative meaning in plurilingual settings. It is central and pertinent to the statement by Mazzafero (2018:4): "Interactional communicative practices are sensitive to how linguistic and semiotic materials are creatively and critically processed by speakers to construct and organise their everyday life, by acquiring knowledge about the context and the participants involved in the interaction."

The concept of translanguaging is fundamental to this study. It clarifies the intersection of translanguaging and interpreting praxis in plurilingual interpreting settings. Translanguaging in the interpreting context is understood in this study as the application of interpreting strategies and decision-making in everyday interpreted communicative events in order to satisfy communicative intent. Interpreting communicative intent presents a nexus of negotiated and constructed strategies, resulting in a meaningful social interaction that recognises and affirms the linguistic repertoires of plurilingual persons, as defined by Mazzaferro (2018) and Garcia and Li Wei (2014). The statement by Mazzaferro (2018:3) is significant in redefining interpreting in a plurilingual, translanguaging environment as follows: "Languages are not fixed entities, but are continuously shaped and reconstructed because language is not an abstract system of fixed rules and norms, but practice and action performed by individuals in reflexive, relational and dialogical ways". Further to the understanding of translanguaging strategies is the evidence presented by Kusters et al. (2017) of translanguaging in Deaf communities, where sign language interpreters are expected to function and render coherent interpreting products in the target language/s based on translanguaged input language, in this context a sign language input language that has elements of translanguaging.

1.5 Aim and Objectives of the Study

The motivation for this inquiry is two-fold:

- First, to understand plurilingual interpreters' cognitive language processing using neurological investigation.
- Second, to access the idiosyncrasy of simultaneous interpreting from sign language (visual-gestural mode) into spoken language/s (audio-mode).

1.5.1 Aim

The study aims to provide evidence of cognitive language processing during simultaneous interpreting in SASL interpreters.

1.5.2 Objectives

The primary objective of the study is to document the cognitive areas activated under PET-brain imaging during simultaneous interpreting. The secondary objective is to develop an interpreting model informed by translanguaging strategies during simultaneous interpreting.

1.6 Statement of the Research Problem

Interpreting studies research mainly investigates the technicalities and models of interpreting processes as seen in the scholarly works of Harrington and Turner (2001), Pöchhacker and Shlesinger (2002), Janzen and Korpinski (2005) and Locker McKee and Davis (2010). Previous research by Kahane (2000), Kellett (2002), Shlesinger (1997), De Wit and Sluis (2014) and De Wit (2011; 2016) documented the quality of interpretation in both spoken and sign languages. Studies that demonstrate the quality of interpreting are mainly discussed by Pöchhacker (2002). The quality of sign language interpreters and interpreting has been covered by Cokely & Winston (2008; 2009), Napier (2003), Napier and Barker (2004) and Napier and Rohan (2000). The quality of spoken language interpreters has been documented by Edwards, Temple and Alexander (2005) and Locker McKee (2008). Aspects of conference interpreting quality have been discussed by Gile (1990; 2001), Kurz (1993), Vuorikoski (1995), Moser (1995; 1996), Kalina (2002) and Diriker (2011). The studies mentioned focus on various aspects of interpreting and drawing conclusions based on the overt interpreting product. However, it will aid our understanding of interpreting by researching cognitive functioning during simultaneous interpreting to corroborate and present evidence on the cognitive processes of interpreting using imaging studies. Contributions from researchers focusing on models of interpreting present a unidimensional lens, since they exclude the implicit, covert, cognitive processes demonstrated by neurological experiments.

1.7 Statement of Research Questions

1.7.1 Primary research question

Which brain clusters are activated neuroanatomically while interpreting SASL to spoken language under PET-brain imaging?

1.7.2 Secondary research question

a) Which specific brain areas show significant activation during simultaneous interpreting?

b) How does the optic chiasm present when processing SASL into spoken language/s, simultaneously under PET brain imaging?

c) What does the perisylvian region present during interpreting simultaneously from a visual-gestural modality to audio-speech modality?

In an attempt to answer the research questions, the illustrations below are incorporated to clarify the biology of the brain and the link to the research questions. The figure below illustrates the brain and highlights the 14 brain cluster areas of interest in this study concerning the primary research question.

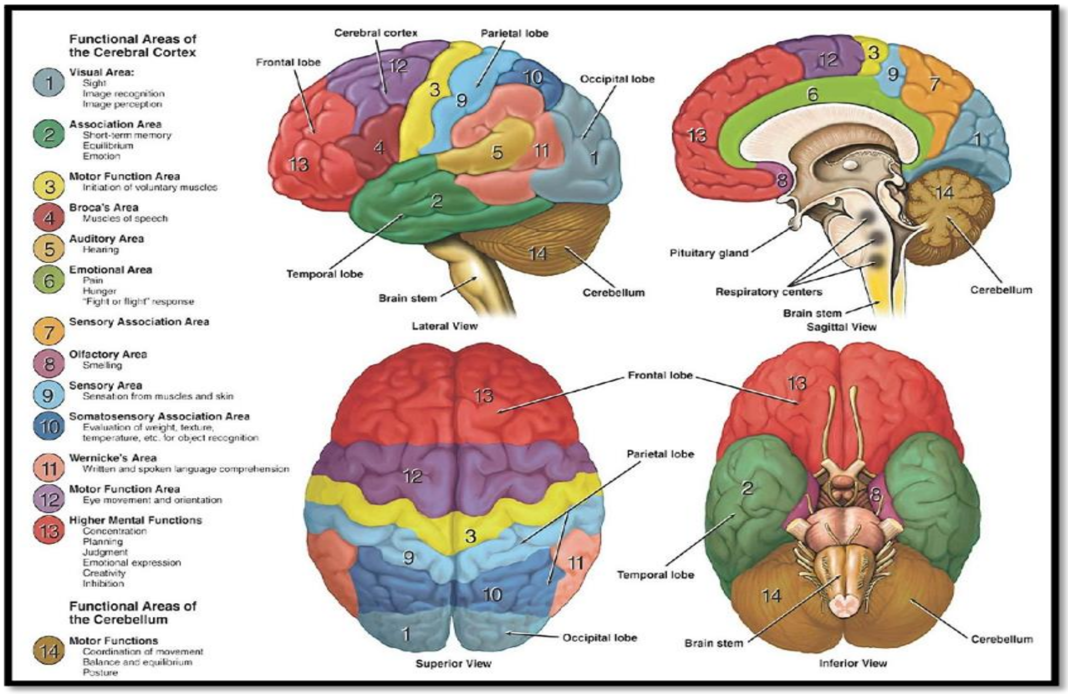


Figure 1: Anatomy of the brain (Zhang, 2019).

Figure 2 below illustrates brain areas relevant to the secondary research questions of the study, questions a and c.

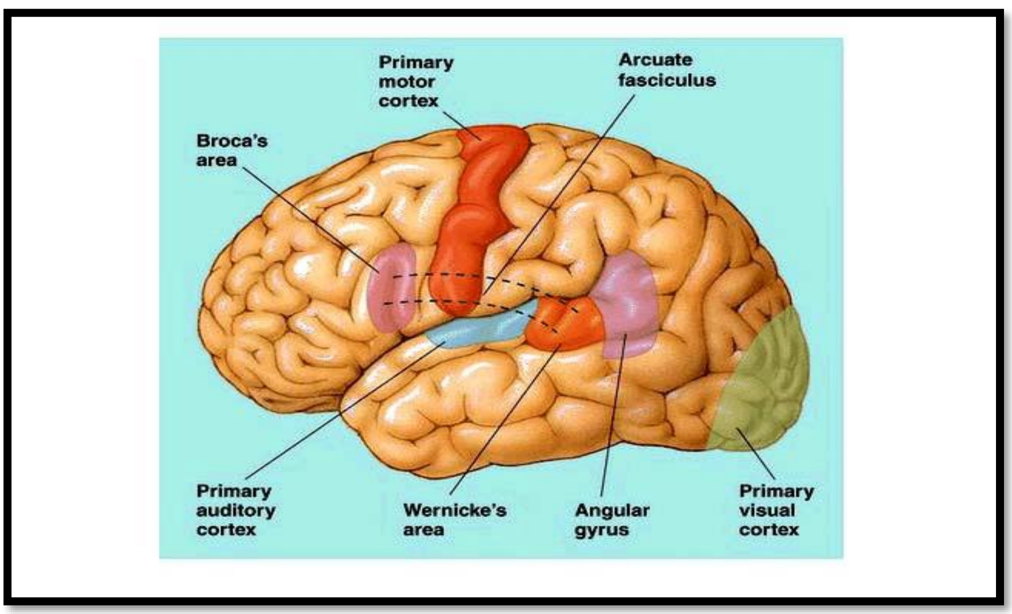


Figure 2: Perisylvian language areas (Broca's and Wernicke's areas) and other language-associated brain regions (Pinel, 2000).

Figure 3 below illustrates the optic chiasma. The optic chiasm links to the visual cortex to make sense of visual information. This aspect of visual information is relevant to the study because of the visual language input by SASL. This information will assist in responding to the secondary research question (b).

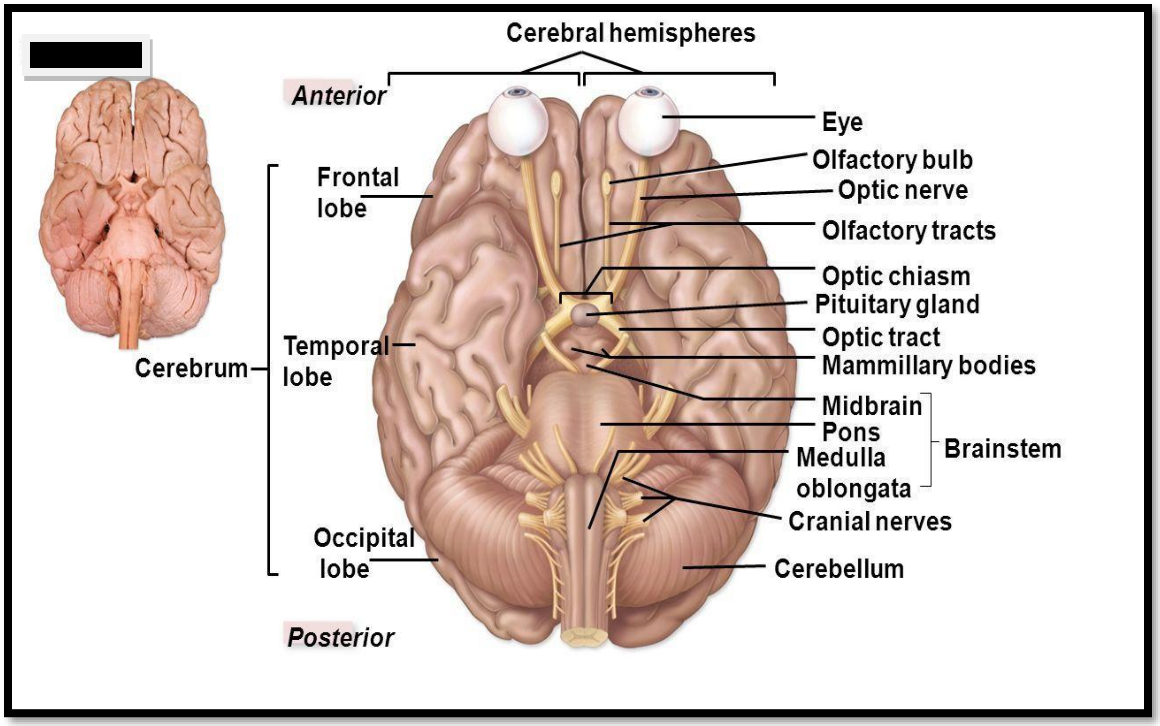


Figure 3: Integrated neurological functional visual-processing model (LaPres, 2009).

1.8 Statement of the Predictive Hypothesis

From sign to spoken language/s, the simultaneous interpreting product is directly linked to the nexus of cognitive language processing and the linguistic repertoire of a plurilingual interpreter.

1.9 Theoretical Framework

This study is underpinned by the motor cognition theory (MCT) and the adaptive control theory (ACT) to allow for application on a theoretical level contextualised to the act of interpreting in a plurilingual setting using PET brain imaging. It anticipates sketching contours of the extended application of the MCT and ACT in interpreting studies.

data collection tools namely a questionnaire, voice recording of the interpretation, and PET brain imaging. The data analysis tools include AmberScript Audio Transcription Software, EUDICO Linguistic Annotator (ELAN) and PET brain analysis software NeuroQ^{TM}.

1.10 Methodology

The research design is a mixed method study that employs both qualitative and quantitative methods. Cresswell (1998:457) defines the mixed method approach as: "One in which at least one quantitative method and one qualitative method is used to collect, analyse and report findings in a single study".

1.10.1 Participants in the study

The study subjects are plurilingual sign language interpreters. The study used purposive sampling, a non-probability sampling method based on the characteristics of a population and included plurilingual interpreters with a minimum of three languages inclusive of SASL. The sampling target was twenty interpreters.

1.10.2Medical protocol

Developing protocols for PET brain imaging provide valid dosimetry procedures with preparation and acquisition times according to standard clinical practice (Vaquero and Kinahan, 2015). This project's protocol follows standard clinical procedures for PET brain imaging as, posited by Harris et al. (2005), Jeong et al. (2006), Alessandrini et al. (2014), Verger and Guedj (2018) and Chiaravalloti et al. (2019). The detailed medical protocol developed for this specific study is discussed in Chapter 4, Methodology. Reference is made to relevant PET brain imaging protocols in the data analysis, Chapter 5, section C.

1.10.3 Data collection and analysis

More than one method is used to obtain converging evidence, that is, a triangulation of data. Data were collected using three tools, questionnaires, voice recordings (interpretation) and PET brain imaging.

The specific focus of the data analysis in this study was the analysis of the interpreting processes of reception (SASL input) and production (spoken language(s) output) to map the linguistic-interpreting strategies presented during the experiment. No prior research could be found that focuses specifically on translanguaging during simultaneous interpreting between two language modalities.

The following approach was used for data analysis:

A) Questionnaires: analysis follows the themes according to the questionnaire.

B) Voice notes: the interpreted recordings of the respondents (voice notes) were transcribed and analysed using AmberScript and ELAN.

C) PET brain imaging: NeuroQ^{TM} software was used to analyse cognitive activity and areas of significance under activation.

1.10.4 Ethics

Medical ethics clearance applies to this study since it employs medical technology (PET brain imaging). In addition, video and audio recordings were made, which impacted anonymity and confidentiality. The respondents were informed of the aims and processes of the research before they agreed to take part. Informed consent was obtained using the participant information sheet (PIS) and the consent form for both the interpreter respondents and the SASL source text contributors (Appendixes A (I), A(1) (a), A (II). A briefing and orientation document was prepared that outlined the process, which orientated the respondents when they presented for the scan (Appendix A (iv) – Briefing and orientation document).Ethical clearance for this study was obtained from the University of the Witwatersrand Human Research Ethics Committee (Medical), Clearance Certificate M 1811100 (Appendixes A, A (V), A (VI).

1.11 Organization of chapters

Chapter 1: introduces the study and provides context by locating it in the emerging field of cross-disciplinary scholarship between Humanities (Interpreting Studies/Language Practice) and Cognitive Neuro-Science (PET brain imaging). This chapter provides a background to the study, the definition of critical concepts, rationale, aims and objectives, a statement of the research problem and research questions. It provides the reader with a map of the thesis by briefly outlining the theoretical framework and methodology. In addition, it introduces the reader to the data collection tools and processes followed in the study. Finally, the limitations of the study are presented.

Chapter 2: focuses on the literature review and comprises three sections: Section I: Cognitive language processing, Section II: Interpreting and Section III: Translanguaging.

Chapter 3: provides the theoretical framework.

Chapter 4: guides the reader on the methodology followed in the study.

Chapter 5: documents the data collection tools and collection processes. It presents and illustrates the data analysis of the study and discusses the findings and extension of the application of the MCT and ACT to interpreting contexts.

Chapter 6: is the concluding chapter of the study and presents limitations, conclusions and recommendations for future research. This chapter presents the novel praxeological model of interpreting, the Sankofa Interpreting Model.

CHAPTER 2
Literature Review

Section I

Cognitive Language Processing

"There is no greater impediment to a unified cognitive neuroscience than our inveterate Aristotelian tendency to consider cognitive functions as separate entities"
(Fuster, 2008:11).

2.1 Introduction

According to Meir et al. (2012), language and its origins inspire a natural curiosity to understand where it started, and how its evolution progressed across time. Kent (2012) frames language development as a natural process that reaches maturity. Despite the continued curiosity, Hauser et al. (2014) suggest that various investigations into the origin of language remain unverifiable and, therefore, the origins and evolution of humans' linguistic capacity remain inconclusive.

One view of language and its origin is that of Chomsky (1968:11), who is an established scholar in the philosophical study of mind and language. He stated the following: "Human language is a biological object". Entrenched in this statement is the view that language is an inner mental function. The view of language as an innately specified mental object is linked to language acquisition, and the acquisition processes directly implicate a higher-order function according to Chomsky (2000), Cowie (2017) and Kedar (2019). In extending our understanding of human language, perceived to be domain-specific, Hauser, Chomsky, and Fitch (2002) bring to the fore cognitive and perceptual systems as part of human language hubs. The current magnification and brain imaging techniques enable the analysis of tissues and molecules, which is believed to aid in the functional mapping of the cerebral cortex and the physical map. According to Ackerman (1992:65): "Mapping reveals the differential distribution of certain molecules along the lines of function [in the various regions]". Kaas (1997) suggested that studies done on mammal cortices through electrophysiology[6] and cytoarchitecture[7] presented topographical maps, which illustrated the innate connectedness of neurological components and functions. In addition, the most recent analysis of brain networks is done by new imaging acquisition methods, graph theory, and dynamic systems (Sporns, 2013).

In this section of the literature review, the focus is on the biology of the brain and cognition experiments that conform to language and brain functioning.

2.2 Neuroanatomy of the Brain

This section of the literature review provides a holistic orientation to the brain and cognitive functions. This study is equally interested in both hemispheres, due to the analytic language processing (in the left hemisphere) and the visual-gestural nature of SASL (in the right hemisphere).

2.2.1 The cerebrum

According to Anderson and Lightfoot (2002), the cerebrum compromises four lobes: the frontal, temporal, parietal, and occipital. The cerebrum is the most substantial part of the brain that regulates cognitive functions. Contralateral brain function means that the left hemisphere governs the right side of the body, and *vice versa* according to Corina et al. (2003), Concha, Bianco and Wilson (2012), Groen et al. (2012), Turner et al. (2015), Karolis, Corbetta, and Thiebaut de Schotten (2019), and Neubauer et al. (2020). Kroll and Sunderman (2003), Leisman, Moustafa and Shafir (2016) and Olulade et al. (2020) argue that language, rhythmic perception, temporal-order judgments, and mathematical thinking skills are found in the left hemisphere. The right hemisphere is the hub for pattern-matching tasks, recognising faces, and spatial orientation according to Kroll and Sunderman (2003), Thompson-Schill, Bedny and Goldberg (2005) and Leisman et al. (2020).

[6] Electrophysiology according to Carter & Shieh (2010) is defined as: "the branch of neuroscience that explores the electrical activity of living neurons and investigates the molecular and cellular processes that govern their signalling" (Carter & Shieh, 2010: 91).
[7] Cytoarchitecture, see Bludau et al. 2014.

Studies conducted by Murray, Bussey and Wise (2000) and Nystrom et al. (2000) produced evidence that the left frontal lobe is activated when language is produced and the anterior right lobe is activated in visuospatial processing. This evidence is supported by Friederici (2004), Friederici, Meyer and Von Cramon |(2000) and Friederici and Gazzaniga (2004), who name the specific brain areas activated during semantic processing as the Pars Triangularis (BA 45), and the Pars Opercularis (BA 45/47).

According to Gow (2012) and Chee et al. (2004), the temporal lobe presents activation during lexical tasks. According to Hesse et al. (2006), Kemeny et al. (2006) and Stephan, Fink and Marshall (2007), activation of lexical tasks is not restricted to the temporal lobe. Hashimoto and Sakai (2003), San Jose-Robertson et al. (2004) and Jacquemot and Scott (2006) present evidence that phonological word forms and phonetic processing is found in the mid- to posterior superior temporal cortex. In addition, these scholars propose that phonological processing in speech/sign production presents in the left hemisphere.

Conceptual-semantic knowledge and non-phonological lexical information present in the cortical areas. Note that this cortical region is different from the superior temporal region that contains word forms and phonology. Worsley et al. (1992), Block (1995), Beeman and Chiarello (1998), Wolpert, Goodbody and Husain (1998), Hashimoto and Sakai (2003) and Boden (2006), conducted hemodynamic neuroimaging studies. They presented evidence that the left cortical side of the brain is activated during processing of lexicon. Neuroimaging studies conducted by Horwitz et al. (2003a, b) and Kemeny et al. (2006) suggest that both the temporal lobe and the mid-posterior superior temporal cortex in the supramarginal gyrus are activated in lexical processing. The authors further refer to the exact Brodmann areas activated when the brain processes lexicon namely, BA 40, BA 6 and BA 44 (Horwitz et al. 2003 (b) and Kemeny et al. 2006).

Of relevance to this study are the findings from an experiment developed by the Max Planck Institute for Human Cognitive and Brain Sciences by Friederici et al. (2000) and Frederici and Gazzaniga (2004). Evidence from the studies suggests that cognitive syntactic processing occurs when the brain performs phonological processing on a word that is heard in a sentence (Frederici et al, 2000 and Frederici and Gazzaniga, 2004). In addition to these findings, evidence suggests that BA 44 is implicated in morpho-syntactic integration that further activates BA 45 and BA 47 (Frederici et al. 2000 and Frederici and Gazzaniga, 2004). However, the study did not present conclusive evidence of correcting an error or omission under the experiment, also referred to as repair and revision as part of the monitoring phase in interpreting. Repair and revisions are interpreting strategies whereby the interpreter corrects the error in the target language output (Gile, 2005). Mahendra et al. (2003) present evidence of the basal ganglia in repair and revision incidences.

When comparing studies of the brain in sign language to clinical neuropsychology studies, there is an inconsistency with the imaging data, according to Pettito and Marentette (1991), Pettito et al. (2000; 2001; 2016) and Pettito (2005; 2009). Clinical neuropsychology and imaging present activation of the left hemisphere for sign language processing, but the imaging data do not provide conclusive evidence regarding activation because the images also highlight the activation of the right hemisphere (Kroll and Sunderman 2003; Kovelman et al. 2008). The activation of the right hemisphere is supported by Pettito and Kovelman (2003) and Pettito & Dunbar (2004), who presented evidence showing that left cognitive areas are responsible for multimodal language processing. In this context of multimodality and that of sign languages as visual-gestural languages McGuire et al. (1997) and Neville et al. (1997) suggest that processing of abstract linguistic properties is evident in the temporal areas.

2.2.2 Broca’s and Wernicke’s Area

The Broca and Wernicke areas apply to this study since they show how language is processed on a syntactic and lexical level, and how it integrates by interpreting. Both the upper part of the lateral temporal lobe (Wernicke’s area) and the lower lateral part of the frontal lobe (Broca's area) fall within perisylvian regions according to Hagoort (2006). The Broca area is concerned with language production and comprehension and is the brain area where syntactic processing, language comprehension and motor-related activities occur (Hagoort, 2006 and Stinnett, Reddy and Zabel, 2021).

The Broca area is connected to Wernicke's area by a neuronal tract named the arcuate fasciculus (Gannon et al. 1998). These areas are situated in the parietal/temporal region in the left hemisphere and show evidence of lexical errors and incidences of comprehension impairment. Wernicke's area focused on semantics (Pandya, 1995; Dronkers, 1996; Aboitiz and García, 1997; 2009 and Nasios, Dardiotis, and Messinis, 2019). Broca's area is made up of the pars triangularis (BA 45) and the pars opercularis (BA 44) and extends down to BA 47 and back to the frontal operculum (Caplan et al. 2000 and Hagoort, 2006). The anterior portion is implicated with semantics and the posterior is associated with phonology (Nasios et al. 2019). Broca's area is also necessary for language repetition, gesture production, sentence grammar, and fluidity and is involved in interpreting the actions of others (Pettito, 2005; 2009).

Emmorey (2002) states that syntactic processing presented in the left perisylvian regions is the same in both sign and spoken languages. This finding is confirmed in a study by Horwitz et al. (2003) on spoken and sign languages with evidence of activation in the Broca area. Murray et al. (2000) suggest that higher word order recognition is processed in the anterior and ventral auditory regions in the left hemisphere.

2.2.3 The optic chiasm

According to Kent (2012), the optic chiasm links visual information and processes it. However, he states there is a fragmented view on cognitive language processing and its link to the optic chiasm. Recent studies present some basic findings related to optic chiasm functioning. Partial crossing of optic nerve fibers at the optic chiasm allows the visual cortex to receive the same hemispheric visual field from both eyes (Herrera and García Frigola, 2008 and Mehra and Moshirfar, 2020). The optic tract plays a central role in visual processing and is composed of nerve fibres that convey visual input (Mehra and Moshirfar, 2020). The lateral geniculate nucleus of the thalamus plays an essential role in visual processing. The lateral geniculate nucleus receives input from the cranial nerve nuclei, tectum, tegmentum, colliculi, medulla, and pons.

2.2.4 The cerebral cortex

To understand how nerve impulses that eventually give effect to an action originate, I refer to the studies conducted by Horwitz et al. (2003) and Kemeny et al. (2006), where they explain the processes that aid in cognition. These scholars posit that electrochemical nerve impulses emanate in dendrites and cell bodies, and are conducted along the axon of the axon terminal. When the impulse reaches the axon terminal, it must release neurotransmitters. The neurotransmitters attach to receptor molecules that generate their own nerve impulses. These nerve impulses, contextual to this study, are understood to give effect to a spoken language interpretation. If this interpretation is delivered, we can deduce that cognition was successful. This part of cognition is linked to the theoretical framework of this study, which refers to the motor cognition theory (MCT) discussed in Chapter 3, Theoretical Framework and Methodology).

2.2.5 The cerebellum

The cerebellum, specifically the lateral neocortical region, provides a base for higher cognitive functions and shows involvement during language, memory, and emotion (Fuster, 2004). The cerebellum is made up of the basal ganglia and the hippocampus (Kemeny et al., 2006). The right cerebellum is involved in searching for lexical knowledge (Caplan et al., 2000 & Caplan, 2001). Retrieving lexical items depends on the basal ganglia and the inferior frontal gyrus, specifically Broca's area and BA 47 (Caplan, 2001 & Kotz et al., 2003).

2.3 The Network Paradigm

By fleshing out the neurological areas linked to interpreting processes and functions, Fuster's network paradigm[8] assists with understanding the intricacies of cognitive processes (Fuster, 2009). This paradigm states that across various regions of the brain, higher cortical functions decussate voluminously. What this implies, with reference to the neurological network, is that a single neuron

[8] The network paradigm is posited by Fuster who states the following: "memory or an item of knowledge defined by a pattern of connections between neuron populations associated by experience" (Fuster, 2009:2047). (See Fuster: 2003; 2004; 2008; 2009).

forms part of various network channels, to present a whole integrated function. According to Brodmann's classification, each faculty, illustrates lexical, morphological, syntactic, grammatical and computational functions that operate holistically. According to Fuster (2009), linguistic and cognitive processes are synchronised by executive control.

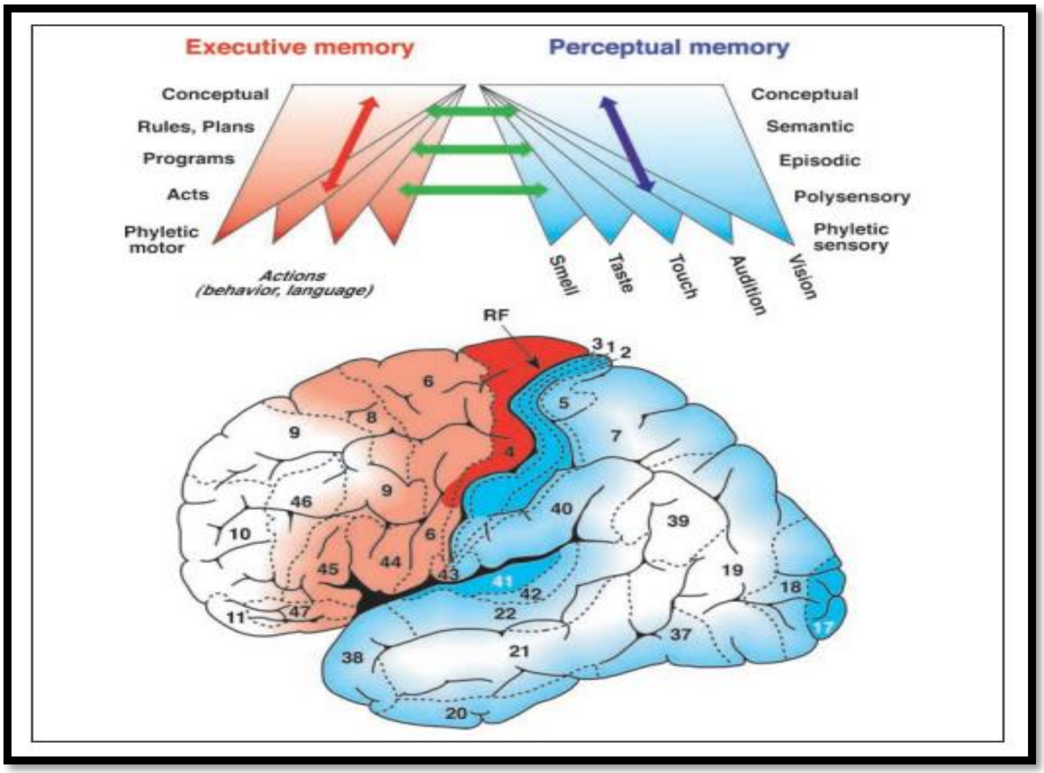


Figure 4: Representational map of the human lateral cortex (Fuster, 2009:2062).

The complexities of language processing are often regarded as an automatic process. However, as presented by cognition and language processing studies and the Network Paradigm, the process is much more complex than this.

2.4 Executive Operationalisation Processes

The understanding of a message involves cognitive processing ability. According to Dabrowska (2012), various linguistic features such as grammatical, morphological, semantic and syntactic items must be processed simultaneously to arrive at either the expression or reception of a coherent message.

This section of the literature review focuses on functional organisations of the sensory and perception systems of the brain and their relation to speech and visual recognition. Behavioural, cognitive and linguistic action can be seen in the cortex of the frontal lobe (Fuster, 2001). In an fMRI study, Koechlin, Ody and Kouneiher (2003), presented premier evidence of the cascading neuro dynamics of the executive frontal hierarchy in motor action. It is by this data that they inferred that the rostral prefrontal cortex controls behaviour. Botvinick (2008) presents models of prefrontal functions. The significant finding relevant to Koechlin et al. (2003:1181) is that: "The lateral prefrontal cortex is organized [sic] as a cascade of executive processes from premotor to anterior prefrontal cortex regions that control behaviour according to stimuli, the present perceptual context, and the temporal episode in which stimuli occur".

This implies the circular flow of information from the environment to sensory structures, to motor structures and back again to the environment during the processing of goal-directed behaviour. The study explains the pattern of prefrontal activation of the caudal and rostral left prefrontal cortex areas related to learning, episodic memory, working memory, and task-switching paradigms. Of further significance is that Koechlin et al. (2003) presented evidence that activation of the prefrontal regions and the posterior-anterior axis is not based on relational complexity or memory load. Instead, it is based on the temporal structure of representations underlying executive control.

Cutsuridis (2013) presents cognitive models of the perception action cycle (PAC) on artificial intelligence (AI) models. For this study, there is a focus on perception and action (interpreting). Koechlin et al. (2003) present the PAC based on imaging studies on humans. Negrón-Oyarzo, Aboitiz & Fuentealba (2015) propose a cognitive mapping of the PAC. According to these authors, the PAC refers to an appropriate behavioural response based on perceptual information integration in the prefrontal cortex. The activation of the PAC is explained by Negrón-Oyarzo et al. (2015:2) as follows:

> For the execution of the perception-action cycle, the PFC projects to neural systems involved in generating behavioral responses and executing actions. The PFC projects to several outputs, such as the premotor cortex, the hypothalamus, the striatum , and the ascending arousal system. Thus, the PFC projects to motor, neuro-modulatory, and visceral

> brain systems to generate an appropriate response according to internal and external demand in a goal-directed manner.

Negrón-Oyarzo et al. (2015:2) state that internal and external environmental information is transmitted from the orbitofrontal cortex (OFC) and the insula to the prefrontal cortex. In addition to this transmitted information, the specific areas involved in the learning of new information, transmission of information and memory:

> The thalamus (mediodorsal and reuniens nuclei), which is involved in learning new information, from the hippocampus (HPC), which is involved in spatial and episodic memory and in memory consolidation [44, 45], and from the amygdala, which carries information about the motivational significance of sensory stimuli.

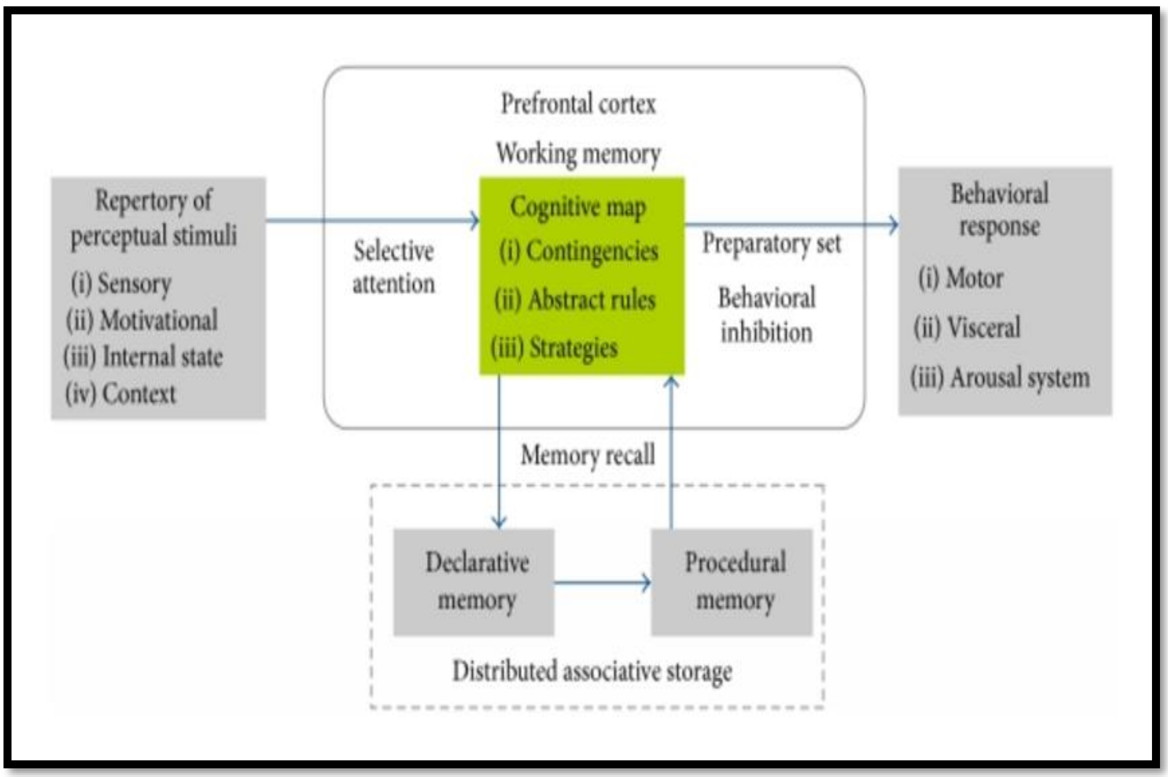


Figure 5: Cognitive map of the perception-action cycle in the PFC (Negrón-Oyarzo et al. 2015:3).

2.5 Language and Cognition Studies

The literature on cognitive functioning has two distinct schools of thought; one is a separatist view, where brain areas separate. The other understands brain areas as functionally inseparable (Fuster, 2004 and Pessoa, 2014). With interpreting, the current view supports the second view, in that during the act of interpreting, various linguistic mechanisms and cognitive control mechanisms are coordinated with each other (Hervais-Adelman amd Babcock, 2019).

According to Wagner, Malisz and Kopp (2014), human communication is made possible by speech, gesture, and signs. Wagner et al. (2014:219), propose that "communication is the product of multimodal strategies". Sign language as a communication mode is a full-fledged linguistic system, independent of a spoken language (Emmorey, 2002; Sandler and Lillo- Martin, 2006 and Pfau, Steinbach and Woll, 2012). According to Emmorey (2002), neuro-cognition studies of sign language present similar cognition activation linked to cognitive faculties of human language, with the only difference being the sensory modality. We can deduce from this statement that language processing is not solely determined by the auditory input modality (hearing). The conclusion is that spoken and sign languages present similar activation of specific brain areas. Thus, these languages are similar in relation to cognitive functioning (Braun at al. 2001; Emmorey, 2002 & Campbell, MacSweeney and Waters, 2008).

Language in various implicated areas of the brain makes reciprocal and recursive in formation possible. According to Perry and Lupyan (2013), language and thought are central to the linguistic activity.

2.6 PET Brain Imaging Studies

Numerous PET brain and fMRI studies have found activation in the temporal lobe regions when word forms or meanings are used under intervention (Buckner et al., 2000).

2.6.1 Imaging methods

The two brain imaging methods applicable to this project are Positron Emission Tomography (PET) and Functional Magnetic Resonance Imaging (fMRI). These imaging methods provide a noninvasive method where brain activity, can be investigated under controlled conditions. These methods provide increasingly accurate brain scans that inform our understanding of localised cognitive functions. Fowler and Ido (2002:6) define FDG, used in this study as follows: “Fluorodeoxyglucose (18F) (INN), or fluorodeoxyglucose F 18 (USAN and USP), also commonly called fluorodeoxyglucose and abbreviated [18F] FDG, 18F-FDG or FDG, is a radiopharmaceutical used in the medical imaging modality positron emission tomography (PET)”. In this project, FDG will provide insight into language functions, locations of language areas, and its interaction during intervention. Frackowiak and Friston (1994:8) endorse cutting edge brain imaging techniques by stating the following: “The advent of brain imaging is opening new vistas and provides new data, thus improving our understanding of the biological basis of language.” Peperkamp and Mehler (1999) present evidence of sign language being partially inconsistent with imaging data due to neuropsychology and imagery presenting activation of the left hemisphere. In contrast, only a few studies present evidence of activation of the right hemisphere. The main findings of the 1999, Peperkamp and Mehler study are that

> Sign languages rely more than spoken languages on bilateral cortical representation. This would mean that the involvement of the RH inn sign language processing has been neglected in clinical neuropsychology studies. Second, sign and spoken language processing might share the same basic network of areas in the left hemisphere. This would leave unexplained why some imaging studies have found such massive involvement of the RH in sign language perception (Peperkamp and Mehler, 999: 343).

This study on SASL interpreters utilises PET brain imaging for the reasons stated in Chapter 1 (Overview of the study). PET is a form of hemodynamic neuroimaging which maps changes in the blood flow and metabolism in the brain (Fiez et al. 1996 & De´monet and Cardebat, 2000). According to Binder et al. (1997) and Buckner et al. (2000), PET is used for identifying neurotransmitters and other molecules that underlie language and neurotransmitter-associated language processes. PET brain imaging, using oxygen consumption for blood flow measurement or ^{18}F-Fluorodeoxyglucose (FDG) for metabolism in activation, has been used in previous studies (Raichle, 2015; Wataba amd Hatazawa, 2019 and Jamadar et al. 2020). Verger and Guedj (2018) wrote an editorial on the renaissance of functional brain activation imaging using ^{18}F-FDG. Therefore, in this study ^{18}F-FDG was used to investigate which brain areas are activated when interpreting diamesic texts.

The method of PET brain imaging is non-invasive. The scan of the spatial resolution limits its accuracy in localising activation to a particular brain region (Binder et al. 1997; Buckner et al. 2000; Moser-Mercer, 2010 and Kosslyn et al. 1999). It must be stated here that, according to Moser-Mercer (2010), fMRI scans provide better spatial resolution, which is also mentioned under challenging PET scan interpretations in the writings of Fiez et al. (1996) and Grabowski et al. (1995). These limitations are mentioned in Chapter 1, together with the reasons why PET is an adequate imaging scan for this type of study, specifically in the interpreting direction SASL to spoken language(s), and not the alternative direction of spoken languages to SASL. A PET study by Mazoyer et al. (1993) was the first to explore the brain activation, while respondents listened to spoken sentences. Of all the PET studies that were conducted, none were imaged under the intervention of simultaneous interpreting where the respondents are plurilingual sign language interpreters.

2.6.2 Imaging studies

The cognitive complexities in the language faculties and their coordination during the act of interpreting necessitate this inquiry, specifically for multilingual interpreters to gain insight into the evolving process of the brain. Of interest is the biological basis of language and its relationship to processing and representation in events of high cognitive demand, such as interpreting. The literature refers to spatio-temporal dynamics of language processing, which also considers the real-time temporal interplay of various regions. In addition, focus is placed on the cortical regions of the cerebrum because interpreting is a form of higher cognitive function.

Abutalebi et al. (2008), conducted a fMRI study on German-French bilingual subjects through a picture naming experiment comparing mono-and bilingual contexts. The main finding in this experiment was significant in the left caudate and anterior cingulate cortex when naming in bilingual contexts compared to mono-lingual contexts (Abutalebi et al., 2008). The authors state the following:

> These findings show that language control processes engaged in contexts during which both languages must remain active recruit the left caudate and the anterior cingulate cortex (ACC) in a manner that can be distinguished from areas engaged in interlanguage task switching. (Abutalebi et al., 2008:1496.)

In Geneva, as in many other neuroscience laboratories, functional magnetic resonance imaging (fMRI) is used to conduct imaging studies. By using fMRI, researchers can penetrate the functions of the brain by reading the imaging scans. Concerning the Geneva experiment, where 50 multilingual students were recruited to perform language exercises, in the 3rd phase of the experiment, respondents listened to a text and interpreted it simultaneously. The results showed no neural fireworks, which is of interest given the MCT of this study. According to Hervais-Adelman et al. (2015), no significant differences in comprehension or articulation was seen in the 3rd phase than the 1st and 2nd phases. From this experiment Hervais-Adelman et al. (2015) concluded that the premotor cortex and caudate are significant brain areas activated during simultaneous interpreting. Other imaging studies on language processing were conducted by Peterson et al. (1990) and Posner and Raichle (1994), where respondents read words or short sentences.

Brain imaging studies have provided substantial empirical evidence that different brain regions process syntax, phonology and sentence comprehension (Fodor, 1983). Courtney et al. (1998); Caplan (2001) and Narain et al. (2003), presented evidence that the left lateral premotor cortex and the triangular parts of the left inferior frontal gyrus are activated on a syntactical level. Evidence from studies conducted by Neville (1991); Bavelier et al. (2001); Gutierrez et al. (2012 a, b); San Jose-Robertson et al. (2004) and Scott et al. (2000), suggest that understanding words from different conceptual categories depends on different networks of brain structures, and in addition word meanings depend on the cortex alongside the areas that underlie motor and sensory functions linked to these meanings. According to these authors, there is agreement that the same cortical regions are activated by nonlinguistic tasks such as mental imagery related to the same concepts. Wojciulik and Kanwisher (1999) present evidence that the temporal-occipital ventral area in front of the visual cortex activates based on the input of colour or form. This finding is supported by experiments conducted by Eimer (2011); Emmorey and Özyürek (2014); Bavelier, Dye and Hauser (2006) and MacSweeney et al. (2006), that indeed the temporal-occipital ventral area is activated based on visual stimulation. Nishimura et al. (1999) presented evidence that the posterior lateral temporal region processes motion perception.

Language switching in bilinguals proves an activation of the languages, with switches into the weaker language being more costly than switches into the stronger language (Petitto, 2005). Further to this, Petitto (2005:44) states the following: “High activation of a few items of a weaker language can activate the inhibition of the entire weaker lexicon.” In other experiments prior to Petitto’s (2005) work, Martin, Miller and Vu (2004), presented results that showed difficulty in inhibiting irrelevant verbal information, which implies that cognitive functioning has specific language processing areas and regions. Söderfeldt et al. (1997) investigated sign and spoken language perception on bilingual respondents using Swedish Sign Language (SSL) and audio-visual spoken Swedish. Noted here is that the study was conducted on hearing native signers or children of deaf adults (CODAs), and not necessarily interpreter respondents. Specific findings of the study were that the perisylvian cortex BA 22 and BA43, are activated by spoken language and the visual association areas BA 37 and BA 19 are triggered by sign language (Söderfeldt et al. 1997). This study also reported no significant activation of the parietal regions. This work, implies that sign and spoken language seems to be localised in the same brain areas that the current study seeks to verify by PET brain imaging analysis of the cognitive activity of plurilingual interpreter respondents, because as Sonderfelt et al. (1997:11) state: “A reciprocal relationship was observed between the level of activation in visual language perception areas and that in auditory perception areas.”

Another imaging study by Emmorey & McCullough (2009) found that the bilateral parietal cortex is activated despite a difference in modality. Furthermore, this study presents evidence of increased activation of the right-hemispheric parietal cortex when using American Sign Language (ASL) compared with English (Emmorey and McCullough, 2009). In studies conducted by Neville et al. (1997) and MacSweeney et al. (2008), evidence suggests that sign language perception is lateralized to the left hemisphere and the right hemisphere. The difference in the evidence presented by Sonderfeldt et al. (1997), Neville et al. (1997) and MacSweeney et al. (2008) can be attributed to the experiment (task differences) which affected the brain localisation. A PET study by McGuire et al. (1997), presents evidence of activation of Broca's area for British Sign Language (BSL) respondents, similar to an English speaking task experiment. PET investigation conducted by Pettito et al. (2000) confirms the activation of the left Broca's area during sign language production.

2.7 Conclusion

To synthesise the findings of various cognitive studies referred to in this literature review, I infer that studies conducted based on sign and spoken language present evidence of activation in the left inferior frontal regions for sign language production and planning. Broca's area is always involved, and left hemispheric dominance is always observed. The studies concluded that production uses Broca's area exclusively, whereas the sign perception only activates Wernicke's area. The superior temporal regions are intensively active in perceiving sign language, in planning and production. In summation,, this chapter does not take a position on or provide any evidence for or against the brain faculties activated during language processing as presented by various scholars. This study focuses specifically on plurilingual brains, and how languages are processed during the act of simultaneous interpreting. The literature review covered here does not provide sufficient facts regarding language processing in the plurilingual brain, hence the need for an empirical investigation to contribute to the scholarship on interpreting studies as a focus of this systematic enquiry. However, the literature on cognitive language processing does confirm the following statement made by Fuster (2008:11): "There is no greater impediment to a unified cognitive neuroscience than our inveterate Aristotelian tendency to consider cognitive functions as separate entities". This statement is supported by Hervais-Adelman, who has noted in an interview: "Neuroscientists already know that these structures [premotor cortex and the caudate] play a role in other complex tasks, including learning and the planning and execution of movement. This means that there is no single brain centre devoted exclusively to the control of interpretation" (Watts, 2016).

CHAPTER 2

Literature Review

Section II

Interpreting

"Interpreting has a bright future, despite the adversities that have emerged and will continue to emerge in a world that is both shrinking to the size of a village and at the same time rebuilding the Tower of Babel" (Mikkelson and Jourdenais, 2018: 449).

2.1. Introduction

Since early human life, if not since the story of the Tower of Babel, communication across borders, cultures and languages has been part of communication exchange through informal interpretation, language brokering and much later formalised professional interpretation services. The period between the introduction of formal simultaneous interpretation at the Nuremberg Trials (1945); the United Nations (UN) (1940) and the International Labor Organization (ILO) (1982) was characterised by rapidly increasing numbers of interpreters due to market demand for interpreters with various language combinations (Baigorri-Jalón, 2005; 2014). Since the 1940s and '50s, interpreting has undergone several adaptations and gained advanced insight by scholarly works in interpreting studies. Sign language interpreting is considered a mode of interpreting (Gile, 2018b). Historically, according to Napier (2018), sign language interpreting has been viewed as an isolated, different study and practice field. This differentiation is evident in "…theoretical discussions, research, education and professional practice" (Napier, 2018: 29). This polarity had to effect a separatist development in the field of sign language interpreting studies. The evolving perception of interpreting modes, including simultaneous sign language interpreting, presents evidence of a progressing academic study and practice field. According to Napier, Rohan and Slatyer (2005:186): "The last three decades have seen the emergence of a growing body of research defining the field [interpreting studies] as a discipline in its own right rather than an off-shoot of translation studies'" (Napier et al., 2005:186). An alternative view by Bontempo (2018:112), who is situated in the interpreting studies field, states that: "The discipline of signed language interpreting can no longer be regarded as being in its infancy", who goes on to suggest that sign language-interpreting is facing rapid evolution and growth (Bontempo, 2018). De Wit, Crasborn and Napier (2021:2) posit the view of International Sign (IS) interpreting, concerning the development status compared to conference interpreting by stating the following: "Compared to spoken language conference interpreting, professional sign language conference interpreting is in its infancy, specifically IS interpreting at conferences." The growth, however, is applicable to sign language-interpreting studies and practice in the Global North. Scholarly contributions unique to sign language interpreting studies in the Global South remain sparse and are still in an embryonic phase. Similarly, interpreting practice in developing contexts such as Africa has not yet developed to a professional status.

Napier (2018:129) makes a progressive statement regarding interpreting studies: "There is a shift through increasing cross-linguistic and cross-modality collaboration in interpreter education, interpreting research and various publications that feature the discussion of spoken and sign language across genres of international practice." She states that the slow collaboration between sign and spoken language interpreters will have to effect increased opportunities for collaboration and replication across modalities. This study on cognition and interpreting presents a unique opportunity for cross-disciplinary exchange pertaining to cognitive language processing in plurilingual, SASL interpreters.

Researchers studying language and cognition are astonished by the cognitive processing ability of language tasks considered strenuous (Grosjean, 2001). Concerning cognitive processing ability during simultaneous interpreting, Seeber (2018:83) notes that: "The intrinsic complexity of simultaneous interpreting cannot be credited to increased memory capacity but is possible because of the automated information processing abilities of the brain where the various cognitive structures are activated as per language activation tasks."

According to Kohn and Kalina (1996), interpreting should first be understood from a monolingual receptive and productive process perspective in the context of language acquisition and language processing. Earlier scholarly contributions such as Seleskovitch (1976; 1978) contribute to our understanding of information processing in an interpreting context. Linked to both mono- and bilingualism, Seeber (2018) raises pertinent issues related to interpreting such as bilingualism, directionality, language-specific factors, environmental stimuli and physical proximity that necessitate further empirical investigation. The gap identified in the mono-, bilingual view in interpreting is the view of multi- or plurilingualism. In plurilingual communication settings, the interlocutors engage with various language proficiencies that make up their holistic linguistic repertoires. Based on this gap, it can be inferred that the aim to understand cognitive information during interpreting from a plurilingual stance contributes to the mono-, bilingual understanding proposed by Kohn and Kalina (1996). In engaging with various lenses on cognitive processing of information during interpreting, there is a continuous adaptation of interpreting theory and practice. A plurilingual perspective on cognitive language processing in plurilingual sign language interpreters presents an alternative lens to be considered in traditional interpreting models.

Interpreting, as a communicative act does not exist independently of language speakers and users. Thus, as language and communication norms evolve in speech/sign communities, interpreting transubstantiates in tandem. In an attempt to address the evolving state of interpreting, in a non-polarised way, this literature review uses definitions of an interpreter and interpreting as these apply to this study. Of relevance to this study is the ABC classification of the interpreters' working language. Furthermore, the literature review focuses on various cognitive models of interpreting.

2.2. Definitions of Interpreter and Interpreting

In reviewing various definitions of an interpreter and interpreting in the literature, a homogenous trend identified is the function of an interpreter being a linguistic, cultural and social mediating agent in communicative events. The definitions highlight the evolving classification of an interpreter and interpreting.

2.2.1 Definitions of an interpreter

An interpreter is defined as: “A person who translates speech orally into sign language for parties who speak different languages” (Baigorri-Jalon, 2018:11). Moser-Mercer (2018: 302) delineates the interpreter as:

> One that is accurate, faithful to the original, impartial with a high degree of professional integrity, accurate in terms of rendering all the information that has been provided in the original, faithful in terms of rendering the meaning intended by the original speaker, impartial in terms of not siding with any parties engaged in an interpreted scenario and clear in terms of the level of professional skill.

2.2.2 Definitions of interpreting

Jing (2013:1232) defines interpreting in terms of international status by stating the following: “Interpreting as a modern profession has established its status in the international communities.” Kohn & Kalina (1996:118) defines interpreting from a linguistic-cultural lens: “Interpreting is a special type of communicative interaction which takes place when members of different language communities engage in cross-cultural/language communication, using interpreters as inter-lingual mediators.” Pöchhacker (2004:9) meanwhile defines interpreting as the: “…social context of interaction or setting.” He recognises sign language interpreting as a different modality of interpreting. Bancroft (2018:217) defines interpreting in terms of basic access, stating: “Community interpreting is founded on a simple concept: giving a voice to those who seek access to basic services but who do not speak the societal language.” Baigorri-Jalón (2018:11) defines interpreting in terms of a profession and remuneration: “…professional interpreting is a paid occupation based on expert knowledge and often academic training.”

2.3. Working Language Classification

Conference interpreters work according to their language classification portfolio as assigned (according to their accreditation) by the International Association of Conference Interpreters

(AIIC, 2019). AIIC is a prestigious global professional organisation of conference interpreters. The ABC language classification system for accredited conference interpreters prescribes an interpreter works from and into A, B and C languages. Some conference interpreters have an excellent command (near-native proficiency) in another language (C) that allows them to work into that language.

2.3.1 ABC language classification

Interpreting only into an A-language is the mainstream practice in international organisations, such as the United Nations agencies (UN), the European Commission (EU), the European Parliament, and the African Union (AU). Interpreters employed by the above-mentioned organisations, interpret from their B and C languages into their A language. The classification system is based on the understanding that an A-language is the native or near-native proficient language of an interpreter. The interpreters thus have full professional proficiency in their A language. The B language is a language in which the interpreter has professional proficiency sufficient for understanding but is not the native language of the interpreter. It is an acquired language that can be understood as the L2 of the bilingual interpreter. The C language is a language that the interpreter completely understands but has limited working proficiency. The language classification system does not clearly define and differentiate among the ABC language categories. This provides an open interpretation that implies that the ABC combinations might fluctuate because there are no standard criteria. According to Seeber (2018), the descriptions and definitions of language classifications: "…reflect limitations of the approach" and lead to inconsistent interpretation. Gile proposes a cognitive view on the language classification system by stating the following:

> The assumption that speech comprehension and speech production take up less processing capacity in one's native ("A") language than in one's non-native active ("B") language may lead to opposite conclusions regarding total PC requirements when working into one's A or B language, depending on whether production is assumed to require more or less processing capacity, than comprehension (Gile, 2005:25).

Gile (2005) has further stated that there is no evidence of an interpreter's official A or B mastery of their working languages since many variables contribute to working language classification such as proximity to consistent language use, intrinsic variability of cognitive performance, emotional state at the time of the interpreting assignment, the density of the text and so on.

2.4. Interpreting Models

Interpreting is a punctilious and rigorous cognitive language processing task. Pöchhacker (2002) highlights the need to consider cognition as part of the interpreting process. Wilcox and Shaffer (2005:39) guide interpreters to understand interpreting in terms of cognition by stating the following: "For interpreters who are attempting to throw off the veil of the conduit metaphor and better understand what they do when working across languages and cultures, we believe that cognitive linguistics offers a far better framework."

A premier cognitive model for both consecutive and simultaneous interpreting that focused on "sense" was suggested by Seleskovitch (1978). This and subsequent cognitive models posited by various scholars are discussed and illustrated in this section of the literature review.

The central theme of cognitive models is that in a communicative event, all interlocutors, including interpreters, actively construct meaning based on implicit and explicit communication exchange. Napier (2002) framed this "meaning-making" regarding the adaptability to sociolinguistic and sociocultural factors that impact the context in which the situation and message are interpreted. According to Russell and Takeda (2018:98): "The value of models to interpreting is that they offer guidance in understanding the nature of how communicators structure messages and how interpreters try to access and construct meaning to recreate it in a second language." The authors' further state that models provide insight to the cognitive sub-tasks of interpreting.

2.4.1 Seleskovitch's model

Seleskovitch (1962) posited the interpretive theory of translation (ITT) to explain interpreting and translating as textual analysis and not simply changing words to suit the communicative exchange and intent (Seleskovitch, 1962 and Seleskovitch and Lederer, 1986). The ITT holds that comprehension, deverbalisation and expression is a triangular process of textual analysis to render a sensible interpretation product. The adapted figure below illustrates Seleskovitch's triangular model.

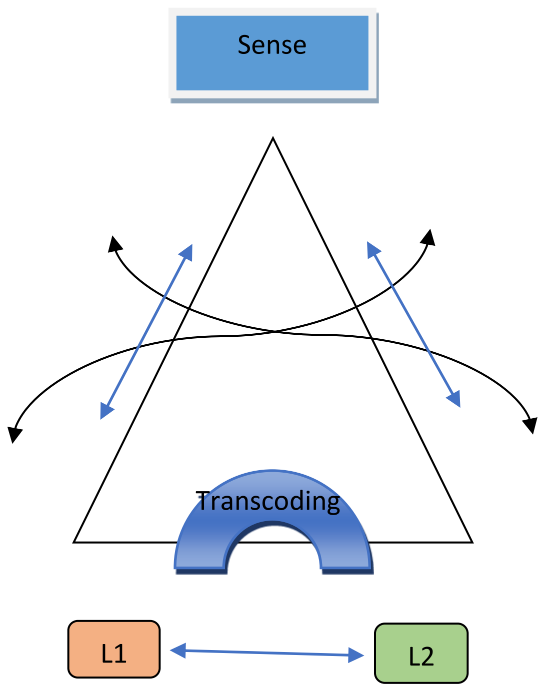


Figure 6: Adapted triangular interpreting model (Seleskovitch and Lederer, 1984:185).

2.4.2 Colonomos' Processing Model

Colonomos' model focuses on the message that the interpreter must extract from the speaker's communicative intent (Wilcox and Schaffer, 2005). This extraction is part of the analysis of the source text's message. To extract the message's intent, the interpreter must have solid metalinguistic skills to render a faithful and functional equivalent expression of the message in the target language. The activation and use of metalinguistic knowledge and the act of extracting meaning during the interpreting process depend on optimal cognitive function.

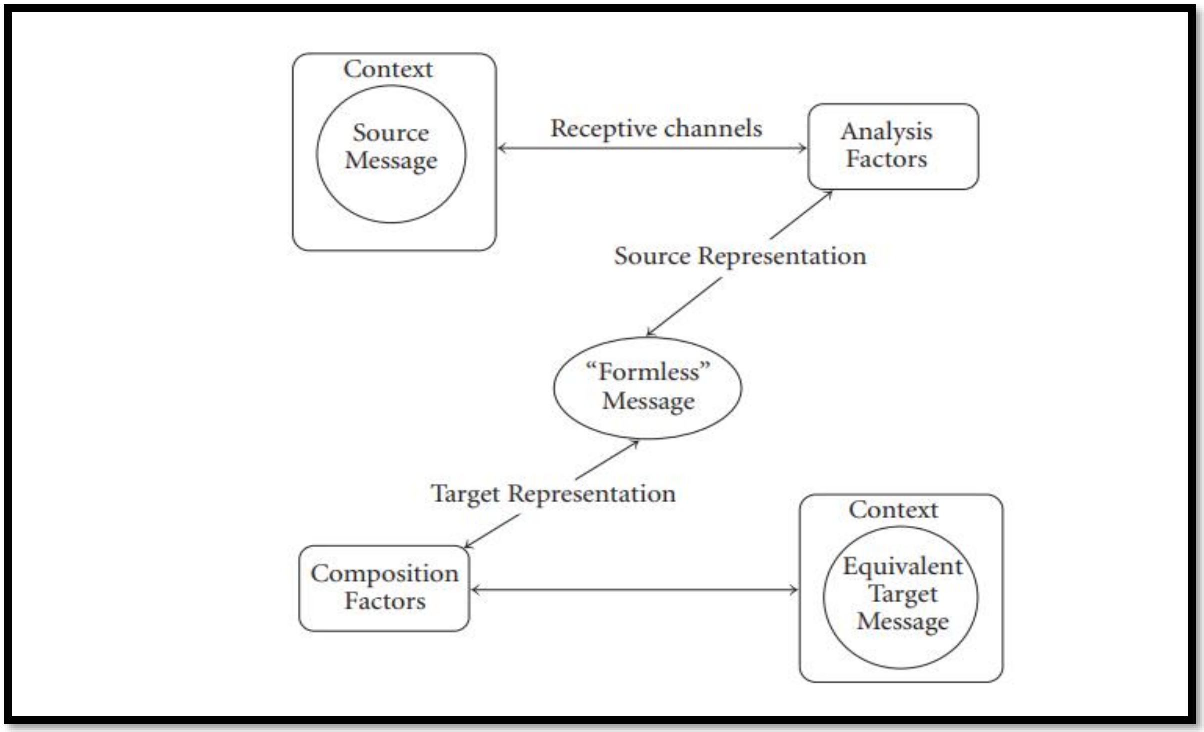


Figure 7: Colonomos' processing model (Wilcox and Schaffer, 2005:31).

2.4.3 Gile's Effort Model

Gile's (1995) contribution to cognition and interpreting concerning interpreting models is his Effort Model and the Tightrope Hypothesis. Gile's model assists in understanding of the interpreting process. His model proposes two main ideas namely: "…interpretation requires some sort of mental 'energy' that is only available in limited supply" and "…interpretation takes up almost all of this mental energy, and sometimes requires more than is available, at which times performance deteriorates" (Gile, 1995:161). In the Effort models, mainly three efforts are proposed: "Listening and analysis (L), production of the source speech (P), and short term memory effort (M)" (Gile, 2005:3). In the mathematical model of simultaneous interpreting, LA represents listening and analysis of source text.

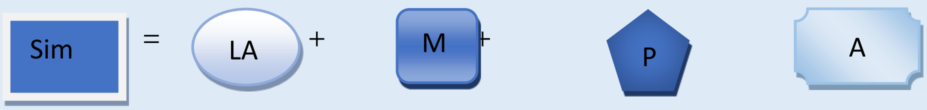


Figure 8: Gile's effort model illustrated as a mathematical notation (Gile, 2018b)

In the above mathematical model of simultaneous interpreting, LA represents listening and analysis of source text. In the revised updated edition of the models, LA is renamed as R, reception to account for the visual perception effort in sign languages (Gile, 2018b). In this mathematical equation, the additive (+) sign is understood as an additive effect and not in the mathematical context of addition. M represents short term memory. P represents production in the target language and includes self-monitoring, A refers to the available processing capacity that could also mean the attentional resources.

SIM = L + M + P + C R(SIM**) = R(**L**) + R(**M**) + R(**P**) + R(**C) → **TOTAL R**

Figure 9: Gile's updated effort model illustrated as a mathematical notation (Gile, 2018b).

In sign language interpreting, Giles updated effort model presents a modality difference in simultaneous interpreting. Gile (2018b) expresses the model as:

> …self-management in space OID, online interaction with the Deaf SMS, spatial positioning, distance to the speaker, angles to optimize [sic] the comprehension of the source speech and transmission to Deaf users of the target speech OID, attending to the

signing by Deaf users of the Target speech, some of which is ‘internal’ and some of which is addressed to the interpreter.

Sim = L + M + P + SMS + OID + C SMS

Figure 10: Gile’s effort model for sign Language Interpreting (Gile, 2018b).

Gile’s tightrope hypothesis extends the understanding of cognition in interpreting by pointing to the interpreter’s dwindling concentration and declining cognitive processing capacity. The tightrope hypothesis points strongly to the aspect of cognition in interpreting. In the event of the interpreter running on nearly depleted cognitive ability to optimise efforts of L, M, P, C the effect is a skewed or inaccurate interpretation. The hypothesis was confirmed by the evidence of processing capacity deficits displayed by errors and omissions in the interpretation product (Gile, 1999). Gile (2005) defines the tightrope hypothesis as:

> A situation where interpreters tend to work at levels of cognitive load close to saturation, which explains the numerous errors they sometimes make even when no clear problem triggers, such as fast delivery, strong accents, particularly complex syntactic structures, non-standard or rare lexical units, disturbing noises etc. can be identified in the source speech (Gile, 2005: 3).

2.4.4 Cokely’s model

Cokely’s model is a sociolinguistic model, focusing on American Sign Language (ASL) and English. His experiment suggested a taxonomy of interpreter miscues, where he refers to the origin of the miscues as that of cognition and language processing (Roy and Metzger, 2014). Cokely’s study is distinct in that he used: “…conversation analysis, discourse analysis which pointed to frames and schemas and to code-switching and code-mixing” according to Roy and Metzger (2014:160). This model presents premier scholarly work on cognitive models for interpreting. However, an angle unexplored in this model is the internal cognitive operation of language processing during the act of interpreting where code-switching and mixing are seen in text analysis.

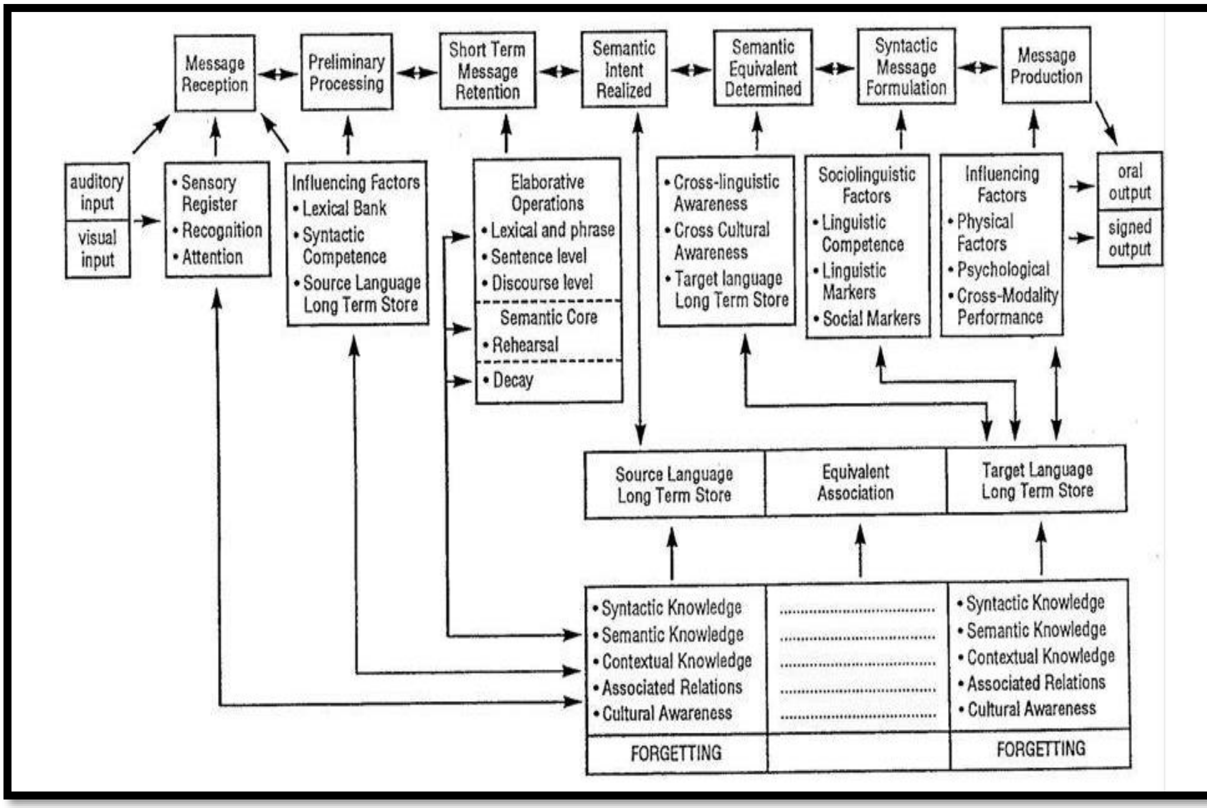


Figure 11: Cokely's Sociolinguistic Model of Interpretation (Cokely, 1992:100).

2.4.5 Mizuno's process model

Mizuno (2005) proposes a process model for simultaneous interpreting and working memory. This model highlights the tasks mentioned in Giles effort model (Gile, 1995). Mizuno (2005:741) states that optimal functioning of interpreting processes involves synchronous managing of tasks such as "listening and comprehension, information retention, retrieval, production, and monitoring". These tasks have their roots within the brain. Thus, the process model fits well with cognition and interpreting models. Mizuno (2005:740) presents an alternative way of seeing cognitive load: "The domain-specific skills for interpreters may be translation strategies that would reduce the processing and memory load rather than or in addition to the skills of allocating resources efficiently and switch attention properly". Reference is made to interpreting strategies to produce an improved simultaneous interpreting product (Mizuno, 2005). The process model points to language processing, comprehension, and production, supported by the interpreter's central executive system and working memory, as seen in the figure below.

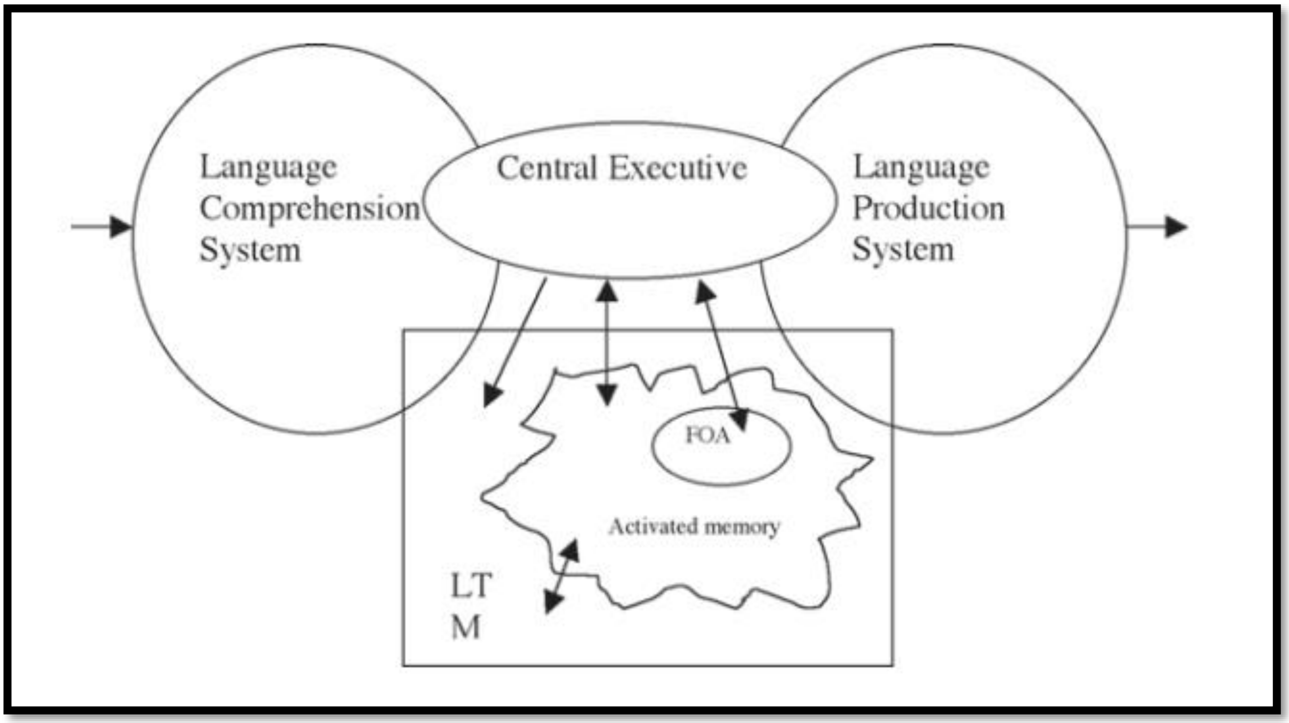


Figure 12: Mizuno's process model (Mizuno, 2005:744).

2.4.6 Kohn and Kalina's model of comprehension and production

The mental model of comprehension and production by Kohn and Kalina (1996) provides some basis and evidence by mentioning discourse-based mental modelling. These processes are captured by theoretical components and do not provide empirical evidence of cognition. On the other hand, it is argued that "Comprehension and production of interpreted communication rely on a diversified knowledge base" (Kohn and Kalina, 1996: 121). In cognition and interpreting, the constructs of comprehension and production are tied to memory access to render interpreting. Further to this, Kohn and Kalina (1996) present insight into the requirement of having linguistic and nonlinguistic knowledge of the working languages of the interpreter. Concerning mental modelling the interpreter is not at liberty to infiltrate the cognitive space of the speaker to comprehend and anticipate the message and its meaning; hence the interpreter relies on accessing his own linguistic cognitive spaces to render an equivalent functional interpretation in the target language. Kohn & Kalina (1996:121), explicitly state the reliance on cognition to enable the functioning of an interpreter:

> In comprehension and production of interpreted communication the interpreter relies on a diversified knowledge base including knowledge about linguistic means of expression and discourse conventions, general world and/or specialized [sic] subject knowledge, knowledge about the communicative situation in which the discourse is embedded, mental modelling on the basis of previous discourse and procedural knowledge relating to strategic principles such as the cooperative principle, the given/new contract or the principles of local interpretation and analogy.

Furthermore, Kohn and Kalina (1996:132) hold that, if comprehension strategies fail there will be a complete breakdown of the interpreting event stating: “There can be no strategically controlled production unless comprehension strategies have been successful”. The complete breakdown referred to above points to the ultimate reliance on cognitive processes and the additional interpreting strategies to operate as an interpreter.

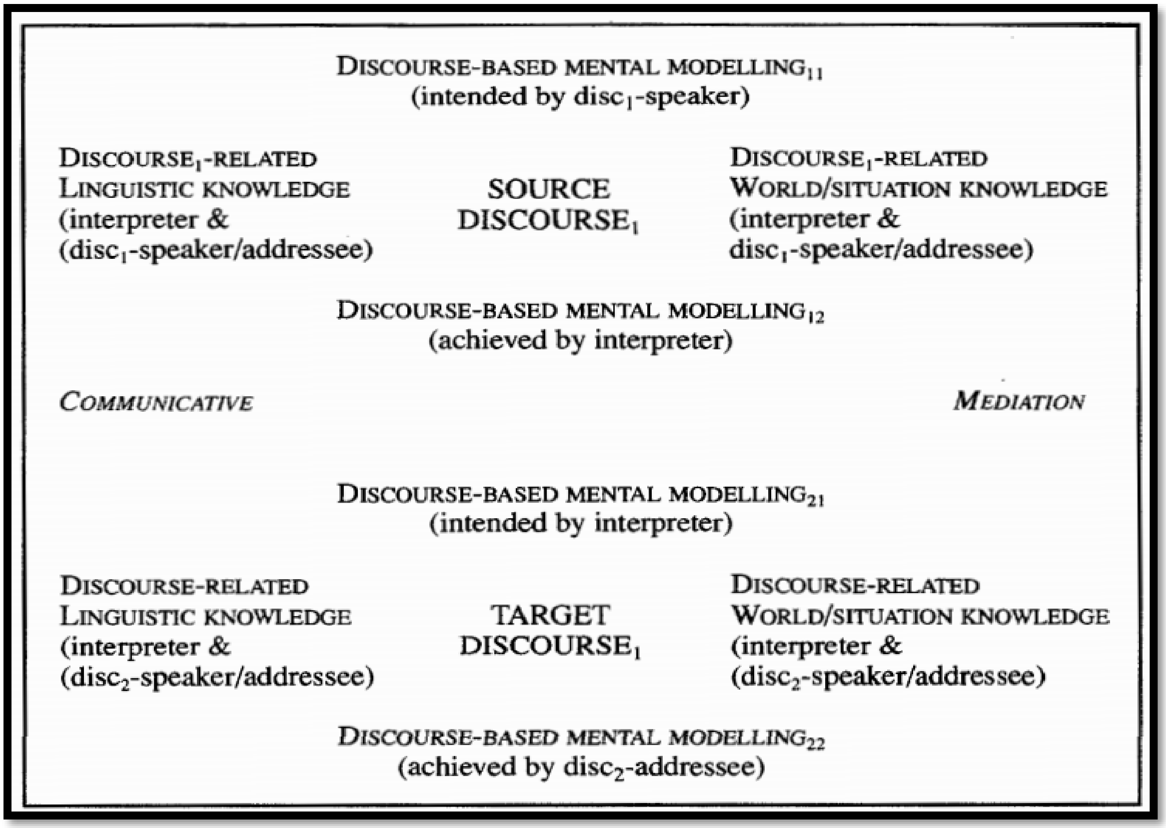


Figure 13: Comprehension and production in interpreting (Kohn and Kalina, 1996:125).

2.4.7 Setton's cognitive pragmatic model

In an attempt to explain interpreting data concerning mental operations, Setton (1999) details the processes that involve linguistics in interpreting. She highlights the ability to deduce intent from the source message. The model highlights the construct of centralisation in comprehension. Cognitive processing of multi-modal input is framed as communication by highlighting synergies of perception, cognition, and action in speech (Pöchhacker, 2005). According to Setton (1999:22):

> Working memory and concentration are prerequisites for aspiring interpreters. But these abilities serve understanding and formulation, not the reverse. It is not memory and attention which are specific to interpreting expertise, but enhanced understanding and speaking. If there is any pedagogical advantage in decomposing processes, we should be focusing on these rather than on the universal processes which subserve them.

Setton (1999) refers to relevance theory in the context of pragmatics in communication and interpretation. Reference is made to the sensorimotor system to handle interpreting as indicated by Gile (1995). Setton (1999) refers to these processes as input, processing, recognition (decoding) and articulation (output). She describes the impact of linguistic and extra-linguistic features of communication on the context. These features are explored by the interpreter accessing their paradigm in the situations where they interpret. In addition, they can tap into their memory to recall, anticipate and infer, rendering a functional interpretation (Setton, 1999 and Maalej, 2001). Maalej's (2001) review of Setton's cognitive pragmatic model calls for further experiments to validate the model.

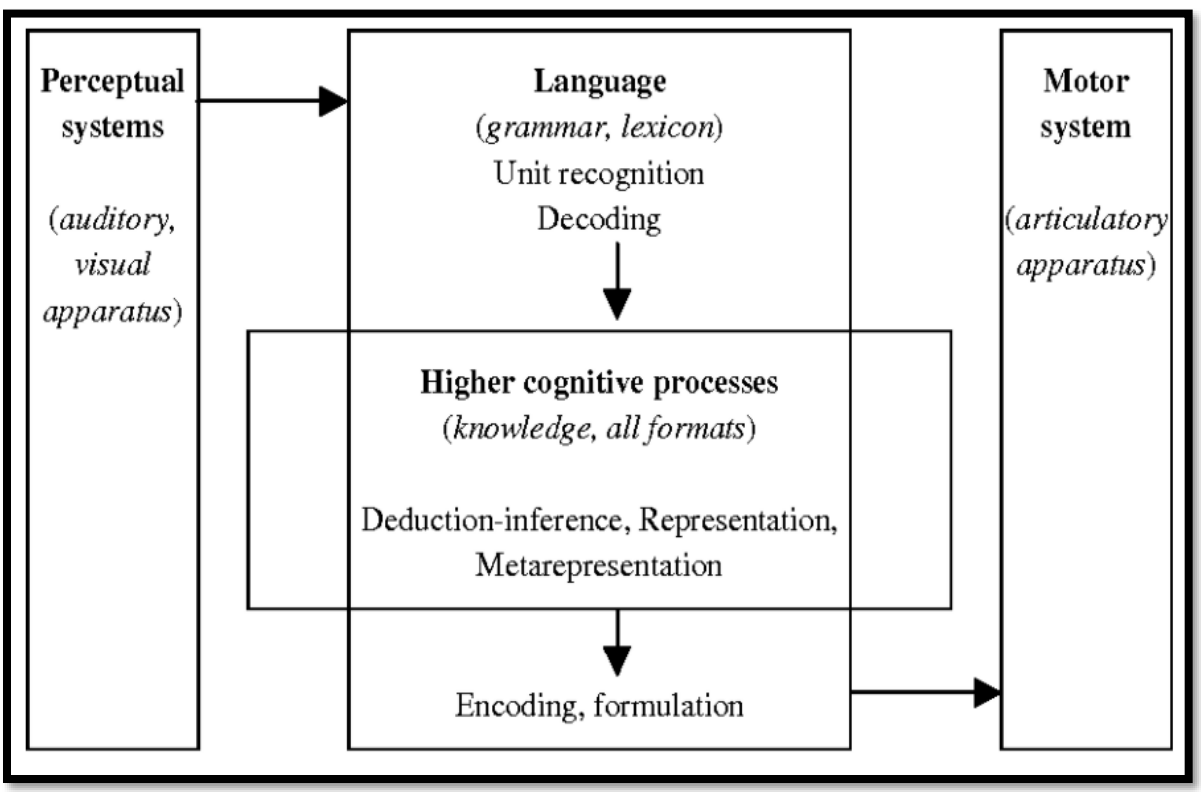


Figure 2.11: Setton's cognitive pragmatic model (Setton, 1999:17).

2.4.8 Wilcox and Shaffer's cognitive model

Wilcox and Schaffer (2005), focus on meaning and grammar in their contribution to cognitive interpreting models. The model points strongly to the evidence of language processing and the imperative of understanding linguistic structures of languages. The authors emphasise the cognitive processes tied with linguistic analysis, specifically, choice of lexicon and how it plays out in semantics:

> The implication for interpreters is that what we are here describing is an essential fact about linguistic communication. It is rare to find in any human language cases where knowledge of a constructional schema and the meaning of its component structures tells us everything we need in order to understand the conventional, fully contextualized meaning of an expression. (Wilcox and Shaffer, 2005:42).

Interpreting the meaning of an expression in the communicative event is imperative to reach the audience. However, if the interpreter cannot function optimally on a cognitive level by processing the incoming language and linguistic intent, the value of interpreting is lost. Wilcox and Shaffer (2015) refer to language creativity in the act of interpreting as: "…the meanings made are the interpreter's own, not the product of an extractive process but of a creative, constructive meaning making process" (Wilcox amd Shaffer, 2005:42).

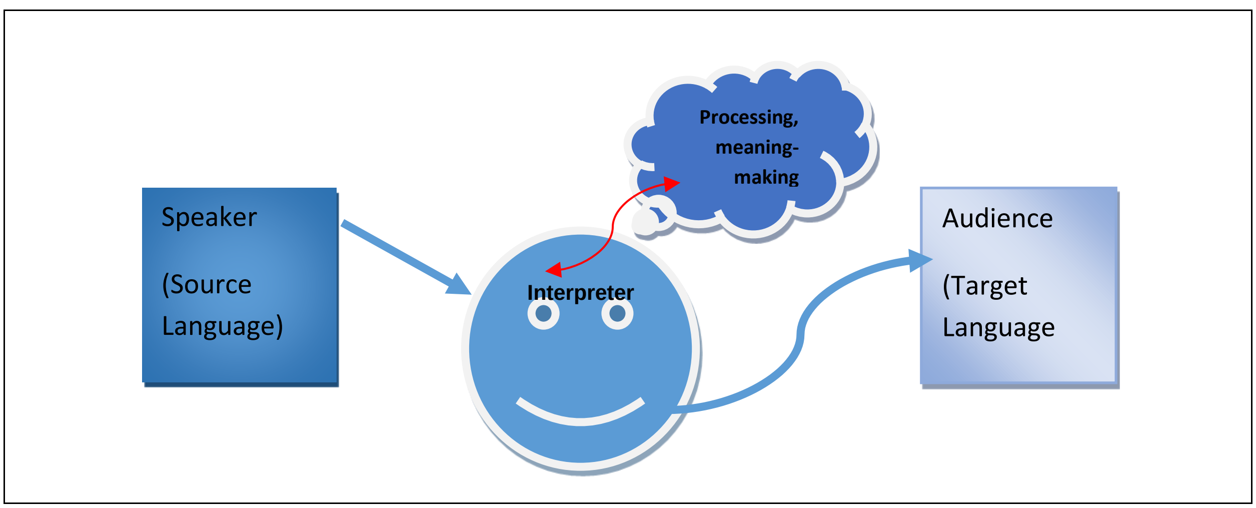


Figure 14: Illustration of Wilcox & Shaffer's cognitive model

2.5. Conclusion

Models covered in this section focus specifically on cognition that lays the foundation for the cognitive angle of the project. Part of the contribution of this study is to present a model that does justice to the act of communicating by stating explicitly the cognitive areas activated during plurilingual interpreting. As Wilcox & Schaffer (2015:44) note: “The problem is that our models of interpreting simply do not do justice to the act of communicating”. The contribution of the current study to interpreting is in laying a brick in rebuilding the Tower of Babel with a novel understanding of how cognition works in plurilingual, translanguaging sign language interpreting. Mikkelson & Jordenais (2018:499) state: “Interpreting has a bright future, despite the adversities that have emerged and will continue to emerge in a world that is both shrinking to the size of a village and at the same time rebuilding the Tower of Babel.”

CHAPTER 2

Literature Review

Section III
Translanguaging

"Translanguaging 'is the communicative norm of multilingual societies".

Garcia and Sylvan (2011:389).

2.1 Introduction

This chapter provides context to plurilingualism and translanguaging related to interpreting in, sign and spoken languages. This chapter is grounded in the works of a leading African scholar, Makalela, who's seminal works related to translanguaging inspired interest in this phenomenon as it relates to interpreting practice, Makalela (2018), applies an African lens to the Western definition of translanguaging. "Ubuntu translanguaging", as coined by Makalela (2018:4), is tied to cultural competence, where multiple African languages are used simultaneously in linguistically complex communication exchanges.

Drawing translanguaging as a phenomenon applied in Deaf communication exchanges Kusters et al. (2017:220) states the following: "Language in use, whether spoken, signed or text, is always and inevitably constructed across multiple modes of communication and through 'contextual' phenomena such as the use of the surrounding physical spaces." Literature in this chapter portrays translanguaging as a phenomenon intrinsically tied to plurilingual speech and sign communities. Plurilingualism is depicted not as an impediment but as a thriving landscape that provides opportunities for advancing the African continent, and the Global South. Alternatively, plurilingualism is a concept that is not always framed in a positive light:

> The linguistic incorporation of the African educated elite [African language practitioners] into the European bourgeois memory is an active contributor to Africa's backwardness. In that sense every educated African [African language practitioners and interpreting studies researchers] who remains doggedly locked within the linguistic walls [interpreting settings] of European languages, irrespective of his avowed social vision of the right or left, is part of the problem (Wa Thiong'o, 2004:30).

This quote frames this chapter that aims to unlock the various scholarly contributions that acknowledge linguistic and cultural diversity. In this chapter, I refer to synchronous translanguaging as it relates to language practice.

2.2 Definition of Concepts linked to Translanguaging

Various scholars have devised concepts to explain and expand our understanding of language exchange as it unfolds in speech and sign communities. Some terms applicable to this study are defined here:

2.2.1 Translanguaging

Translanguaging is a term that was coined by Whittal, meaning *trawsieithu*, that translates into English as 'translinguifying' (Cenoz and Gorter, 2017). The term originates from bilingual pedagogical practice, where the aim is to reach understanding through the synchronous use of two languages (Cenoz and Gorter, 2017). The concept refers to various situated spaces where multilinguals exchange ideas to understand communication exchange by using their linguistic repertoires that consist of shared and non-shared languages and cultures. Translanguaging in the Deaf community is defined as the "…way we view language as processes of meaning-making rather than as enclosed systems" (Kusters et al. 2017:225). For the purpose of this study the definition of Makalela (2018:4) is applied: "classifying languages as first, second, additional and mother tongue are all constructs based on linear view of language acquisition – an acquisition context different from most of the sub-saharan African language acquisition contexts. In order to take a more complex account of language use and to match multilingual spaces in this century, language practices of multilingual students should be characterised by a discursive practice of 'languaging'".

2.2.2 Crossing

Crossing is defined by Rampton (1995) as a form of "code alternation". This alteration occurs in the form of navigating linguistic, social and ethnic boundaries when L2 language speakers are not accepted by most of the speech community (L1 speakers). The definition of crossing is further explained by Rampton (1995:502) by pointing to interactional competence.

> Crossing emerges as a practice closely tied to the shared norms, values and activities of a particular cultural collectivity. It requires a specific kind of interactional competence to situate the use of outgroup codes in liminal moments and events. Crossing showed sensitivity to a complex set of situational contingencies, the stage and state of talk, the activity type, the institutional setting, the relationship between interlocutors and so forth - and as a skillful, group-specific practice, effective and accepted crossing generally only came with substantial experience of local multiracial peer group life.

2.2.3 Polylanguaging

Polylanguaging, according to Jørgensen et al. (2011), presents when speakers integrate various linguistic features on a sociocultural level across the languages that they do not know completely.

2.2.4 Metrolingualism

Metrolingualism, as defined by Pennycook and Otsuji (2015), presents the language as a fluid, sense-making process that finds meaning using various languages, registers, styles, and modes. Communication sense is based on the interactions and activities that occur in particular spaces.

2.2.5 Plurilingualism

Plurilingualism is reflected in desegregated language proficiency. Holistic language proficiency across the various languages that the speaker knows is acknowledged as part of the homogenised linguistic repertoire of the speaker (Canagarajah, 2009). Marshall (2020) describes plurilingualism as a sociolinguistic phenomenon, an alternative lens in understanding language use in context and an innovative pedagogy aiming to embrace equality of languages and cultures.

Regarding plurilingualism and lived experience Marshall and Moore (2018:12), state: "…a person's languages and cultures interrelate and change over time, depending on individual biographies, social trajectories, and life paths". Makalela (2018:2) captures the story of Mapungubwe in directing our understanding by stating that: "precolonial southern Africa did not have discrete language systems but an amorphous repertoire that stretched beyond the current linguistic codes".

Plurilingualism is a daily occurrence, whereby a situated actor (Coste and Simon, 2009; Gumperz, 1982) finds expression through communicative events and functions to reach the communicative aim through bridging intercultural understanding and competence. The Council of Europe (2001:168) considers linguistic competence by defining plurilingualism as "A single competence that encompasses all the languages in the speaker's linguistic repertoire."

2.2.6 Linguistic Repertoire

A linguistic repertoire refers to the entirety of linguistic resources of an individual by taking a holistic approach to language use that renders communication effective (Busch, 2012). Backus (2000) explains that a repertoire is composed of many different communicative tools, with varying degrees of functional specialisation. He says: "No single resource is a communicative panacea; none is useless" (Backus, 2000:25). Semiotic repertoires (Kusters et al. 2017) are also embraced in this research, which implies gesture and body orientation. Recent investigations into sign bilingualism added dimensions of multilingualism, which acknowledge the plurilingual aspect of Deaf peoples' linguistic repertoires (Kusters et al. 2017).

2.2.7 Code-switching & code mixing

There is language convergence, borrowing and replacement in multilingual societies that effect hybrid languages, for example, pidgins, creoles, and so on. This phenomenon presents two sociolinguistic terms namely code-switching and code mixing. (Abu-Krooz, Al-Azzawi and Saadoon, 2019). Macswan (1999:37) states that: "…code switching is a speech style in which fluent bilinguals move in and out of two (or conceivably more) languages." Barnali (2017) similarly describes code switching as: "…the alternate use of two or more languages in an extended stretch of discourse, where the switch takes place at sentence or clause". According to Müller et al. (2015), code-switching can be identified when language use is modified. MacSwan (2000:38) refers to code-switching as a "speech style".

Zhou and Wei (2007:3) share the view that: "Research on the acceptability of mixed code in the social and cultural context across the linguistic and cultural boundaries suggests that code-switching is neither random nor meaningless". These researchers present code-mixing of spoken languages by stating the following:

> One of the most important results of the sociolinguistic research of recent decades on code-switching demonstrates that a speaker's vocal movement from one language to another, both over prolonged stretches of discourse and in single words or phrases, constitutes a continuous unitary communicative performance. (Zhou & Wei, 2007:3).

However, code mixing is also evident in sign languages, as suggested by Berent (2008) and Zeshan and Panda (2015).

2.2.8 The distinction between translanguaging and code-switching

The difference between code-switching and translanguaging is that firstly, they have different epistemological orientations and translanguaging bears some components of code-switching, but in addition, present the use of additional language resources and meta-linguistic awareness based on the context and communicative event (Garcia and Wei, 2014). Wei (2018b) defines code switching and translanguaging as: “Code-switching refers to the alternation between languages in a specific communicative episode, like a conversation or an email exchange and translanguaging is a process of meaning- and sense-making.”

It is in the distinction between the two concepts that this study focuses its lens on translanguaging.

2.2.9 Translanguaging and interpreting

The phenomenon of translanguaging as is seen in plurilingualism in multilingual settings is applied to the context of interpreting in this section. Here, reference is made to Muysken (1997:362), who suggests three processes linked to translanguaging, namely, “insertion, alternation and congruent lexicalisation”. According to Muysken (1997:362): “…congruent lexicalisation is characterised by a shared grammatical structure of elements from different languages.” Insertion is characterised by the immersion of various language structures across the language spectrum of the repertoire (Müller et al., 2015:18). Alternation refers to the complete change in language structure, grammar and vocabulary, therefore, intra-sentential mixing contains fragmented language components (insertion) or integrated language components (alternation). The paradox remains as to whether, if translanguaging is a natural occurrence in language communities, it could be considered an accepted interpreting practice.

2.3 Theory and Application of Translanguaging

The Research Centre for Plurilingual Teaching and Interaction (GREIP2) studied various stakeholders, who suggested reconsidering the theoretical view of language use, language research and education based on plurilingualism (Vallejo and Dooly, 2020). Blommaert (2013:621) urges the activation of an alternative that reconsiders: “…speakers’ fluent and hybrid communicative practices into one-language-only (OLON) parameters”. OLON poses a regressive view and conforms to traditional models and theories of interpreting studies concerning the ABC language classification system in the preceding chapter on interpreting. In reconsidering plurilingualism and the ABC language classification of interpreting, there is an alignment to trends in the field of translanguaging. In this regard, McNamara (2011:493) advocates that we: "…take a more complex and more critical stance toward issues in multilingual and monolingual practices in education". The discursive practice of fluctuating between languages confirms the use of the holistic linguistic repertoire as a discursive construct (Rampton 1995). In advancing alternative perspectives and debates of interpreting practice, translanguaging in plurilingual speech and sign communities are highlighted further in this chapter.

2.4 Evolving Language Communities

The application of plurilingualism to linguistic repertoires is critical in comprehending of translanguaging as is seen in daily societal communication. There are 7106 languages globally, of which 10% in Sub-Saharan Africa are extinct or nearly extinct (Lewis, Simons and Fenning, 2013 and Lewis and Simons, 2013). According to Teixeira (2021), English is the most spoken language with 1132 million speakers, followed by Mandarin Chinese with 1117 million speakers, in third place is Hindi with 615 million speakers, Spanish with 534 million speakers and last in the top five languages spoken is French with 280 million speakers. Globalisation is a significant determinant of multilingualism and how it is experienced by native language speakers and in interaction with the linguistic repertoires of various speakers and signers. In an attempt to understand the locality and proximity of language communities, it is apt to provide the background of how the Global North and the South are experiencing evolving linguistic and language borders due to increased immigration.

The globe is geographically fissured by the Brandt Line (BL) into affluent and impoverished countries (Lees, 2021). According to Lees (2021), the BL can be described thus: "[it] is a visualisation created to illustrate international inequalities and the socioeconomic gulf that separates regions of the world, popularised in North-South: A Programme for Survival – also known as the Brandt report" (Lees 2021:85). Lees questions the relevance of the 1980s Brandt report by positing the changing political and economic conditions by South-South collaboration and the formation of BRICS (Brazil, Russia, India, China and South Africa). The finding by Lees confirms the following: "The Brandt Line is still a useful way to visualise important economic inequalities and political divisions in world politics. It remains meaningful to speak of the North and the Global South in international relation'" (Lees, 2021:104). This statement provides a way to contextualise the BL with migration by linking immigration and mobile language communities to resources. It gives insight into translanguaging and its natural occurrence in plurilingual and pluricultural communities. Below is an illustration depicting the Brandt Line and emigration patterns from less and more economically developed countries (LEDCs and MEDCs) (Lees, 2021).

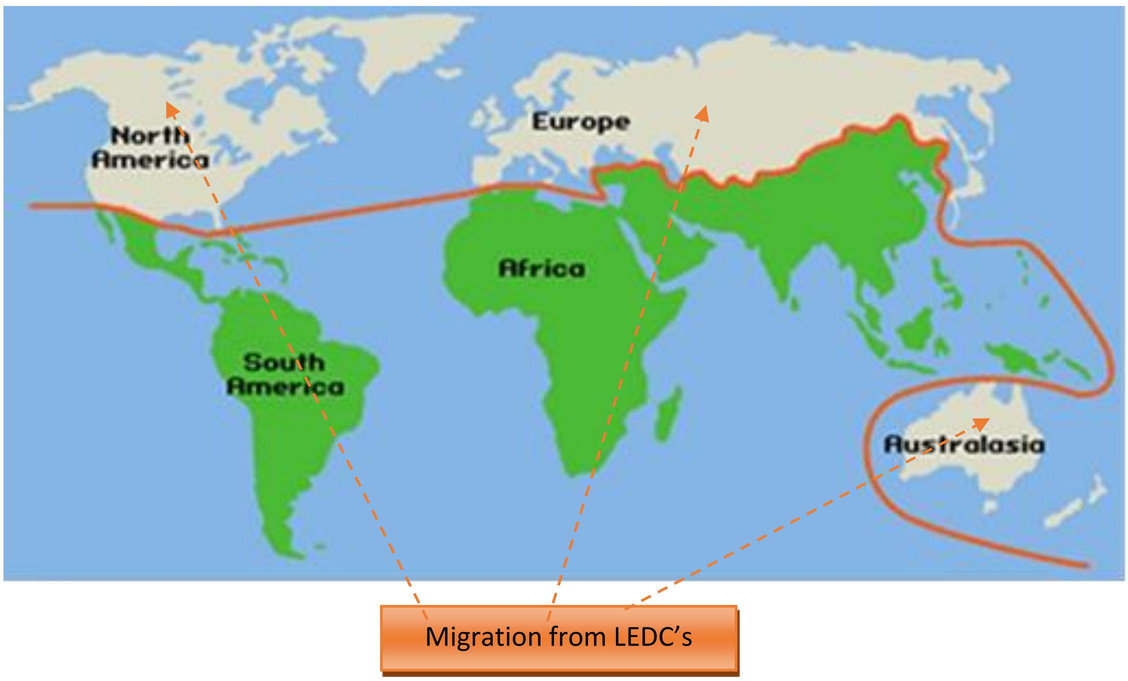


Figure 16: Adapted illustration of the Brandt Line (Lees, 2021).

2.4.1 Global North and South language communities

In the 21st Century, the world is increasingly diverse. Unlike the BL depicted above, some low-income countries experience significant political, economic, and social development (for example BRICS) (Lees, 2021). Hence, there is frequent mobility of refugees to developed nations and across countries to a country perceived to have a more viable economic sector. Based on migration and refugee influx, we can deduce that immigrants, refugees and asylum seekers bring their native language/s and culture/s to communities where they find residence and to other spheres of their lives. According to the United Nations Department of Economic and Social Affairs (UNDESA) (2020), there are 281 million international migrants. Based on the number of international migrants it can be understood that migrants live in a language community to which they bring their languages. In light of the migrant situation, Chiswick and Miller (2014) subscribe to the school of thought that there is no monolingual state in the world (Chiswick & Miller, 2014). However, this is still challenged. Monolingualism is practised in Bulgarian, Czech, Hungarian and Polish/Slovak regions. However, these countries have monolingual practices, despite having language policies that point to plurilingualism and language diversity. This masked situation of language policy versus reality of language use is suggested by Blackledge (2000), who provides insight regarding monolingual ideologies in multilingual states. Four countries are highlighted as having plurilingual language policies, but are English-dominant, namely, the United States, Canada, Australia, and New Zealand (Blackledge, 2000). Also noted in the literature are countries with an increasing influx of immigrants, yet the language policy seems unresponsive. Blackledge (2000:30) states: "Countries with a considerable number of minority communities, and especially those with major immigration inflows, represent the most interesting sites for language policy analyses." There is no current data that empirically confirms absolute monolingualism. Based on the high immigration figures reported by United Nations departments such as the UNDESA, UN High Commissioner for Refugees (UNHCR) and the UN International Organization for Migration (UNIOM), it is evident language communities are increasingly diversified. Turning to Europe, the Eurobarometer Report (2012) on Europeans and their languages mentions 23 official languages, 60+ indigenous regional and minority languages, and non-indigenous languages introduced by immigrants. This survey's main objective is to understand European citizens' experiences and perceptions of multilingualism.

Language communities in the Global South have consistently presented a plurilingual context. According to Kohli (2012), countries with native, plurilingual communities are Africa, Latin America and Asia, including the Middle East. Garcia and Sylvan (2011:389) state: "…translanguaging is the communicative norm of multilingual societies." The Harare Conference hosted in 1997 concluded that there are between 1250 and 2100 languages in Africa (Chimhundu, 2002). Ndhlovu (2008) claims that there are about 2500 African languages. According to Becker (2019), South America has Spanish and Portuguese as official languages spoken by 11 million people and 70 unclassified languages assigned to indigenous groups. The multilingual nature of societies inevitably leads to a situation in which many individuals from the Global South are plurilingual, and where translanguaging occurs as seen from the figures indicated above.

Regarding BRICS countries, aside from Russia, there is a counter-cyclical exchange with deepened interactions beyond state-to-state engagements covering several areas of economic and socio-cultural action (De Kock, 2018). The exclusion of Russia is explained by Li and Marsh (2016:2976):

> Despite efforts to unite these nations, the BRICS countries differ greatly in terms of their diverse languages, political systems, cultures, media systems, and financial regulations. In terms of politics, China is ruled by one party, whereas India, Brazil and South Africa are democratic countries. Although China, India and Russia have a shared history of socialism or socialist legacy, South Africa and Brazil have historically been more involved with capitalism.

The Beijing Declaration (2017) is relevant in the BRICS context as it relates to Agenda 2030 and the Sustainable Development Goal (SDG) 4, which speaks to the creation of inclusive and equitable education and promotion of lifelong learning opportunities for all (Boren, 2019 and Elfert, 2019). Boren provides insight from micro, meso and macro perspective while Elfert engages with SDG from a lifelong learning perspective.

2.4.2 Language communities in Africa

Considerating geographical and social mobility in the African context where refugees and asylum seekers regionally are exposed to communication barriers, the focus on the training of plurilingual language practitioners becomes imperative. The migration presents a nexus between communication access and interpreting. Transnational and international mobility is increasing, affecting diverse language and communication diasporas (UNDESA, 2020). Given the migration context, the translanguaging phenomenon ought to be considered where it applies to language practitioner professions. A translanguaging lens applied to interpreting practice can aid our understanding of novel language and communication diasporas that inform alternative theories and models in interpreting studies (Mbembe, 2016). Africa is a continent with dense linguistic diversity (Chimhundu, 2002 and Ndhlovu, 2008). African languages are grouped in four main categories namely, the Afro-Asiatic (approximately 200) the Nilo-Saharian (approximately 140) Niger-Saharian (approximately 1000), and Bantu (Mbembe, 2016). According to Whitely, Xue and Wheeler (2019), the Bantu language with the largest number of speakers is KiSwahili. The most spoken languages on the African continent include Arabic, French and English, with KiSwahili having the most speakers (100 million) followed by Amharic (more than 21 million) (Chimhundu, 2002).

In considering agency and lived experiences expressing individual linguistic repertoires, Benor (2010:8) states: "…to be ignorant of one's mother tongue is to be uprooted from one's background." This uprooting manifests itself in how plurilingualism is viewed by African decision-making bodies, such as government structures on regional, national and local levels. Ndhlovu (2008: 80) states that "two diametrically opposed perspectives have emerged in relation to the presence of many languages in Africa". The first view is that plurilingualism is placed negatively by linking language diversity to ethnic wars, divided political camps and poor resources. The second holds that multilingualism is an impediment and burden that is in competition to the already scarce resources in Africa. In this view, equating multilingualism to an albatross for development in a multilingual Africa, this research project focuses on a postmodernist perspective on democracy and human rights. This view promotes human rights and equality, rooted in the concepts of "right of language" and "right to language." People bereft of language rights that impact access to resources are the locus of ableism, particularly in the context of minority languages such as sign language. The meta-discourse located in ableism[9] is that fundamental access to services is optimised for the most official language users, and increases gradual infringement on linguistic human rights.

[9] Ableism is a term from critical disability studies that draws on normative societal views of being able in comparison to persons with disabilities lacking ability to be functional. This view is rooted in the medical model of disability. In the context of sign languages and the deaf community, ableism is located in ableist communication norms (Bitman & John, 2019).

2.4.3 The South African linguistic landscape

In South Africa, the linguistic landscape is diversified on many levels and parallels the linguistic diversity across the rest of the African continent. This diversification is framed from the historical context of colonisation. Dichotomies of primitive vs. civilised, mythopoeic vs. logico-empirical, concrete vs. scientific prevailed during English/Afrikaans dominance over the South African local people (Prah, 2012). During apartheid, English experienced two sources of support, first as a language of political power, and second as a language of the struggle in resistance to Afrikaans (Prah, 2005: 2012). Insight to the South African Deaf community and sign language is presented by Aarons (1999), who states the deaf people are a linguistic and cultural minority group. Signed languages are not universal and neither related to a spoken language of the geographical area in which they occur. SASL dialects are tied to deaf education, where the then apartheid government had schools for the deaf in each province that gave effect to provincial dialects. According to Aarons (1999), sign languages flourished in residential schools for the Deaf, irrespective of their official policies on signing. Penn and Reagan (1994) presented linguistic diversity of SASL and attributed this diversity or dialects to the status and past educational policies of Deaf South Africans.

One of the most pressing issues in South African society is promoting and integrating diverse linguistic and cultural communities to realise the dream of a socially inclusive society. The language debate in South Africa is geared toward using one's native language as a basic human right.

> In South Africa, language has now become a terrain of struggle, a struggle over the basic human right to express oneself in one's mother tongue. It is all about self-worth and belonging and is underpinned by power: economic interests, political muscle and cultural concerns (De Klerk, 2002:8).

It is evident in South African Government departments, institutions and services, that English is the language most often used by politicians and government officials. However, attempts by the South African Government to promote multilingualism are seen in dialogues in parliament and national addresses by various public service departments. A more recent incidence that exposed the need for attention to multilingualism in language practice is the COVID-19 pandemic. In South Africa, inconsistent enforcement of the use of official languages were identified when COVID-19 information had to be translated and interpreted into the official South African languages – including sign language. The need for plurilingual interpreters and translators in times of national emergencies is encapsulated by the statement from PANSALB (2021):

> Never has the importance of the use of language been more pertinent than it is right now during the pandemic. We have witnessed the government constantly attempt to stave off conspiracy theories and misinformation on the COVID-19 vaccine. Therefore, it is particularly critical that information on the vaccine be made available in all our official languages so as to ensure that our people are equipped to make informed decisions. This can be achieved by ensuring that such information is available in languages that people understand. (PANSALB, 2021).

2.4 Translanguaging in Deaf Interactions

Communication between Deaf people who sign is natural and effortless, because of their shared language/s and culture/s extending transnationally by Deaf-Deaf-SAME[10] (Friedner and Kusters, 2015). Jørgensen et al. (2011:35) state: “Resources which are available to speakers in the sense that the features are used around them every day may not be at the service of all of them.” This statement is certainly true for deaf people due to language deprivation and a systemic orientation of the world towards an oral communication mode. Kusters et al. (2017) aptly summarise the approach of translanguaging across sign languages by stating that meaning-making is achieved by drawing on ones’ semiotic resources.

Of significance in this section of the chapter are the language and educational exchanges of Deaf scholars and advocates who cross borders and use translanguaging strategies to communicate effectively. Translanguaging international sign transpires by advancement in communication technologies and increasing affordable travel across borders (Friedner and Kusters, 2015) and

[10] International conventions in capitalising phrases that are transliterations of the signed phrase.

Kelly, Tapio and Dufva, 2015). Quinto-Pozos and Adam (2013:1) encapsulate translanguaging in Deaf communities by stating:

> Language contact is the norm in Deaf communities, and that Deaf people are typically multilingual. They use sign, written, and, in some cases, spoken languages for daily communication, which means that aspects of the spoken and/or written languages of the larger communities are in constant interaction with the sign languages.

According to Murray (2015), Deaf people who use sign language as a primary means of communication are part of a linguistic minority. Deaf people are native language models and expressionists of a grammatical sound, visual-gestural language. According to Kusters, De Meulder and O'Brien (2013:431) people are: "…overpowered by societal structures that are not produced by them or for them, and produce their own, different spaces, authoring their own ontologies and epistemologies, which leads to a form of Deaf essentialism defined by the Deaf experience." The lived experience of Deaf people and identity is expressed by Ladd (2003). This Deaf identity, referred to here, has its place deeply rooted in language expression and language use. Identity is further formed by life experiences by engaging with others primarily using sign language.

According to Sutton-Spence and Woll (1999), sign language lacks vocal-auditory language components, and is thus unrelated to the majority speech community. This statement leans toward acquiring sign language via monolingualism, where it is framed as being independent of spoken languages. It is essential to recognise sign languages as grammatically sound, but it is a narrow interpretation of language use, as it unfolds in real-life language communities where deaf people navigate the hearing world by making sense of spoken languages and using translanguaging. In the same vein, phonocentrism is flagged in socio-structural contexts where sign languages are not recognised. Anglin-Jaffe (2011) and Bauman (2008) present the term 'ontological normalcy', which is realised by equating the ability to talk and to hear as a human condition. Wa Thiong'o (1981) highlights phonocentrism as a dated view on language, democracy and human rights and makes the statement of the right of and to language. In presenting an ideal plurilingual, translanguaging model, deaf and hearing people ought to be acknowledged as equivalent, but alternative language users. This paradigm shift is vital in support of a proposed human rights-based equality discourse that is to replace a disability incapacity discourse (Young et al., 2019).

Evidence of plurilingual repertoires of Deaf people and evidence of translanguaging in the Deaf community lead to the question, if Deaf people themselves are translanguaging, do plurilingual sign language interpreters also harness their linguistic repertoires during the act of interpreting? This question remains unanswered, since no empirical investigation has been conducted but part of the answer to the question can be taken from Dewaele and Li (2013), who suggest the term, cultural frame switching (CFS), which refers to adapted behaviour to conform to local socio-pragmatic norms. The CFS presented in bilingual-bicultural respondents, who reported themselves differently when they had L1 or L2 input (Dewaele and Li. 2013).

Inasfar as mobility and diverse language exchange present in the Global North regarding the Deaf community, it is evident that the plurilingual and translanguaging exchanges are deeply entrenched in communication across sign languages. When looking specifically at sign languages, Kusters et al. (2017) investigated shifts presented by translanguaging strategies based on bilingualism and multilingualism, aiming to present an evolved understanding of language repertoires. Garcia and Wei (2014) and Jørgensen et al. (2011) emphasised that translanguaging is multimodal, but there has been no evidence of further empirical enquiry to broaden the understanding of the concept. Where translanguaging is investigated concerning multimodality, the enquiry is focused on social media or cell phone texting. Quer and Steinbach (2019) suggest that varying socio-linguistic statuses in the Deaf community and signers (from the same linguistic community) demonstrate increasing variability within the same community. These aspects have not been analysed further and are not applied within the frame of plurilingualism and translanguaging and sign language interpreting. Based on this context and concerning this project, mobility is understood and interpreted as the geographical, social and education movement of Deaf persons between African countries, South African provinces, schools and social groupings. The fluid social-communication typology of structure in the Deaf community is taken into account and is based on how interpreters navigate the murkiness of communication across these structures.

In South Africa, Deaf people translanguage using SASL dialects, ASL, BSL, ISL, International Sign and spoken/written languages to which they are exposed. Tapio (2013; 2014) writes: “Deaf signers deal with many linguistic varieties and an exceptional number of modes in which and with which those languages are situated”. There are several dialects of SASL linked to provincial dialects and spoken language geographical locations and influence in the South African situation. The dialects of overseas sign languages, such as ISL, BSL and ASL, date back to the missionary schools established for the Deaf, where Deaf learners were educated in these sign languages (Akach, 2010). In South Africa, it can be deduced that Deaf people translanguage using dialects, ASL, BSL, ISL and International Sign, which is based on an observation that Tapio (2013; 2014) makes concerning multiple modes and linguistic varieties presented in communicative spaces. The impact of educational institutions using various dialects of SASL is seen in the provincial schools for the Deaf. The dialects linked to educational institutions are a global phenomenon, for example in the Netherlands, where regional dialects were identified in five schools for the Deaf (Schermer, 2012). The dialects identified are linked to lexicon, phonology, and grammar (Schermer, 2012).

Given that South Africa is a multilingual country with 11 official languages, other sign languages influence SASL and exposure to Deaf signers. who translanguage due to the transnational connections that use a mixture of signs, mouthing and gestures, SASL interpreters are increasingly exposed to translanguaging. According to Friedner and Kusters (2015) and Kelly, Tapio and Dufva (2015) translanguaging (in international sign) internationally (between overseas Deaf people) is realised through the advancement in communication technologies and increasingly affordable travel across borders. Young et al. (2019) support the elements of translanguaging when Deaf people from around the globe meet. These physical and online meetings make transnational communication possible: “…drawing on their existing knowledge of a signed language and fluidly find a commonality of expression and understanding within a similar visual grammatical structure across different signed languages” (Young et al., 2019:90). Tapio (2013; 2014) presented evidence of translanguaging by highlighting linguistic varieties in sign languages. Code-switching between sign and spoken languages is highlighted by De Quadros, Lillo-Martin and Chen (2014), and between two sign languages by Zeshan (2015) and Zeshan and Panda (2015). According to Zeshan and Panda (2015), reiterative code-switching and code crossing presents by decreasing phrases and increasing lexical items.

The European Community for Research (ERC) project on sign multilingualism focused on cross-signing, sign-switching, and sign-speaking (Zeshan, 2015 and Zeshan and Panda, 2015). These works are instrumental in leading to a better understanding of multilingual and multimodal repertoires. In communicative exchange, Deaf people navigate between modalities, of which a relevant example will be that of chaining. An example of chaining is when the Deaf person signs a concept/object and then follows it up by fingerspelling (Bagga-Gupta, 2000; Humphries and MacDougall, 1999; Tapio, 2013). The formation of diverse multilingual and multimodal repertoires is acquired by exposure and interaction with various social, cultural and communication platforms (Busch, 2012; 2015; Canagarajah, 2013; Creese and Blackledge, 2010 and Jørgensen et al. 2011). In contrast, Vermeerbergen, Leeson, and Crasborn (2007) and Tapio (2013) presents inconclusive evidence of meaning making gesture and speech. Recent gesture studies (Goldin-Meadow and Brentari, 2017) have, however, provided evidence that gestures are indeed associated with spoken language components. In the same vein, Liddell (2003) posits the incorporation of gestures in sign languages.

2.5 The Sign Language Interpreter's Linguistic Repertoire

Extending Gumperz's (1960) sociolinguistic concept of 'verbal repertoire', the approach supported in this study is poststructuralist, where the empirical approach is based on the ownership of representivity. In this approach, language speakers' perception and representation of their heteroglossic repertoires is the starting point, which centralises the linguistic community and the respondents. Gumperz (1964:10) adequately captures a holistic view on plurilingualism in that: "…language and dialects form a behavioural whole, regardless of grammatical distinctness, and must be considered constituent varieties of the same verbal repertoire". When interrogating the 'behavioural whole' in the interpreting context, it can be deduced that as a linguistic whole an interpreter has more than one language and dialect at play at any time during the act of interpreting. The rendition of a translanguaged interpreting product reflects how multilingual interpreters employ their holistic communicative resources to create meaning during communication exchange. Linking to the practice of SASL interpreters to the nine provincial sign languages dialects and the 11 official spoken languages it presents a fluid environment for ubuntu translanguaging.

The notion of tolerance ambiguity (TA) serves in better understanding the holistic linguistic repertoire. Budner (1962:92) mentions “originality, complexity, and dispersibility” as features of ambiguous situations. Further to this, an ambiguous situation presents where the context is complicated by varying behavioural and communication cues (Budner, 1962: 92). For interpreters, a TA situation could present itself when interpreting a speaker with a foreign accent (Seravalle, 2011).

Turning the focus now to situated language practice, these are defined as: “…are the bundled activities that one type of social order performs” (Schatzki, 2010:71). To clarify the reference to practices, Pennycook (2010:12) states:

> Language is an integral part of such bundles of activities that are the central organisation of social life’. Language practices move the focus from language as an autonomous system that pre-exists its use, and competence as an internal capacity that accounts for language production towards an understanding of language as a product of the embodied social practices that bring it about.

Alimi and Matika (2017) suggest that the language practices of people in multilingual societies are expressed by translanguaging. Garcia and Sylvan (2011:389) hold a similar view, and state: “…translanguaging is the communicative norm of multilingual societies”. Wei (2011:122) provides a linguistic view on translanguaging by defining it as: “…going between different linguistic structures and systems and going beyond them” and notes that “Translanguaging includes the full range of linguistic performances of multilingual language users for purposes that transcend the combination of structures, alternation between systems, transmission of information and representation of values, identities and relationships.”

In addition, concerning translanguaging, Wei notes that “…fostering intermingling to produce new identities, values and practices” (2011:122). These practices are observed in plurilingual pendulum language practitioners navigating their various languages to reach equilibrium in deciding which concept can be interpreted successfully while translanguaging. Wei (2011) references creativity framed as adhering to linguistic and communicative norms, and posits criticality that is framed as responding effectively to a non-normative situation.

Translanguaging repertoires of plurilingual sign language interpreters stem from the evolving concept of an interpreter operating not purely in an L1 and L2, but crossing cognitively, culturally, and linguistically so as to provide communication access by a shared understanding of the interlocutors' communication system, as is seen in a melting pot language community. Complementing this understanding is the critical role that language practitioners ought to embrace in order to apply strategy and context to code-switching into varieties of the language communities they serve. As Rampton (1995:485) states: "switching across social or ethnic boundaries raises issues of legitimacy", in which the traditional lens of interpreting questions the authenticity in terms of accuracy of L1/L2 interpreting products.

Reflective practice is vital in advancing language practice in its development towards changing linguistic environments. Referring to reflective practice, Wei (2011) acknowledges the translanguaged product by framing it as criticality, where the interlocutor can think through the non-normative context and respond effectively. This reasoned response can be enhanced by adding the cognitive functions of analysing and processing the message to ensure the communicative functions during an exchange are managed accurately and adequately by the interpreter. Wei (2011) states that these reasoned responses are decisive moments where a decision is made to either follow or flout the rules and norms of language use. The decision is grounded in local practices, making it a regular communicative exchange domesticated and welcomed in a local setting. Hence, the natural communicative act of translanguaging ought to be encouraged as a strategy during interpreting to allow for natural communication exchange between interlocutors.

The concept of translanguaging in interpreting practice marks a shift away from structure, system, and regularity, to approaches that acknowledge fluidity and creativity in linguistic practices. For this reason, language practice ought to evolve and complement the understanding of a translanguaging environment.

2.6.1 Dominant language constellation (DLC)

In this section on sign language practice, the concept of dominant language constellation (DLC) is investigated. An attempt is made to locate its relevance to the concept of the interpreting function as it relates to plurilingual societies.

DLC refers to an individual's group of languages, that operates as a whole and allows optimal functioning in plurilingual environment (Aronin and Singleton, 2012). The authors describe DLC as made up of various languages used by a community to achieve communicative aims. Given this context from a practice perspective, the extent to which a community shares linguistic norms across its multilingual language repertoires makes criteria referencing important. Criteria referencing in sign language interpreting, as an example, is the broadcast of a presidential address, where the interpreter uses SASL with mouth morphemes in English and isiZulu. This interpreting product requires specific criteria to which the consumer and other language practitioners can refer. At present, such criteria do not exist. The use of English mouthing and SASL signs is accepted as the norm, and serve as criteria against which the interpreter is rated. From this situation, one can conclude that a DLC includes languages with various status levels as they are used in society by the government and regarding their official, legal status. Aronin and O' Laoirie (2012:62) states: "…it is the community DLC which furnishes the essential tools for communication and which is indeed the basis of community identity".

Language repertoire encompasses the communities' linguistic heterogeneity and an individual's unique proficiency, which enables optimal functioning within and across various registers of a mosaic of languages in the speech/sign community (Gumperz, 1964; Rampton, 1995; 2011, Schiffman, 1996; Garcia, 2009 and Busch, 2012). It is appropriate to focus on sign language interpreter practitioners' linguistic repertoires and DLC and how these factors feed into each other. Three languages are recommended as a minimum criterion for working in plurilingual interpreting settings. Aronin and Laoire (2012:63) argue that "…out of the whole repertoire of languages known and is used by a multilingual only a sub-set is used intensively and bear the load of the functions necessary to meet the individual's routine needs." Limiting the use of three languages only restricts the use or partial use of the languages that make up the individuals' plurilinguistic repertoire. The three language usage debate links back to the language classification of AIIC as discussed in the literature review Chapter 2, Section II.

In a plurilingual country such as South Africa, where some language practitioners are equally competent in more than three languages, there should exist a platform to acknowledge the use of these languages. A DLC is fluid, and relevant to an individual's lived experience, such as personal or socio-historical events. This fluidity in DLC requires the community of practice to be responsive. This responsiveness can create enabling platforms for constructing vibrant sociolinguistic interpreter profiles, which advance a dynamic ambit for 21st Century careers in the language practice. Furthermore, it embraces plurilingual interpreters coached in a comfortable spectrum to produce the vernacular target and source languages on equal footing to English.

2.6.2 Metalinguistic awareness of the translanguaging practitioner

Kubota (2014:33) poses the question: "Can all English users regardless of their racial, gender, socioeconomic, and other background equally transgress linguistic boundaries and engage in hybrid and fluid linguistic practices?" In an attempt to respond to such a question, I link to the concept of translanguaging, where language users in a communicative event employ all their linguistic resources to enable communication. If an interpreter is required where all interlocutors are speakers of different types Englishes, there is an obvious lack of commitment of the interlocutors to navigate their linguistic repertoires. Kubota (2014:23) frames the plurilingual advantage of metalinguistic awareness by stating: "the awareness of language itself is independent of the message it is conveying."

2.7 Conclusion

This chapter highlights various scholarly references to plurilingualism and translanguaging. It presents a topic for debate that plurilingual individuals have heightened language awareness. The awareness of the interpreter's plurilinguistic repertoire ought to prompt empirical investigation of the phenomenon in interpreting. Investigations into the application and use of translanguaging strategies in interpreting can make way for novel and complex theories and models. The study is timely in that South African sign language interpreters are increasingly exposed to Deaf signers who translanguage due to transnational interactions that use a mixture of signs (geographic dialects), different hand forms, mouthing and gestures. In addition, SASL interpreters are exposed to plurilingual communities where translanguaging is typical. This chapter concludes with a statement by Kusters et al. (2017:220): “Language in use, whether spoken, sign or text, is always and inevitably constructed across multiple modes of communication and through ‘contextual’ phenomena such as the use of the surrounding physical spaces”. The next chapter focuses on the theoretical framework and methodology.

CHAPTER 3

Theoretical Framework

3.1 Introduction

Adom, Hussein and Adu-Agyem (2018:438) agree that the theoretical and conceptual framework "assist in stimulating research while ensuring the extension of knowledge by providing both direction and impetus to the research inquiry. They also enhance the empiricism and rigor [sic] of a research."

The theoretical approach in this study draws on motor cognition theory (MCT) and adaptive control theory (ACT). It guides on how data is perceived, making sense of and interpreting it. The value of a theoretical framework exists to: "…explain the meaning, nature, and challenges associated with a phenomenon, often experienced but unexplained in the world in which we live, so that we may use that knowledge and understanding to act in more informed and effective ways" (Ravitch and Matthew, 2017:45). The theoretical framework is taken 'on loan' from the original theorist to shape and apply its constructs to the investigation to contribute to the applicability of the theory. "It is a blueprint that is often 'borrowed' by the researcher to build his/her own house or research inquiry" (Adom et al. 2018: 438).

The framework facilitates the contribution of new knowledge by testing the theory in a specific context to confirm, reject or extend it. Merriam (2009:49) notes that qualitative research informs existing theory:

> Data are analyzed [sic] and interpreted in light of the concepts of a particular theoretical orientation and findings are usually discussed in relation to existing knowledge with the aim of demonstrating how the present study has contributed to expanding the knowledge base.

A theory can be defined not only in academic terms but also concerning the applicability to real life issues hence the term ‘publishing research with impact’ is used in academic circles (Saldana and Omasta, 2018). Saldana and Omasta (2018:257) state: “Social life holds transferable applications to other settings, context, populations, and possibly time periods.” The University of York notes that research with impact is “When the knowledge generated by our research contributes to, benefits and influences society, culture, our environment and the economy” (What is research impact, 2021). The University of the Witwatersrand (Wits) states its vision for producing research with impact:

> Wits aims to produce increasing amounts of research with impact, which includes research that changes disciplinary thinking, discovery research, research that influences policy and practice, translational research, and research that can be taken to the market to generate economic activity, innovative research (Impact on Society, 2020).

In this project, the focus is on the cognitive aspects of language processing in relation to interpreting in a plurilingual setting. The study is conducted on plurilingual SASL interpreter respondents, who render a diamesic interpretation under PET brain imaging. Other variables noted, but not part of the investigation include environmental, social, physical, and emotional factors that could impact interpreting or the interpreter.

Concerning methodology and research bias, Guba and Lincoln (1994:110) state: “…critical theory adopts a more transactional and subjectivist epistemology where the investigator and the investigated object are assumed to be interactively linked, with the values of the investigator, inevitably influencing the inquiry.” Entrenched in this statement is my proximity as a researcher and language practitioner (SASL interpreter), and the way in which my paradigm regarding interpreting influences the approach to the study and interaction with the respondents. This proximity and status are labelled as “practitioner-researcher” by Jarvis (1999). I therefore acknowledge biases that could present as blind spots in this study, as informed by my years of practice in the interpreting field.

3.2 Theoretical Framework

3.2.1 Motor cognition theory (MCT)

Motor cognition theory (MCT) holds action and perception are activated by sensori-motor mechanisms (Pulvermüller et al., 2014). During the act of visual perception, motor and sensory information is integrated by the activation of mirror neurons (Rizzolatti and Sinigaglia, 2010). Yeung and Werker (2013) clarify the formation of linguistic-articulatory action schemas by presenting evidence of how action-perception is linked to manual, mouth actions and visual and acoustic perceptio00ns. According to Hubel (1995:9): “Modality specific sensory modules route information to the central systems for attention, memory, language, concepts, decisions which propel motor output.” The right frontal areas of the brain are activated during sign language comprehension according to Corina and Knapp (2006:24): “…language-born resonance is more diffuse than motor resonance evoked during action observation or imitation.” This statement agrees with Jeannerod (2006:65), who states: “…cognition is built from action and perception, upon sensory and motor brain mechanisms.”

This study focuses on the cognitive areas activated in plurilingual sign language interpreters. There is no clear evidence of MCT being accepted as a basis for how perception is translated into action as a result of findings of cognition-action covariation based on cognition studies that focus on how perception, cognition, and action interrelate in the brain (Freeman et al., 2011). The mediating of the processes is expressed by Freeman et al. (2011) thus: “For instance, neurophysiological studies often observe cortical areas traditionally thought as perceptual or motor in nature to contain signals appropriate for higher-order cognitive decision making” (Freeman et al., 2011: 2).

This study uses SASL as perception input and the action required is the interpretation product. When a person hears a language utterance, cognitive mechanisms are stimulated to effect an action (Pulvermüller et al., 2014). Rizzolatti and Craighero (2004) state that there is an entwined process for language, perception and production. Sommerville and Decety (2006) state:

> Motor resonance is a function of making a sensible judgement, rather than comprehending the sentence, which implies that motor resonance arises during comprehension and not merely during lexical access, before the associated linguistic constituent has been fully processed; thus aspects of visio- spatial cognition are explored within this theory.

Pulvermüller (1996; 1999) and Pulvermüller et al. (2014) state that the mechanism for an action schema is noticeable in the language domain where articulatory-motor and acoustic-perceptual schemas are stored. The comprehension of sign language as input involves visiospatial processes described by Emmorey (2002:67) as follows: "Comprehension of sign language consists of hand configuration, motion discrimination, identification of facial expressions and recognition of linguistically relevant spatial contrasts." The comprehension that Emmorey (2002) refers to can be applied to this study and stated as the understanding and sense-making of the input language to deliver an accurate, functional interpretation in the target language, which is a spoken language(s).

3.2.1.1 The action perception circuit

Of relevance to this study is the action perception circuit (APC) as it relates to MCT. APC is an associative learning mechanism that synchronises motor, sensory, and intermediary connecting neurons, which has to effect a specific action (Braitenberg and Schüz, 1998). In Chapter 2 (II) of the literature review, cognitive models of the perception action cycle (PAC) were presented by the studies of Koechlin et al. (2003); Cutsuridis (2013) and Negrón-Oyarzo et al. (2015) (Figure 3.1). The APC plays a critical role in the language domain. According to Pulvermüller (1996:73): "…articulatory-motor and acoustic-perceptual schemas are entrenched in the cortico-cortical long-distance neuroanatomical links between relevant areas, for language in inferior-frontal and superior-temporal cortex and correlated activation of both motor and sensory neuron sets". The APC thus provides a foundation for social-communicative function (Keyser and Perret, 2004). The applicability of the APC in this study is linked to the lexical-semantic processing to contribute to sense-making in the delivery of a syntactically appropriate format. The appropriate format is the interpretation product linguistically, culturally, and socially fitting and understood *in situ*. When focusing on semantic-conceptual processing the perisylvian areas in the frontal and temporal cortex are vital to understanding language mechanisms. Figure 17 highlights the cognitive areas and language mechanisms.

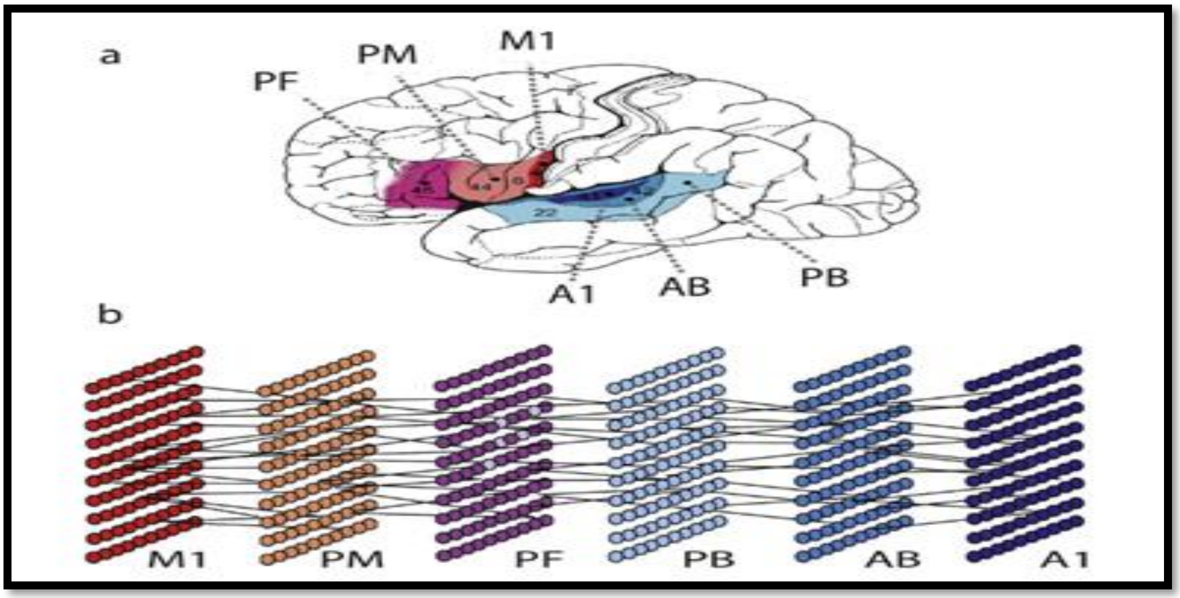


Figure 17: APC illustrated with cognitive areas inferior motor (M1: BA 4), premotor (PM: BA 6 and 44), and prefrontal cortex (PF: BA 45 and adjacent sites) in the frontal lobe, and auditory core (A1), adjacent auditory belt (AB), and parabelt (PB) cortex in superior temporal lobe, gyrus, and sulcus (Pulvermüller, 2018:6).

Motor resonance according can be defined as, "…the internal activation of an observer's motor system specifically attuned to the perceived movement" (Hamilton, 2013:14). According to Jeannerod (2006) and Sommerville and Decety (2006), communicative motor resonance is the reaction of the APC where the motor system responds to communicative input. In this study, visual input by SASL as a source language and the 'referential motor resonance', is the reaction of the motor system that creates meaning and which leads to sense-making in understanding the input. Here, the interpreter respondent understands the source language (SASL) and the presenter's communicative intent: thus, the interpreter can articulate the message in the target language/s. The MCT and APC will be applied to understand motor-cognition in interpreting, specifically pointing to cognitive processes of interpreting in this experiment.

This project explores cortico-cortical long-distance neuroanatomical using NeuroQ^{TM}, discussed in the methodology section of this chapter (See 3.3. Research Design and Methodology).

3.2.2 Adaptive control theory (ACT)

Adaptive control is used mainly in the engineering sciences for designing control systems, where the direct and indirect controls deal with uncertainties (Cao, Ma and Xu, 2012). ACT thus points to an adaptive function that allows for adjustment to effect a desired stability state. In the context of applying ACT to languages and interpreting, Green and Abutalebi (2013:515) conducted a study on bilinguals, suggesting the following hypothesis:

> Language control processes themselves adapt to the recurrent demands placed on them by the interactional context. Adapting a control process means changing a parameter or parameters about the way it works (its neural capacity or efficiency), or the way it works in concert, or in cascade, with other control processes (e.g., its connectedness).

Kheder & Khaan (2018:67) refer to cognitive control processes thus: "Speech perception and interpretation is steered by cognitive and physical control processes."

Green and Abutalebi (2013:515), applied ACT as it relates to cognitive, perceptual and brain sciences, by stating: "…speech comprehension and production are governed by control processes." These authors confirmed the hypothesis that: "…language control processes themselves adapt to the recurrent demands placed on them by the interactional context" (Green and Abutalebi, 2013:516). The control processes are "…goal maintenance, conflict monitoring, interference suppression, salient cue detection, selective response inhibition, task disengagement, task engagement and lastly opportunistic planning" (Green and Abutalebi, 2013:518). These control processes were identified in three interactional communication contexts: "…single-language, dual-language and dense code-switching" (Lai and O'Brien, (2020: 2). Single-language context refers to a monolingual exchange in distinctly separate environments, for example, when different languages are spoken or signed in the communicative exchange. A dual-language context refers to two languages used with different interlocutors, for example, when a spoken language is used with a hearing person and a sign language is used with a signing-Deaf person. In a dense code-switching context, code-switching is framed as a translanguaging strategy on lexical, semantic, and syntactic levels. It is within the scope of translanguaging in the interpretation that the ACT applies to this study.

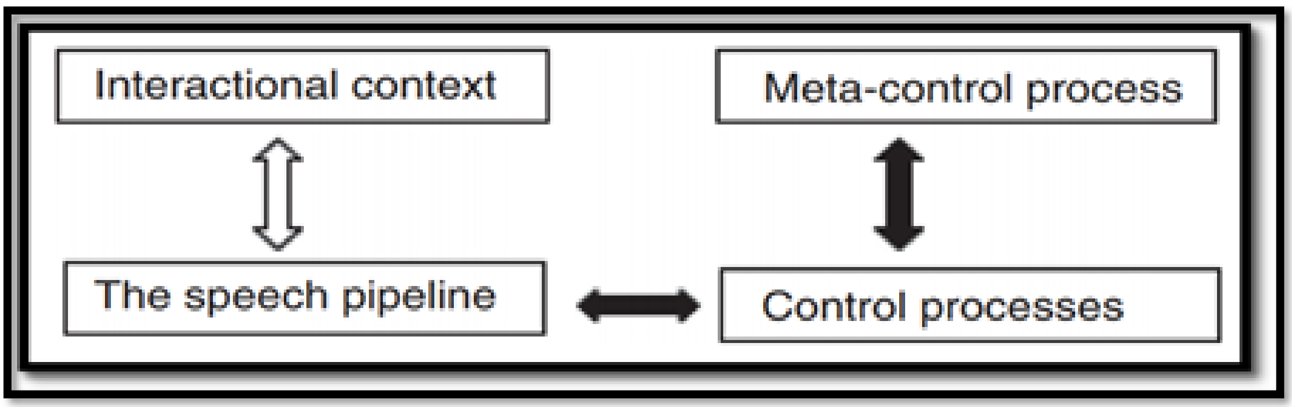


Figure 18: Adaptive control process (Green and Abutalebi, 2013:517).

The application of the ACT to the interpreting experiment will provide a platform to engage and expand the applicability of the theory not only in bilingualism as proposed by Green and Abutalebi (2013; 2018), but in plurilingual contexts as well. Abutalebi and Green (2016:690) describe the cognitive processes involved in bilinguals:

> The cognitive processes underlying language control cover the intention to speak in a given language, selection of the target response (the word in the intended language), inhibition of words from the nontarget language, and monitoring speech for potential intrusions (viable candidate words in the other language as well as language disengagement and engagement (i.e., ceasing to speak in one language and switching to another. Abutalebi and Green (2016) conducted the experiment on bilingual interlocutors based on conversational turn-taking and not in the context of interpreting. They specify multilingual code-switching and the brain areas implicated in the illustration below.

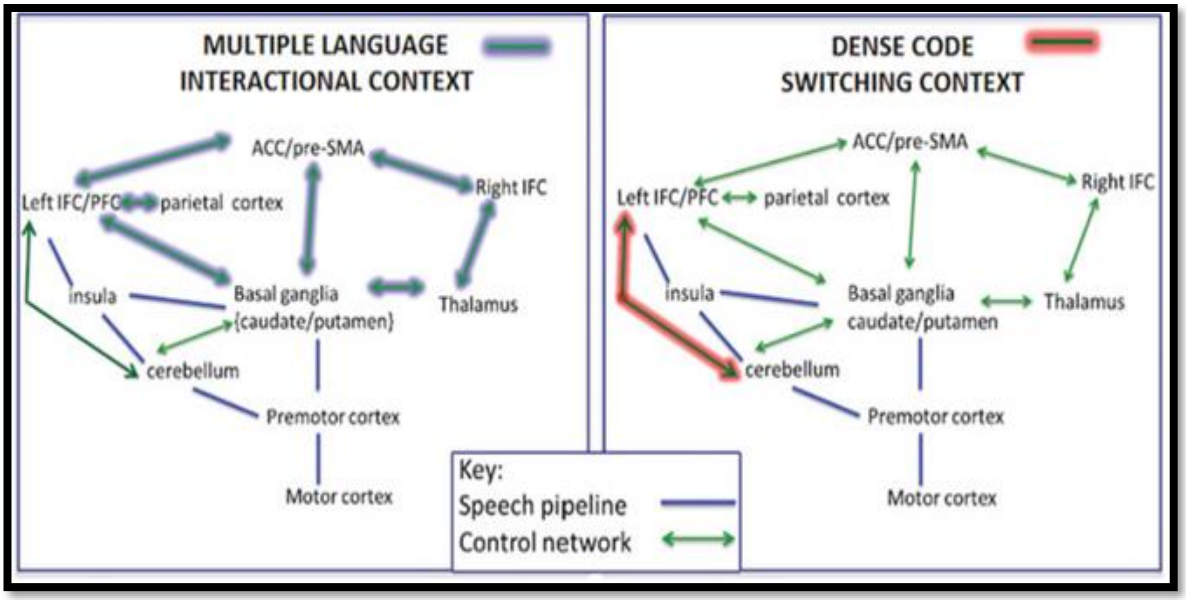


Figure 19: "Brain Regions related to language control in multiple language interactional context and dense code-switching contexts" (Abutalebi and Green, 2016:691).

A study conducted by Lai and O'Brien (2020) tested the ACT hypothesis on bilingual respondents in communicative interactions and the cognitive control processes associated with the verbal Stroop task and the non-verbal Global–Local task (Lai and O'Brien, 2020). They concluded:

> The findings of this study points to inter-sentential and intra-sentential switching also named code-switching. Through the use of multiple language switching measures that include objective, rigorous, and naturalistic tasks, results from the current study showcase the multi-dimensionality of language switching and its complex interaction with cognitive control processes (Lai and O'Brien, 2020:19).

In this study, the conditions of plurilingual language use, as it pertains to diamesic interpreting, is examined in a clinical setting to test cognitive language processing. The uncertainty of the control in this plurilingual interpreting experiment is two-fold. The first relates to the environmental conditions of the study. The respondents had not previously participated in a PET brain experiment to interpret under clinical conditions while lying down. The second concerns the fact that the interpreters had not previously been exposed to the source text as it is an organic text recorded by signing Deaf people. The known control in the experiment is the interpreters' brief that allows for a frame of reference to develop during preparation for the assignment. Not providing the respondents with the actual SASL source text before the experiment mirrors a real situation in interpreting, where interpreters generally do not receive the preparation material before the assignment. This situation creates probabilities and uncertainties, which are framed to allow the testing of the ACT.

In principle, the ACT is grounded in the understanding that a system (in this project, the cognitive system) can modify its operation to achieve its best functionality. The relevance of adaptive control as a theory for this study is its correlation with the mental processes that occur during interpreting, specifically observation, processing, output and monitoring. The adaptive control system in this experiment consists of the cognitive functions activated during interpreting. Cognitive functions ought to provide continuous information about the state of the process, while comparing incoming stimuli (SASL source language) with the desired performance (target language/s), and simultaneously making decisions around modification (in this context, monitoring).

The three principles of the ACT are identification, decision, and modification. It is of interest to the study how ACT presents in a decision-making act in a plurilingual context, where the communicative aims are at stake and where the interpreter respondent is faced with a decision to modify the interpreting product to allow for communication flow, without jeopardising the faithfulness of the interpretation. In this context the adaptive control process as posited by Green and Abutalebi (2013:33) is upheld: “Adapting a control process means changing a parameter or parameters about the way it works (its neural capacity or efficiency) or the way it works in concert, or in cascade, with other control processes.”

In the current study, the experiment aimed to identify which areas are activated during code-switching using NeuroQ™ software.[11] In the context of dual language use and dense code-switching, Green and Abutalebi (2018) argue that speakers adopt conversational practices that match the communicative situation. In this study, the adaptability of the plurilingual interpreters

[11] NeuroQ™ is a leading software package that measures brain activity by regions and clusters through analysis of a PET/CT brain imaging scan (Jafari and Silverman, 2015).

interpreting capability was explored regarding the language production strategies linked to translanguaging and cognitive areas activated.

3.3 Conclusion

The theoretical framework provides a solid base for this study. Its application and contextialisation to a diamesic interpretation is discussed in Chapter 5, where the results of the study is integrated to modify the ACT as it this relates to plurilingual SASL interpreters, or sign language interpreters in general.

Chapter 4
Research Design and Methodology

4.1 Introduction

Research is based on three essential components namely, epistemology, ontology, and methodology (TerreBlanche and Durrheim, 1999). Working through these three components contributes to the meticulous and coherent qualities of the study (Collins and Stockton, 2018). This chapter presents the interrelated approach of theory and methodology to conduct an empirical investigation of cross-disciplinary research in interpreting studies and neuroscience.

4.2 Research Design and Methodology

This section highlights the research design and methodology for the experiment that investigates cognitive language processing using PET brain imaging, drawing data from plurilingual SASL interpreters by simultaneous, diamesic interpretation. This study is a mixed method study, that uses both qualitative and quatitative methods.

According to Mohajan (2018:1): "Every research must involve an explicit, disciplined, systematic (planned, ordered, and public) approach to find out most appropriate results." Achieving this lies in solid and clear research design and method. This project considered the validity and reliability aspects of data collection and analysis to ensure a sound research method was followed. In this study, reliability is supported by the consistent application of the data collection tools. In addition, the SASL source text remains the same input text in the experiment. The validity of the study is assured by utilising NeuroQ^{TM} software to ensure the measurements of cognitive activity, both in baseline and activation imaging, remains consistent.

Reeves and Hedberg (2003:32) note the following comcerning contextual analysis: "The interpretivist paradigm stresses the need to put analysis in context". The interpretive paradigm frames an understanding of the context from subjective individual experiences (Reeves and Hedberg, 2003).

Qualitative data analysis is the formal interpretation of collected data to create order, elicit meaning and communicate findings (Noble and Smith, 2014). Noble and Smith state: "High quality qualitative data analysis requires a researcher with expertise, vision and veracity". Embedded in this quote is the need for the analysis to be contextually considered, and systematic, while simultaneously processing the data on an abstract and conceptual level. According to Morse (2011), the research context could present the need to triangulate data. This project adopted a reflexive style of analysis that allowed a 'mix-and-match' approach to both data collection and analysis to triangulate the data. Ibrahim (2015:99) offers a definition of data analysis: "The word analysis refers to a closely related operation with the purpose of summarizing the collected data and organizing in such a manner yielding answers to the questions" [all sic]. Noble and Hale (2019:67) capture the essence of triangulation succinctly by stating:

> Triangulation is a method used to increase the credibility and validity of research findings. Credibility refers to trustworthiness and how believable a study is; validity is concerned with the extent to which a study accurately reflects or evaluates the concept or ideas being investigated. Triangulation, by combining theories, methods or observers in a research study, can help ensure that fundamental biases arising from the use of a single method or a single observer are overcome. Triangulation is also an effort to help explore and explain complex human behaviour using a variety of methods to offer a more balanced explanation to readers. It is a procedure that enables validation of data and can be used in both quantitative and qualitative studies.

This project used data triangulation with data analysis tools that included speech-to-text transcription software AmberScript, ELAN transcription software and NeuroQ™ PET brain analysis software. In addition, manual transcription methods were used to transcribe the vernacular spoken languages into English to compare the interpreted text against the source text. The manual analysis of the questionnaire was done by analysing across themes in the questionnaire. The three data analysis methods described aimed to identifying patterns, themes and meanings across the three data sets. Diversifying data analysis supports the credibility of the study and reduces the bias that could arise from a single data analysis method (Noble and Hale, 2019). Furthermore, the authors refer to triangulation as a complex and time-consuming approach to data analysis. The timeline of the study was intended to allow for data collection and the analysis of the data.

4.2.1 Respondents and sampling method

Turner (2019: 8) defines sampling as: "…the selection of a subset of the population of interest in a research study". The respondents in this study are plurilingual SASL interpreters, based in the Gauteng Province of South Africa. This study used non-probability sampling (Turner, 2019). The recruitment criteria clearly stated the respondent characteristics to be a practising SASL interpreter, aged 18-50, multilingual with three and more languages, one of which must be SASL, a minimum three-year experience in interpreting, in good health, and should not be pregnant or breastfeeding. The sampling target was 20. At inception of the study, 20 respondents were recruited, but three respondents had to withdraw for health and operational reasons. This meant that three additional respondents had to be recruited to make up the target of 20 respondents. Thus, the total number of respondents recruited for this study was 23, but data were collected from 20 respondents only. There were 15 female and 5 male respondents in this study. This sample is unrepresentative of the population of plurilingual SASL interpreters. A sample size of 20 was decided on due to the financial implications associated with the high cost of procuring the FDG molecules (Appendix B- Pharmaceutical Quote on FDG single dose). This study used two doses of FDG for baseline and activation PET brain imaging. Given these financial implications, it was not viable to increase the sample size. SASL interpreter contacts on the databases of the Deaf Federation of South Africa (DeafSA), South African Sign Language Interpreting National Centre (SASLinc) and the South African Translators Institute (SATI) were accessed in order to invite sign language interpreters to participate in the study (see Appendix C-Email request to access contact details of sign language interpreters).

4.2.2. Medical protocol

The development of novel protocols for PET brain imaging provides valid dosimetry procedures with preparation and acquisition times according to standard clinical practice (Vaquero & and Kinahan, 2015). The protocol for this project thus follows standard clinical procedures.

i) Patient preparation

Respondents were requested to fast for at least four hours before the study. The blood glucose level of each respondent was measured in the morning of the study before injecting Fluorodeoxyglucose (18F) (^{18}F-FDG). Routinely, FDG activity given to individuals attending nuclear medicine department at Charlotte Maxeke Johannesburg Academic Hospital for PET brain imaging, is between 150 and 185 Megabecquerel (MBq). Generally, the activity injected during PET brain imaging depends on the clinical application (Buck et al., 2002). The authors stated that the amount of the activity (FDG) for brain imaging has been evolving so as to allow the injected dose to be reduced and in their institution, a standard dose of 100 MBq is administered (Buck et al., 2002). In the Alzheimer's Disease Neuroimaging Initiative (ADNI3) PET Technical Procedures Manual for brain research imaging, it is recommended to administer 185 MBq (+- 10%) for FDG brain imaging and imaging should not occur if the dose is below the minimum of 93 MBq (Buck et al. 2002).

ii) FDG acquisition

Respondents had two PET- brain images performed, baseline and activation, at two different timed intervals. On the day of the baseline study the nuclear medicine radiographer administered ^{18}F-FDG using a pre-inserted intravenous catheter into a cubital vein in the arm. Respondents were advised to remain lying down in a relaxed resting position. The PET scan was started after 30 minutes after the administration of FDG. The respondents were placed comfortably on the bed of the PET scanner, with a fixed head position, using the orbitomeatal line from the laser beams as a reference. The respondents' head position was secured with Velcro strips to minimise motion and enhance imaging quality. On the day of the activation study, the same medical procedure was applied for the baseline scan. In addition, 30 minutes were dedicated for the second scan viewing the source text (SASL video) interpreting into spoken language/s while imaging is performed. The video was played via an iPad screen placed at the gantry of the PET scanner directly facing the respondent. An audio recorder was placed next to the respondent in the machine to record their voice (the interpretation). A camera was set up adjacent to the gantry to record the respondent (Appendix D- PET-brain procedure). For both baseline and activation, a 3D mode acquisition was done and attenuation correction was used with the CT of the PET/CT scanner.

Numerous studies have used ^{18}F-FDG-PET imaging to evaluate glucose metabolic changes as a response to stimuli of different types (Table 4.12) below.

Table 1: Summery of the most relevent studiea on PET imaging with FDG in different types of tasks

Task	Number of subjects	Type of PET imaging modality	outcome	Reference
Visual task	5 subjects	Visual stimilation was started 5 minutes before injection of FDG and continued throughout the study	Hypermetabolism in the primary and associative visual cortex, as the complexity of visual scenes increased	[35]
Motor task	1 subject	The valunteer underwent 20 min periods of rest and motor avtivation (motor task, which involved repetitively grasping and releasing the right hand, performed during the initial 5 min of the activation period)	Hypermetabolism in the contralateral primary motor cortex, the supplementary motor area, and the ipsilateral (right) cerebellum.	[14]
Force and position motor task	2 subjects	FDG injection has been performed during both a force and posotion task (sepatated by 7 days, with the elbow flexor muscles at 15% maximal valuntary contraction force)	Greater metabolism in the occipital and temporal cortices of the brain during the posotion task comared the force task.	[15]
Volitional swallowing task	8 male subjects	PET-FDG at rest and while swallowing (20- second intervals for 30 minutes) in the erect s seated position	During swallowing hypermetabolism in left sensorimotor cortex, cerebellum, thalamus, precuneus, anterior insula, left and right lateral postcentral gyrus, and left and right occipital cortex; decreased metabolism in the right premotor cortex, right and left sensory and motor association cortice, left posterior insula and left cerebellum.	[16]
Complex visuospa-tial/motor task	8 male subjects	Subjects underwent PET-FDG perfoming a complex visuospatial/ motor task (the computer game Tetris), before and after 4-8 weeks of daily practice on Tetris	After practicing glucose metabolism in cortical surface regions decreased despite an increased performance: subjects who improved their Tetris performance the most after practice showed the largest glocose metabolic decreases in several areas. These results suggest that learning may result in decreased use of antraneous or inefficient brain areas.	[17]
Osmic task	11 subjects; 26 subjects	Injection of FDG in bolus during neutral (rest) and during a pure (stimulation) olfactory condition in both papers.	At rest mainly increased glocose metabolism in left superior, inferior, middle, medial frontal, orbital gyri and anterior cingulate cortex, while during olfactory stimulation hyperactive in the cuneus, lingual, and parahippocampal gyri, mainly in the left hemisphere in both papers.	[22,23]
Passive problem solving rask	22 subjects	PET-FDG have been perfomed while the subjects viewed videos on two occasions, task with no inherent reasoning or problem solving, and date have been compared to Raven's Advanced Progressive Matrices test (RAPM) scores.	Hyperactivation in specific posterior brain areas in high RAPM scores. Subsequent analyses revealed a high/low RAPM group difference in functional connectivity between left activity and the left anterior cingulate/medial frontal gyrus. These data provide evidence that individual differences in intelligence correlate to brain function even when the brain is engaged in nonreasoning tasks.	R.J. Haier, N.S. White and M.T. Alkire,"Individual differences in general intelligence correlate with brain function during nonreasoning tasks," Intelligence, vol.31, no5,pp 429-441,2003.

Task	Number of Subjects	Type of PET imaging modality	outcome	Reference
Visual lexical decision task	11 right - handed male subjects	Subjects underwent PET-FDG during rest and two versions of a visual lexical decision task (novel or repeated stimuli performed during the 30 min FDG uptake period).	Comparisons of the task with the resting condition revealed significant relative activations of visual and motor areas. Novel words evoked significantly greater activation in the left and right anterior cingulate gyri and right hippocamoal formation than did repeated words in the same task. Relative glucose metabolism in the left angular gyrus was significantly greater to novel words than to resting. Thus, two tasks equated in sensory, motor, and decision process, but differing in the familiarity of the stimuli, evoke sugnificantly different patterns of brain activation.	V.I. Nevon,E. Halgren,M. Mandelkern and M.E. Smith, 'Human brain metabolic responses to familiarity during lexical decision." Hum Brain Mapp, vol.1 pp.249-268,. 1994
Car driving task (active and passive driving)	30 subjects	Subjects have been divided into three subgroups for examination by PET-FDG: active driving (10 subjects that drove for 30 minutes), passive driving (10 subjects that participated as passengers on the front seat) and control (10 subjects remained seated in a lit room) groups.	In active driving: hyperaction in the primary and secondary visual cortices primary sensorimotor areas, premotor area, parietal association area, cingulate gyrus, the parahippocampal gyrus, thalamus and cerellum. In passive driving: manifested a similar-looking activation pattern, lacking activations in the premotor area, cingulate and parahippocampal gyri and thalamus. Direct comparison of the active and passive driving conditions revealed activation in the cerebellum.	M.Jeong, M. Tashiro, L.N. Singh, K. Yamaguchi, E. Horikawa, M. Mayike, S, Watanuki, R. Iwata, H. Fukuda,Y. Takahashi and M. Itoh, 'Functional brain mappig of actual car-driving using [18F]FDG-PET," Ann Nucl Med, vol.20,no. 9, pp. 623-628, 2006
Horizontal and vertical navigation task in real space	24 right-handed male subjects	Spatial orientation was tested during a horizontal and vertical real navigation task. Video tracking of eye movements was used to analyse the behavioral strategy and combined with simultaneous measurements of brain activation and metabolism.	During horizontal navigation metabolism increased in the right hippocampus, bilateral retrosplenial cortex, and pontine tegmentum; during vertical navigation in bilateral hippocampus and insula. Direct comparison revealed a relative activation in the pontine tegmentum and visual cortical area during horizontal navigation and in the flocculus, insula, vertical navigation.	A. Zwergal, F. Schoberl, G. Xiong, C. Pradhan, A Covic, P. Werner, C. Trapp, P. Bartenstein,C.la Fougere, K. Jahn, M. Dieterich and T.Brandt, 'Anisotropy of Human Horizontal and Vertical Navigation in Real Space: Behavioral and PET Correlates," Cereb Cortex,vol.26, no.11, pp. 4392-4404, 2016
Word repetition and word cognitive association tasks	8 subjects	Two different tasks were performed in randomized order during PET-FDG scanning: word repetition (after the auditory presentation of nouns) as a control condition, and word association (after the auditory presentation of nouns) as a specific semantic activation.	Word association was associated with Activation in the left prefrontal cortex, the left frontal operculum (Broca's area) and the left insula, indicating the involvement of these areas in associative language processing. Decreased metabolism was found in the left posterior cingulum during word association; during word repetition, highly significant niegative correlations were found between the left prefrontal cortex, the contralateral cortex areas, and the ipsilateral posterior cingulum.	M. Schreckenberger, E. Gouzoulis-Mayfrank, O.Sabri, C. Arning, G.Schulz, T. Tuttass, G. Wagenknecht, H.J. Kaiser, H. Sass, and U. Buell, "Cerebral interregional correlations of associative language processing: a positron emission tomography activation study using fluorine- 18 fluorodeoxyglucose" Eur J Nucl Med, vol.25, no.11, pp.1511-1519, 1998
Continuous emotion task	10 subjects	PET FDG performed during facial emotion recognition studies and neutral on a different day	Activation the left amygdala and activation of the emotional recognition-related areas	E. Fernandez-Egea, E. Parellada, F. Lomena, C. Falcon, J. Pavia, A. Mane, G. Sugranyes, M. Valdes, M. Bernardo, ' A continuous emotional task activates the left amygdala in healthy volunteers: (18) FDG-PET study," Psychiatry Res. 2009 Mar 31;171(3):199-206

Task	Number of subjects	Type of PET imaging modality	Outcome	Reference
Long-term free recall of emotional information	8 right-handed male subjects	Subjects viewed two videos during PET scanning, separated by 3-7 days, consisting either of emotiona7lly arousing film clips or of neutral film clips. Three weeks after the second session, memory for the videos was assessed in a free recall test.	Glucose metabolism rate of the right amygdaloid complex while viewing the emotional films was highly correlated with the number of emotional films recalled and was not correlated with the number of neutral films recalled.	L.Cahill, R.J. Haier, J. Fallon, M.T. Alkire, C. Tang, D. Keator, J. Wu, and J.L. McGaugh, 'Amygdala activity at encoding correlated with long-term, free recall of emotional information."Proceeding of the National Academy of Sciences of the United States of America, vol.93, no.15, pp. 8016-8021,1996.

Table 1: Most relevant studies on PET imaging with FDG in different types of task adapted from Chiaravalloti et al (2019).

During the pre-scan the respondents were not presented with any intervention. This was necessary in order to obtain a baseline reading of cognitive activity under normal circumstances without any experiment being performed.

At the second scan, on a median of six days, the respondents were presented with a thirty minute SASL source text (Appendix E- SASL Source Text “World of Work – Interview”) and an interpreters’ brief (Appendix F – Interpreters Brief). The source text was created by six SASL presenters, who made presentations around questions related to their employment (Appendix G- PIS SASL source text presenters).

The interpreting brief for this experiment was shared with the respondents a day before their second scan appointment. This was necessary to allow the interpreter respondent to prepare vocabulary related to employment settings and prepare simulations similar to employment environments. The preparation before an interpreting assignment is a standard requirement and was provided to all respondents to ensure the experiment mirrored a real-world situation, even though experiment was conducted in a clinical setting. The interpreters’ brief did not explicitly state that the interpreter must interpret into English. The brief oriented the interpreter respondent to a plurilingual setting and he or she was given the instruction to interpret into their spoken language/s. When I shared the interpreting brief before the second scan and on the day the respondents presented for the scan, the respondents were not coerced into interpreting into English. They were told that they could interpret into any language they felt comfortable in to ensure continuity. The respondents were also advised that if they got stuck on a lexical or syntactic item and could produce the word/phrase or concept in one of the other languages they know they could do it, to ensure continuity. This was to allow for the interpretation to flow freely and not create a situation where the interpreter stops the experiment. Here I did not overtly raise the issue of translanguaging since this is a variable under investigation. I wanted to obtain the most organic interpreting product the respondent could provide under the experimental conditions by giving the interpreter respondents a brief to allow them to feel comfortable using the language in a simulated plurilingual setting, which was an interview panel consisting of plurilingual individuals.

The process for the second scan was both video and audio-recorded to complement the recordings of neural activity for analysis and interpretation. The total scanning time took about 40 to 50 minutes including setup and actual procedures. PET brain imaging was done using a 40 slice PET/CT scanner (Biograph TruePoint PET/CT, 2019). At this point of the second scan, the researcher, monitored the recording process with the nuclear medicine technician. At every ten minutes interval (four times), the researcher accessed the scanning room to ensure sound recording (respondent voice into spoken language/s) proceeded without any technical glitches and that the camera was recording the process. When the scanning procedure was completed, the respondent proceeded to the waiting room to allow the nurse to remove the line.

4.2.3 Data collection

It was proposed that more than one method be used to obtain converging evidence, triangulation of data (Noble and Hale, 2019). Data were collected using questionnaires, voice notes (interpretation) and PET brain imaging.

4.2.3 a) Questionnaire

Qualitative data in this study were collected through a questionnaire (Appendix A (III) - Questionnaire). The questionnaire was divided into themes that covered aspects of sign language interpreting, education training standards, language comprehension, processing and plurilingualism. The information was collated to form an interpreting profile of the respondents.

4.2.3 b) Voice recording (interpretation)

While under activation, the respondents' interpretation (voice notes) were recorded and analysed using the EUDICO Linguistic Annotator (ELAN). ELAN is an open source software that can manually and semi-automatically annotate and transcribe audio or video recordings (ELAN, 2020). ELAN is programmed on a tier-based data model that provides a qualitative and quantitative analysis. In this investigation, the respondents' interpreting product (voice notes) were uploaded as a source file. The data (interpreting product) were analysed against the target text (Appendix H – Interpretation transcript of SASL source text into English). The analysis proceeded as a comparison between the source text (ST) and target text (TT) to highlight incidents of translanguaging.

The following tiers were created on ELAN:

1. Interpretation –highlights the interpretation sections from SASL to spoken languages.
2. Code-Switching –highlights incidents of code-switching as a strategy of translanguaging.
3. Code-Mixing –the parent tier of code-switching.
4. Lexical Borrowing – highlights the use of lexical borrowing as a translanguaging interpreting strategy.
5. Semantic Equivalence –highlights the respondent rendition of the target text against equivalences of style and rhythm of the signs used in the SASL source text
6. Semantic Shift –focused on incidents of word form and meaning changes.
7. Colloquial Expression –highlights incidents where interpreters make use of general expressions in spoken language(s).
8. Socio-Cultural Intervention –highlights references to culturally appropriate terms in this experiment.

4.2.3 c) PET brain imaging

The medical interview conducted before PET brain imaging covered questions in accordance with the standard medical information and consent form and was administered by a nurse (Appendix I – Medical information record). Before this, the respondent was briefed by the researcher about how the experiment would unfold, including the ethical implications and provided with a questionnaire, only if they had not returned it electronically before their first scan. At the time of receipt of the respondent's consent to participate in the study a document detailing the medical experiment was shared so as to allow the respondent complete information regarding the study (Appendix A (I) PIS & Appendix A (I) (a) PET procedure before scanning). This was also done to ensure that each respondent was fully aware of the ethical implications of the study in so far as the presentation of the data is concerned. Respondents were briefed before their scanning dates and in person when they presented for their brain imaging, regarding what the PET-brain imaging process entailed, and how they should prepare for it, such as the requirement to fast and not to drink any fluids for at least four hours before the administration of ^{18}F-FDG.

For this project, two imaging methods were considered: Positron Emission Tomography (PET) and Functional Magnetic Resonance Imaging **(**fMRI). It was decided that PET is the best applicable imaging technique for this study. The reasons are discussed below.

fMRI has many superior points compared to PET, but the decision to use either depends on the data quality that needs to be collected. Studies that used fMRI range from language (Ardila and Bernal, 2016), language learning (Plante et al., 2017), and second-language acquisition (Andrews et al. 2013 and Yang et al., 2015). Applicable to this study are fMRI studies conducted concerning interpreting such as cognition and simultaneous interpretation (Moser-Mercer, 2000), the neurobiology of simultaneous interpreting (Hervais-Adelman et al., 2015; Hervais-Adelman et al., 2011 and Hervais-Adelman and Babcock, 2019), translation and language-switching (Price, Green and von Studnitz, 1999), bilingual cognitive control in language switching (Crinion et al., 2006; Abutalebi et al., 2008 and Ma et al., 2014), language structure in the brain (Henderson et al., 2016) and cortical organisation of semantic processing (Bookheimer, 2002).

The current study used PET brain imaging, since no fMRI machine is available at the Charlotte Maxeke Johannesburg Academic Hospital, where the scanned data were collected. The fMRI scan would not have been appropriate for this project because the respondents were required to interpret while under intervention and activation (voicing the source text). The fMRI machine does not allow for movement while under the scan since this can distort the signal and give an incorrect reading. In addition, the recording of the interpreted product (voice notes) was imperative to analysing the production. Ravicz, Melche and Kiang (2000) measured the comparative noise levels for two fMRI machines with different static magnetic field strengths. They found that the noise levels are high, which impacts adversely on research-dependent audio recordings, thus, that the fMRI machine would not have been suitable for this study.

Positron Emission Tomography (PET) is described as a type of imaging by Brownell (1999).FDG-PET can be a useful imaging tool in evaluation of task-related brain activity. The brain tissue can be considered as a three-compartment model. The deoxyglucose-6-phosphate (DG-6-P), once formed, is trapped in the tissue for a reasonable time after injection and for the duration of the experimental procedure allowing to obtain images of the brain after the injection; 40% of the radiolabelled compound is extracted in the brain in the first minutes after the injection allowing the detection of the cortical brain areas that are activated in the first timings of the task.

There is a variety of software packages, each with its unique features, to analyse fMRI data. The table below is provides a summary of the various software:

Software Name	Reference to original paper
SPM: Statistical parametric maps in functional imaging: A general linear approach	Frinston, K.1995
AFNI: Software for analysis and Visualization of Functional Magnetic Resonance Neuroimages	Cox, R. 1996

AIR: Automated Image Registration: I. General Methods and Instrasubject, Intramodality Validation	Woods, R. 1998
DPTools: Whole Brain quantitative CBF and CBV measurement using MRI blus tracking: comparison of methodologies.	Smith, A. 2000
MRICRO: Stereotaxi display of brain lesions.	Rorden, C. 2000
BrainVISA: software platform for visualization and analysis of multi-modality brain data	Cointeps, Y. 2001
FreeSurfer: Whole brain segmentation: automated labelling of neuroanatomical structures in the human brain.	Fischel, B. 2002
fMRLAB: An ICA toolbox for fMRI data analysis	Duann, J. 2002
FSL: Advance in functional and structural MR image analysis and implementation as FSL	Smith, S. 2004
PLS: Partial least squares analysis of neuroimaging data applications and advances.	McIntosh, A. 2004
Neurolens: NeuroLens: an integrated visualization and analysis platform for functional and structural neuroimaging.	Hoge,R. 2004
VOXBO: Viewing facial expressions of pain engages cortical areas involved in the direct experience of pain.	Botvinick, M. 2005

BrainVoyager: Analysis of FIAC data with BrainVoyager QX: From single-subject to cortically aligned group GLM analysis and self-organizing group ICA.	Geobel, R. 2006
NeuroQ™: Uses an algorithm for measuring, after correction for tissue-based attenuation, radioactive events/second emanating from pixel locations falling within standardized regions of interest, it automatically measures metabolic activity in 240 regions of brain in a few seconds and is widely used as a quantitative tool to assist with differential diagnosis of neurological conditions.	Jafari &Silverman. 2015
The MatLab-based software (BRAPH-BRain Analysis using graPH theory)	Mijalkov, M. 2017

Table 2: Software packages for analysis of brain images (Behroozi & Daliri, 2012).

fMRI and PET scans both measure brain activity, the PET scan provides a lower resolution and the fMRI scan provides clearer temporal and spatial resolution. This disadvantage was compensated for by using improved software, NeuroQ™, to allow for enhanced interpretation of the data during analysis. Precise definition of functional brain areas in the individual research subject is crucial for accurate quantitative analysis of PET brain images, and their meaningful interpretation. Raw data of all PET brain imaging were entered into NeuroQ™ for analysis. According to Jafari and Silverman (2015):

> NeuroQ™ is a software package that uses an algorithm for measuring, after correction for tissue-based attenuation, radioactive events/second emanating from pixel locations falling within standardized regions of interest, it automatically measures metabolic activity in 240 regions of brain in a few seconds and is widely used as a quantitative tool to assist with differential diagnosis of neurological conditions. Radiologists, nuclear physicians, and

other professional Brain PET interpreters use NeuroQ™ to gain a higher level of decision support and confidence from NeuroQ™ for PET-FDG brain imaging studies.

The following 49 brain areas are listed on the NeuroQ™:

	Abbreviation	Name of brain area
1	lAVC	left Associate Visual Cortex
2	rAVC	right Associate Visual Cortex
3	lCbm	left Cerebellum
4	rCbm	right Cerebellum
5	lCN	left Caudate Nucleus
6	rCN	right Caudate Nucleus
7	liLAT	left inferior lateral anterior Temporal Cortex
8	riLPT	right inferior lateral posterior Temporal Cortex
9	riLAT	right inferior lateral anterior Temporal Cortex
10	liLPT	left inferior lateral posterior Temporal Cortex
11	liPL	left inferior Parietal Cortex
12	riPL	right inferior Parietal Cortex
13	lLN	left Lentiform Nucleus
14	rLN	right Lentiform Nucleus
15	lMPT	left posterior Medial Temporal Cortex

16	rMAT	right anterior Medial Temporal Cortex
17	rMPT	right posterior Medial Temporal Cortex
18	lMAT	left anterior Medial Temporal Cortex
19	lPCC	left posterior Cingulate Cortex
20	rPCC	right posterior Cingulate Cortex
21	lPVC	left Primary Visual Cortex
22	rPVC	right Primary Visual Cortex
23	lsLT	left superior lateral Temporal Cortex
24	rsLT	right superior lateral Temporal Cortex
25	lsPL	left superior Parietal Cortex
26	rsPL	right superior Parietal Cortex
27	lTh	left Thalamus
28	rTH	right Thalamus
29	lPTC	left Parietotemporal Cortex
30	rPTC	right Parietotemporal Cortex
31	MB	Midbrain
32	lGFs	left superior Frontal Cortex
33	rGFs	right superior Frontal Cortex
34	lGFm	left mid Frontal Cortex
35	rGFm	right mid Frontal Cortex

36	lGFi	left inferior Frontal Cortex
37	rGFi	right inferior Frontal Cortex
38	lGFd	left Medial Frontal Cortex
39	rGFd	right Medial Frontal Cortex
40	lSM	left Sensorimotor Cortex
41	rSM	right Sensorimotor Cortex
42	lBROCA	left Broca's Region
43	rBROCA	right Broca's Region
44	lGCa	left anterior Cingulate Cortex
45	rGCa	right anterior Cingulate Cortex
46	Pons	Pons
47	V	Vermis

Table 3: NeuroQ™ 47 brain regions (Jafari and Silverman, 2015)

Silverman created the NeuroQ™ software, stating in an interview (Brain Wellness Center, 2012), that NeuroQ™ provides the added value of the visual interpretation of a PET brain imaging scan and provides measurements of changes in the brain regions. The automated calculations of changes in brain regions are done in a short time, providing a reliable method because the physical calculation of the changes is not possible in a clinical setting. The software provides readings against normal brain activity in a specific region which is then compared with the imaging of the patient and can indicate the range of normality or deviations from the norm. The software allows the regions with increased or decreased metabolism in the reconstructed brain image to be highlighted by a simple click on the metabolism icon tab in the displayed summarised data tab of the screen. This will allow the areas either with most hyper- or hypometabolism to displayed in the upper left of Figure 4.5 below.

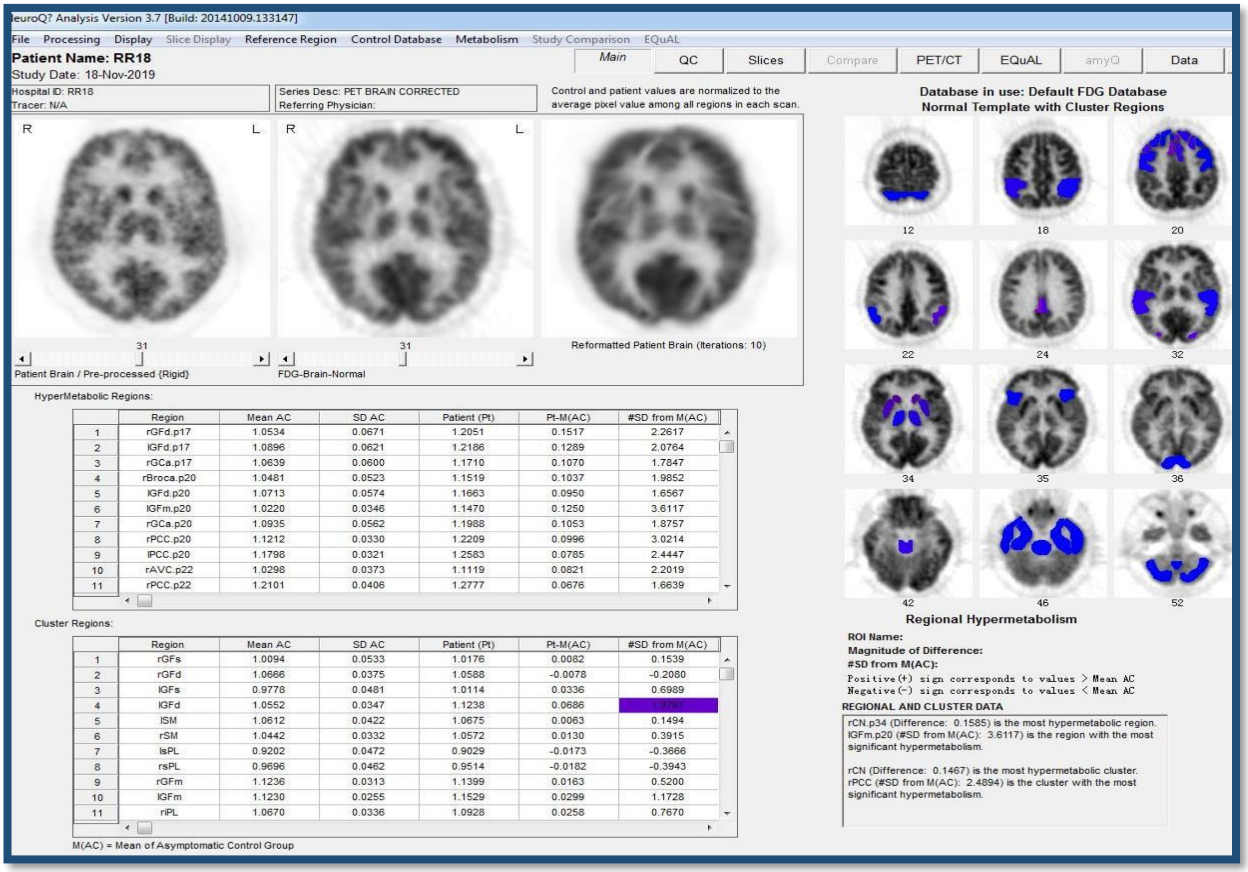
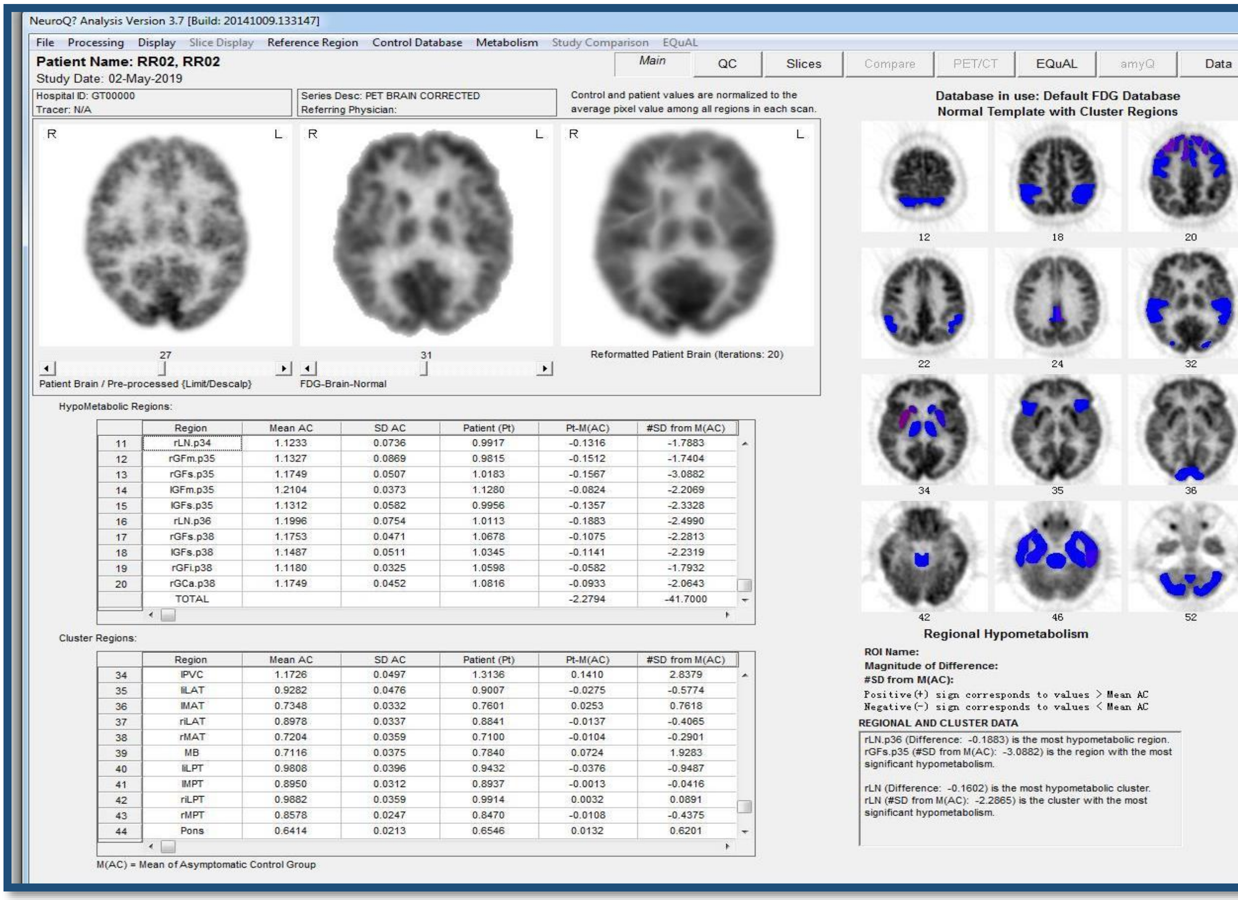


Figure 30: Showing the areas of hypometabolism in A and hypermetabolism in B. Note the change from purple to blue in the 12 superimposed brain images from A to B.



	Region	Mean AC	SD AC	Patient (Pt)	Pt-M(AC)	#SD from M(AC)
11	rLN.p34	1.1233	0.0736	0.9917	-0.1316	-1.7883
12	rGFm.p35	1.1327	0.0869	0.9815	-0.1512	-1.7404
13	rGFs.p35	1.1749	0.0507	1.0183	-0.1567	-3.0882
14	lGFm.p35	1.2104	0.0373	1.1280	-0.0824	-2.2069
15	lGFs.p35	1.1312	0.0582	0.9956	-0.1357	-2.3328
16	rLN.p36	1.1996	0.0754	1.0113	-0.1883	-2.4990
17	rGFs.p38	1.1753	0.0471	1.0678	-0.1075	-2.2813
18	lGFs.p38	1.1487	0.0511	1.0345	-0.1141	-2.2319
19	rGFi.p38	1.1180	0.0325	1.0598	-0.0582	-1.7932
20	rGCa.p38	1.1749	0.0452	1.0816	-0.0933	-2.0643
	TOTAL				-2.2794	-41.7000

	Region	Mean AC	SD AC	Patient (Pt)	Pt-M(AC)	#SD from M(AC)
34	lPVC	1.1726	0.0497	1.3136	0.1410	2.8379
35	liLAT	0.9282	0.0476	0.9007	-0.0275	-0.5774
36	lMAT	0.7348	0.0332	0.7601	0.0253	0.7618
37	riLAT	0.8978	0.0337	0.8841	-0.0137	-0.4065
38	rMAT	0.7204	0.0359	0.7100	-0.0104	-0.2901
39	MB	0.7116	0.0375	0.7840	0.0724	1.9283
40	liLPT	0.9808	0.0396	0.9432	-0.0376	-0.9487
41	lMPT	0.8950	0.0312	0.8937	-0.0013	-0.0416
42	riLPT	0.9882	0.0359	0.9914	0.0032	0.0891
43	rMPT	0.8578	0.0247	0.8470	-0.0108	-0.4375
44	Pons	0.6414	0.0213	0.6546	0.0132	0.6201

Figure 31: Participant RR02 baseline

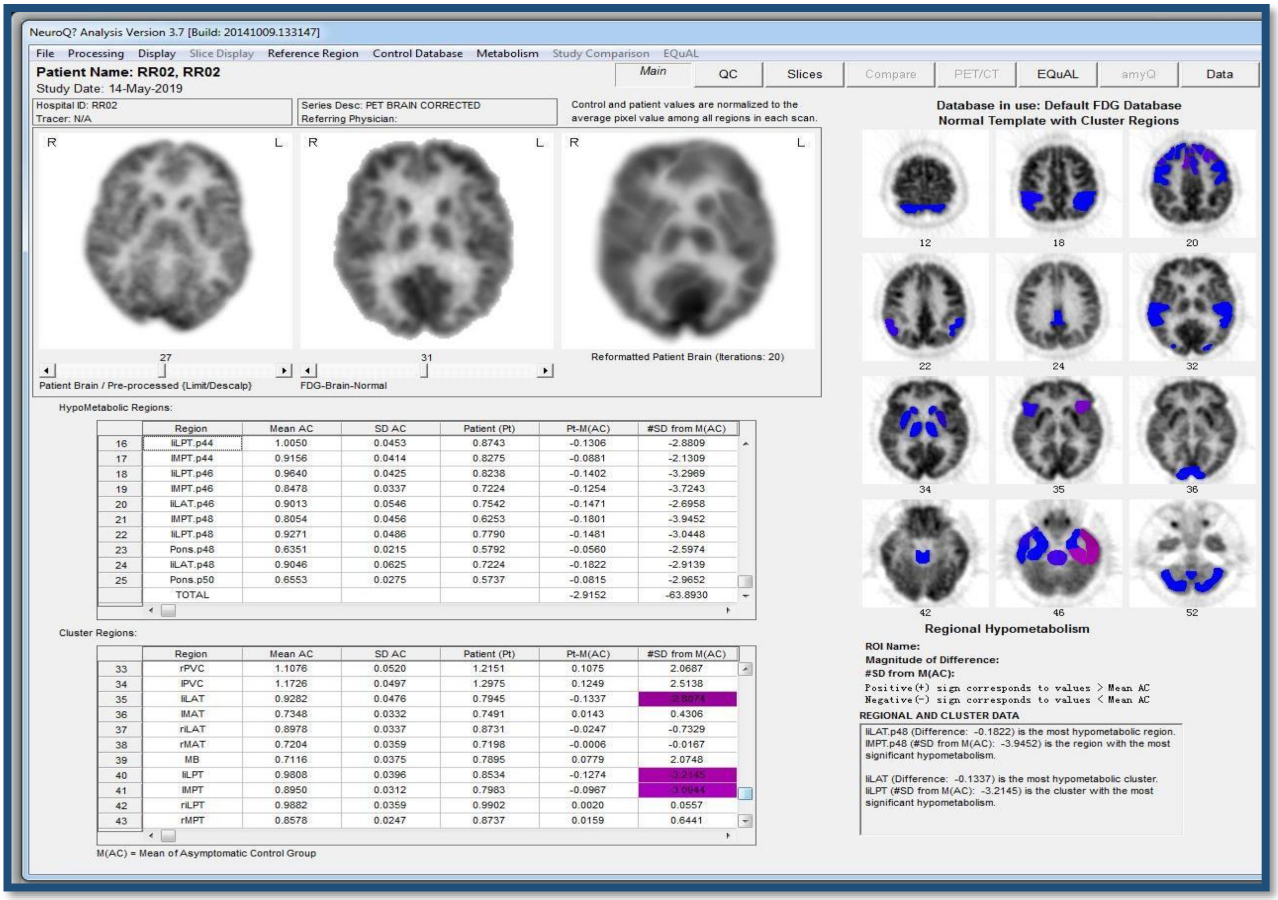


Figure 32: Activation in the same participant (RR02)

Silverman mentions the exposure to radioactivity to be insignificant, not posing a threat to patients. PET brain imaging could expose respondents to radioactivity (which they were informed about before taking part in the study through the PIS and consent form), whereas fMRI does not use radioactivity. The table below provides insight into the differences between PET and fMRI, applicable to this project.

Positron Emission Tomography (PET)	**Functional Magnetic Resonance Imaging (fMRI)**
Signals are generated by the use of radioactive traces.	Signals depend on deoxyhemoglobin and there is no radioactive exposure.
Imaging occurs only once.	Imaging can occur more than once.

The temporal resolution is 30 seconds, which is relatively slow since cognitive processes should be recorded at 1s.	The temporal resolution between 1 to 4 seconds means improved accuracy and detailed imaging.
Increased sensitivity for brain images.	Decreased imaging accuracy in some brain areas such as the sinus.
PET provides increased accuracy for audio recordings. (The primary reason why PET was used for this project is that the interpreting product (voice notes) must be recorded while under activation at the same time that the brain scan is performed in the PET machine*)*	fMRI has upper-level noise levels which makes audio recordings problematic.
Head movements during the scanning time do not alter the signals and hence do not affect the scan.	Signals are easily altered due to head movements and affect the accuracy of the scan.

Table 4: Difference between PET and fMRI (Kameyama, Murakami and Jinzaki, 2016; Crosson et al. 2010 and Varvatsoulias, 2013).

PET is a form of hemodynamic neuroimaging (Fiez et al. 1996) and has been in existence since the 1970s. It is a type of imaging method which maps changes in blood flow in the brain (Démonet and Cardebat, 2000). According to Australia's Nuclear Science and Technology Organisation (ANSTO) (2019):

> Neutron deficient radioisotopes decay by three different modes, but the one of interest in this study is positron emission. In a PET scan, the patient is given a dose of medicine containing a positron-emitting neutron deficient isotope. The resultant coincident pairs of gammas from the annihilation are detected by PET cameras. The cameras are arranged in a ring through which the patient is moved. From this process a series of ‘slice’ images are obtained and these can then be combined to give a three-dimensional picture.

According to Binder et al. (1997) and Buckner et al. (2000), this technique is used for identifying neurotransmitters and other molecules that underlie language and associated language processes. The method of PET is a non-invasive medical experiment and its accuracy in localising activation to a particular brain region is limited by the scan of the spatial resolution (Binder et al. 1997; Kosslyn et al. 1999 and Buckner et al. 2000). According to DBpedia (2020):

> Positron emission tomography-computed tomography (better known as PET-CT or PET/CT) is a nuclear medicine technique which combines, in a single gantry, a positron emission tomography (PET) scanner and an x-ray computed tomography (CT) scanner, to acquire sequential images from both devices in the same session, which are combined into a single superposed (co-registered) image.

Delso et al. (2011:77) state: "The standard approach used by the dual-mode PET–CT scanners is to convert the CT image to attenuation coefficients for 511 keV photons using a bilinear transformation with different scale factors for soft tissue and bone." According to Vaquero & Kinahan (2015:2): "Positron emission tomography (PET) imaging is based on detecting two time-coincident high-energy photons from the emission of a positron-emitting radioisotope". PET imaging produces additional translational possibilities compared to any other modality due to its combination of sensitivity and quantitative accuracy (Vaquero and Kinahan, 2015). Further to this, Delso et al. (2011) hold that: "PET is a noninvasive imaging modality that provides physiological information through the injection of radioactive compounds (radiotracers), detection of radiation, and reconstruction of the distribution of the radiotracer" Delso et al. (2011:78). Vaquero & Kinahan (2015:2) suggest that, "The physics that enable PET imaging are based on the emission of a positron by a neutron-deficient radioisotope". The most commonly used radioisotope in PET studies is fluorine-18 (18F). According to Vaquero and Kinahan (2015:2):

> As the radioisotope decays to a stable state the emitted positron travels a short distance (typically 1–2 mm) and interacts with an electron; this interaction annihilates both the electron and the positron, thus producing two high-energy photons. The photons travel in opposite directions along an approximately straight line, and can be detected outside the body by the PET scanner.

The process of fluorine-18 (18F) is illustrated in the figure below.

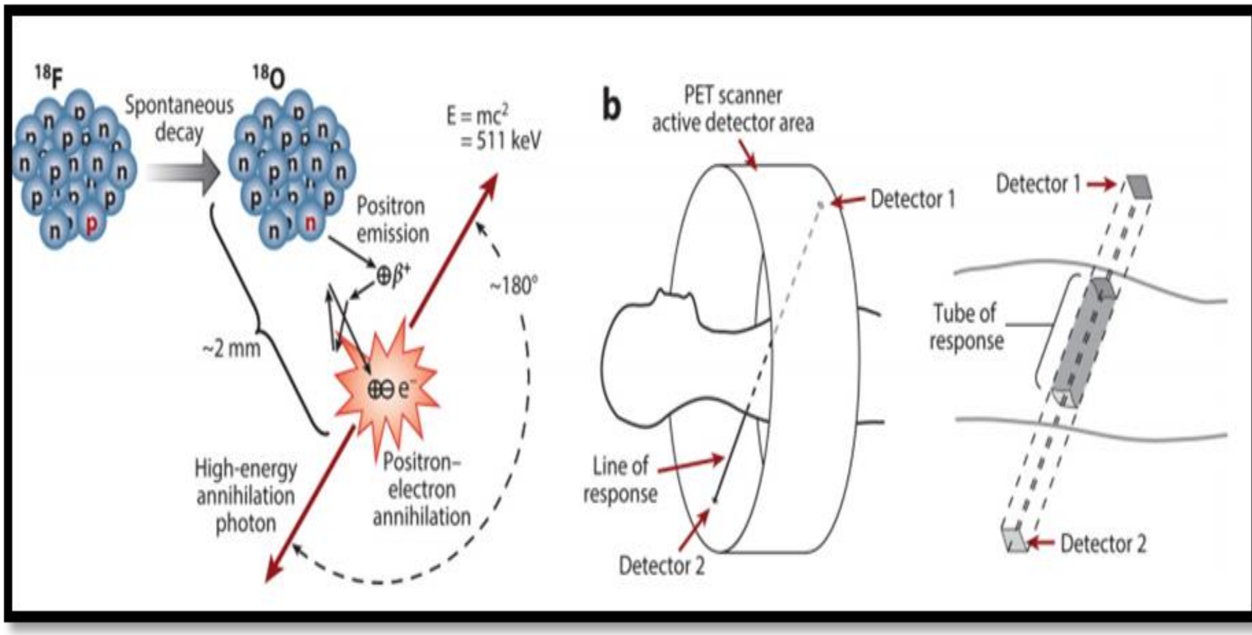


Figure 20: Process of FDG uptake illustrated (Vaquero and Kinahan, 2015)

4.3 Ethics

Thakur and Lahiry (2019:354) comment as follows on the complex nature of medical research:

> The distinctive issues raised in this review, testify that the ethics around medical research are becoming increasingly complex. As research questions become more sophisticated, the research context as a whole grows to an increasing level of the interplay among diverse actors. The ethical discourse has to keep abreast of these changes to provide adequate guidance for medical research in the future.

An issue related to ethics is that of cultural sensitivity, according to Ryen (2004). Miller (2004:94) makes a point of the applicability of cultural awareness in framing the research study by stating the following|:

> In sum, taking cultural considerations into account in social psychological research is needed not only for the methodological reasons of ensuring the validity of assessment

> techniques, but also for the theoretical reasons of testing the universality of psychological theories and of formulating new conceptual models. Extending beyond merely an understanding of diversity in psychological functioning, such attention can provide new process understandings of the psychological functioning of widely studied Western populations.

Medical ethics clearance was obtained in this study because medical technology by PET brain imaging was used. In addition, video and audio recordings were made during the intervention, which impacted confidentiality and privacy. Before participation in this study, The respondents were informed that their anonymity could not be guaranteed given that sign language is a visual-gestural language and because the visuals (screenshots of images) would be used in data analysis. They were also informed that their images would be blocked out to prevent identification but it was reiterated that their anonymity cannot be guaranteed. The major implication for confidentiality and anonymity here is that video and audio-recorded data clearly identify the respondent and thus the respondent cannot remain anonymous. Interpreting respondents were aware of all the ethical aspects mentioned above in the invitation letter and during the interview before PET-brain imaging to allow for a transparent process and informed voluntary consent. Access to the raw data of this study is primarily available to the researcher and supervisors. In addition, in the post-publication phase of the thesis, synthesised datasets and data illustrations will be accessible to the public.

4.4 Conclusion

This chapter explained the blueprint of the project by detailing the theories to be applied to the study. Furthermore, the chapter clearly describes the process of research in the methodology section. The next chapter provides insight into the three data sets collected, analysis and findings.

CHAPTER 5

Presentation, Analysis and Discussion of Data

5.1 Introduction

This chapter engages with raw data and analytical processes to elicit new meaning or knowledge in the vein of cognitive language processing during interpreting. The chapter discusses the data analysis from cognitive language processing of 20 plurilingual SASL interpreters using questionnaires, interpreted voice recordings and PET brain scans. To recapitulate, the primary objective of the study is to document the cognitive areas activated under PET brain imaging during simultaneous interpreting. The secondary aim is to develop an interpreting model informed by translanguaging strategies during simultaneous interpreting. A hypothesis is an assertion, conjecture or premise, subject to verification via research. The predictive hypothesis of the study was:

From sign to spoken language/s, the simultaneous interpreting product is directly linked to the nexus of cognitive language processing and the linguistic repertoire of a plurilingual interpreter

The hypothesis is discussed in Chapter 5 based on findings of the data collected. The expected answers to the hypothesis grow out of the research questions, which are:

Primary research question:

1. Which brain clusters are activated neuroanatomically while interpreting SASL to spoken language under PET brain imaging?

Secondary research questions:

1. Which specific brain areas show significant activation during simultaneous interpreting?

2. How does the optic chiasm present when processing SASL into spoken language/s, simultaneously under PET brain imaging?

3. What does the perisylvian region present during interpreting simultaneously from a visual-gestural modality to an audio-speech modality?

5.2 Data Presentation, Analysis and Discussion

Data analysis begins with categorising and organising data in search of patterns, critical themes and meanings. The qualitative section, questionnaires are discussed, under section A. The SASL contributor's linguistic profiles are presented and that of the SASL interpreter that provided a guide target text interpretation. The questionnaires of the interpreter respondent were analysed according to the following themes: a) Biographical information; b) Interpreter experience; and c) Cognition.

Section B focuses on the qualitative analysis of the interpretation recordings. For analysis of Section B (i), the interpreting recordings of the respondents (voice notes) were transcribed manually for parts where African languages were used and using AmberScript software, when English was used. Manually transcribed voice notes were needed because the Amberscript software can only recognise and transcribe English. In this experiment, respondents used languages other than English. Therefore, two professional plurilingual translator practitioners competent in Sesotho, Setswana and isiZulu assisted with the transcription of voice notes. Analysis of Section B (ii) provides for both qualitative and quantitative analysis of the voice recordings of the respondents. For analysis of Section B (ii), the voice notes and video file were loaded onto ELAN as an overlay file merged for analysis of the interpretation, grammatical categories, and interpreting themes. The ELAN tiers are then discussed from a qualitative perspective. The overall ELAN analysis was exported into a merged file to provide a holistic view of all translanguaging incidents across the sample. A quantitative perspective on the frequency of translanguaging was produced, highlighting specific phrases or words that demonstrate translanguaging across the nine respondents who used translanguaging strategies.

Section C focuses on the quantitative analysis of the brain imaging scans that were collected by the PET imaging technique. These are presented and discussed in Section C of this chapter. PET brain images were analysed using the NeuroQ™ software.

The structure the analysis will follow is:

5.2.1 Section A (i): Presentation of the linguistic portfolios of the source text and target text contributors
Section A (ii): Presentation of data from the questionnaire according to seven (7) themes,
Section B (i): Presentation of selected sampled transcripts of translanguaging,
Section B (ii): ELAN presentation of translanguaging incidences and
Section C: Presentation of PET brain imaging presenting significant areas of activation.

SECTION A

5.2.1 Section A (i): Linguistic profiles of source-and target text contributors

Questionnaires were administered electronically for the Deaf contributors of the source text. Source text contributors completed the questionnaire online and returned it via email (Appendix A III). The languages across the linguistic repertoires of the Deaf contributors include SASL, Homesigns, Malawian Sign Language, English, isiZulu, isiXhosa and Afrikaans (Appendix J- Linguistic progiles of source text contributors). The profiling of the contributors confirm that they are all signing Deaf people, but their linguistic repertoire expands by the spoken and written languages used in their families, communities and at school. This profiling is in line with Quinto-Pozos and Adam (2013) and Kusters (2017), where Deaf people do not engage in communication by using only sign language but sign, spoken and written languages are drawn on to achieve communication within and across these modes. Thus, it is evident in the production of the SASL source text video, that the contributors do not use one dialect of SASL, but fluctuate between SASL dialects, including International Sign. Evidence of translanguaging is present in the SASL source text. Interpreters are expected to keep abreast of language use in communities: as language and communication norms evolve in sign communities, interpreting should transubstantiate in tandem as seen in the literature on interpreting Chapter 2 II. Given the incidents of natural translanguaging in the source text, it is anticipated that interpreters too will translanguage given the interpreters brief (Appendix F) that the interview panel is made up of plurilingual persons.

Target text contributors completed the questionnaire online and returned it via email The SASL interpreter who contributed to the target text also completed a questionnaire. The linguistic profile of the target text contributor was needed firstly to model the interpreter profile and secondly to record a guide interpretation of the SASL source text in English. The interpreter profile provides a picture of an ‘ideal’ interpreter for an interpreting assignment such as an interview, which requires a mature, trained interpreter, with solid experience to navigate the linguistic and cultural nuances of bridging hearing and Deaf cultures and communication norms (Appendix K- Linguistic profile of the target text contributor). These are important criteria to assess interpreter compatibility for the assignment. The recording of the guide interpretation is needed to see how interpreters express their interpretation product differently, but still within the same sensemaking continuum of how each interpretation differs in terms of output. Furthermore, the interpretation was used as a guide to draw tables of difference to show incidents of translanguaging in Amberscript (Section B (i): Amberscript Analysis of Interpretation).

5.2.1 Section A (ii): Questionnaire analysis

Questionnaires were administered electronically, or in hard copy, to all interpreting respondents. The respondents had time to consider their responses since the consent form and questionnaire were emailed to them on confirmation of their willingness to participate in the research. Respondents returned the completed questionnaire on the day of the 1st or 2nd PET brain imaging date. Those who opted to make an electronic submission emailed the completed questionnaire. A timeline of between two to four weeks was provided to return the questionnaire or alternatively on the date of the 1st or 2nd PET brain imaging appointment. The questionnaire took about 30-45 minutes to complete, as observed by respondents who completed the hard copy questionnaire on-site on the day of their first scan.

The data extracted from the questionnaires are presented across the three sections (A, B & C) through seven categories, namely:

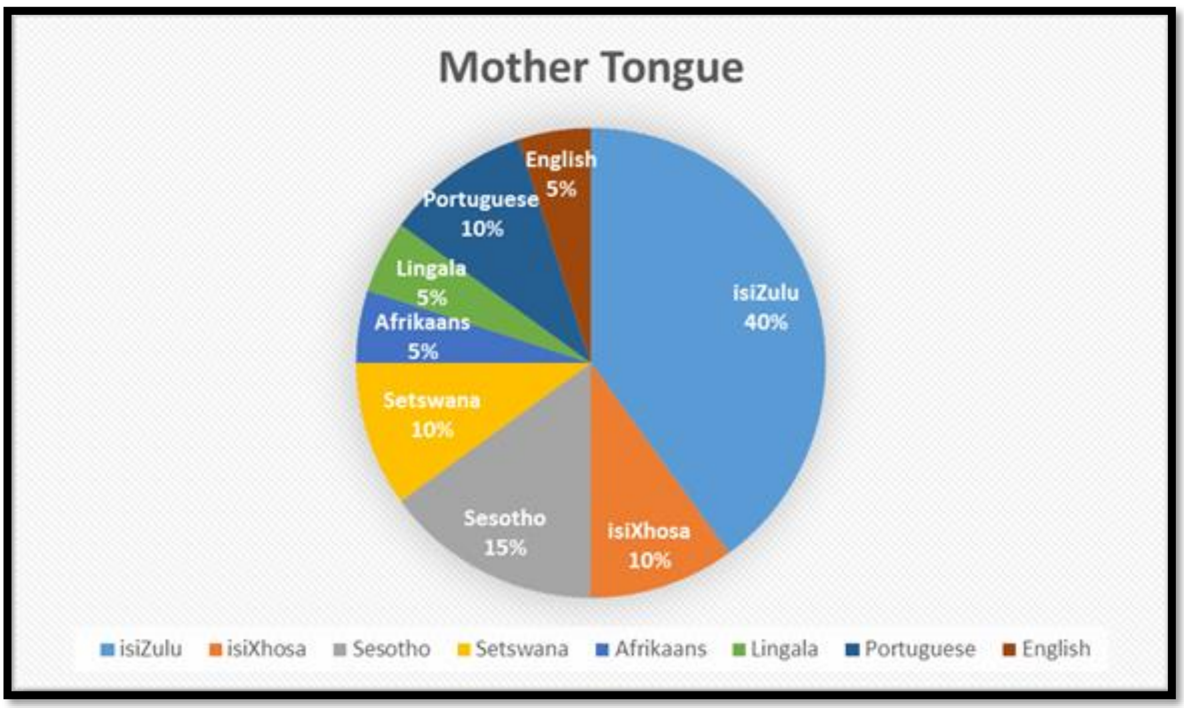
- Category 1: Native language
- Category 2: Age, years of interpreting experience and language proficiency
- Category 3: Gender
- Category 4: Qualifications and training
- Category 5: Cognitive processes
- Category 6: Translanguaging
- Category 7: Self-perception of the ability to interpret from sign to spoken language/s

Category 1: Native language

The majority of respondents are isiZulu native language speakers, representing 40% of the total sample. The outliers are presented by three respondents, two native Portuguese speakers and one Lingala speaker. These are non-South African languages. These respondents are South African citizens with first-generation immigrant parents from Portugal, Angola and the Democratic Republic of Congo (DRC). The rest of the sample comprises of L1 speakers of English, Afrikaans, Sepedi sa Leboa, Setswana and Sesotho.

It is evident from the sample that SASL interpreters are not native English speakers, since only three indicated English as their L1. The language practice teaching and training practices were reportedly delivered in English, which poses a disjuncture between the Language of Learning and Teaching (LoLT) and the native language. A majority of respondents are not native English speakers, yet received training in English. It is evident that SASL interpreters are mostly trained in English and not in the other official languages of South Africa. This evidence corroborates the finding in the ELAN annotation sample that nine out of the twenty respondents interpreted some sections of the target text into African languages other than English, namely: isiZulu, Sesotho, Setswana and Afrikaans, by using translanguaging strategies and eight non-native English speakers continued to deliver an interpretation in English, despite reporting that their L1 is not English. It must however be noted that the English interpretation was influenced mostly by source text interference. An example of such is: [So mina I feel wow, I love this job, why? Because, lento….]. In this example the interpreter respondent produces an interpretation which is directly influenced by SASL sentence structure where [WHY –Rhetorical question] is signed to emphasise the statement. An accepted linguistically and culturally functional interpretation, taking code-mixing in consideration in the example above, would have been: [I really love my job because lento…].

The evidence points to the disjuncture between education and training practices, where the LoLT is English and interpreters deliver interpretation in the language in which they were trained. Furthermore, the nine interpreters who translanguaged are interpreters with more than five years experience in interpreting. Years of experience in interpreting could be a variable that adds to the comfortability to express the interpretation product through using other spoken langauges through translanguaging strategies.



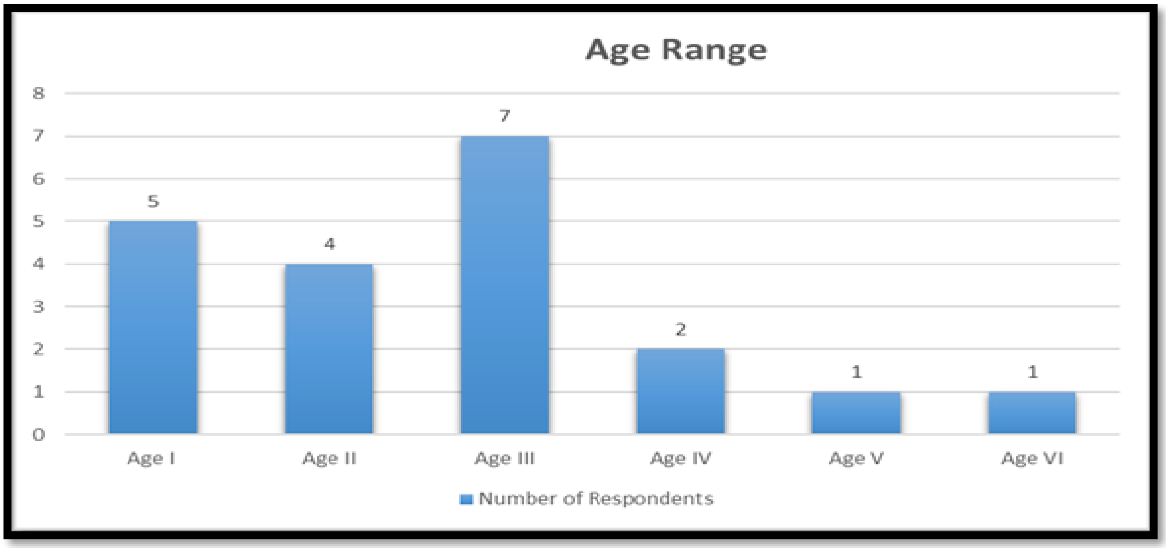
Graph 1: Native languages of the sample group

Category 2: Age, years of interpreting experience and language proficiency

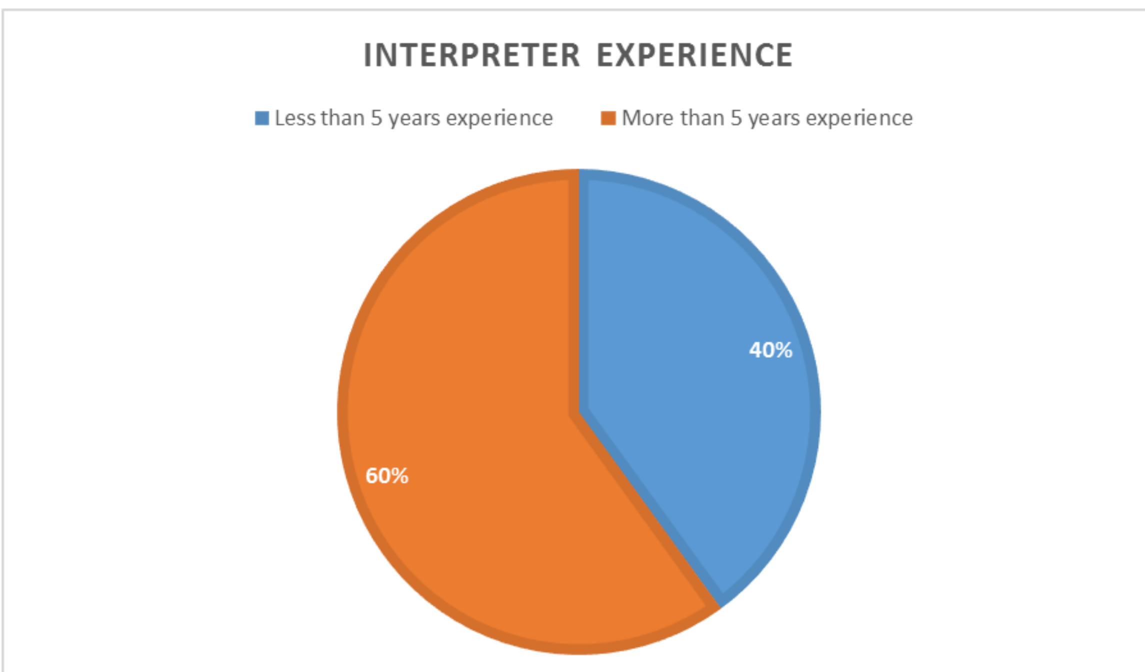
Thirty-five percent of respondents fall into age range III, 31-35 years. Given the age range presented in this study, it is evident that all respondents in this sample have developed their linguistic range in their language combinations and are all stable, well-developed language models in their various sign and spoken languages. The advanced level of language aptitude is self-reported, according to the language proficiency ratings. Official language ability tests have not been administered to the respondents to verify their aptitude. The number of years of experience in interpreting reported ranged between two and twenty-nine years. From the reported years of experience the respondents range between entry and professional level.

The confidence level of the respondents to use their native languages (spoken languages other than English) confidently during interpreting presents a divergent picture. All SASL interpreters in this sample were plurilingual and rated themselves proficient at interpreting into spoken language/s other than English. However, only 45% of them did, in fact, interpret into various spoken languages. This evidence again points to the LoLT, which is a variable that can be considered to contribute to the low levels of confidence when interpreting into a native language. In addition, language aptitude testing could aid in gauging the level of aptitude in the reported languages.

The correlation was drawn between Section A: Question 1 and Question 4 to infer that SASL interpreters are not native English speakers, and are equally uncomfortable with their proficiency in interpreting into the languages (other than English) that make up their linguistic repertoire. There is thus doubt and low confidence in the use of languages other than English when interpreting. Equally, the evidence shows that interpreters are uncomfortable translanguaging during interpreting because the environment calls for the use of the ‘norm’, which is interpreting into English from SASL. This is a norm upheld in both formal education of SASL interpreters and practice, where interpreters reported their LoLT to be English, as seen in the literature.



Graph 2: Respondents' Age range



Graph 3: Years of Interpreting experience

<u>Language Proficiency</u>

A Likert scale to rate language proficiency in all official South African languages and SASL was provided. See below:

0 - Very bad

1 - Bad

2 - Ok

3 - Good

4 - Very good

5 - Excellent

Self-reported language proficiency borders on the higher scales, between 3 to 5, indicating that the respondents believe their language proficiency across their linguistic repertoire ranges from good to excellent. Again, as stated previously, these are self-reported proficiency ratings since a language aptitude or proficiency test was not administered. Provided that language proficiency is rated 'Good to Excellent' in the languages presented, it is expected that the respondents will interpret well into the languages as indicated. However, 55% of the respondents interpreted into English only and did not use any other languages in their linguistic repertoire, specifically those that rated themselves on the higher level of proficiency in their native language. It appears from this evidence that ease to expressing one's complete linguistic repertoire depends first on the language of training in interpreting (how interpreter trainees were taught to voice (from sign language to spoken language, which is done in English) and second, the number of years of experience, where the interpreter is comfortable using translanguaging strategies confidently, by incorporating the languages across their linguistic repertoires. The more experienced interpreter's can also read into the brief as provided and understand that the setting requires various languages to be expressed in the experiment of a plurilingual interview panel. Analysis of the PET brain data, Section C, Tables 4.8 and 4.9, investigates this claim regarding years of experience in more detail.

Research Number	Native Language Rating	Comparison between SASL and Spoken language/s Proficiency Rating (Self reported)
RR 01	SASL (4)	SASL (4) isiZulu (5)
RR 02	isiZulu (3)	SASL (4) English (4) isiZulu (3)
RR 03	SASL (4)	SASL (4) English (4) Afrikaans (5)
RR 04	Portuguese (2)	SASL (3) English (3)
RR 05	English (5)	SASL (4) English (5)
RR 07	isiZulu (4)	SASL |(4) isiZulu (4) English (4)
RR 08	Lingala (5)	SASL (5) English (5)
RR 09	isiXhosa (5)	SASL (4) isiXhosa (5)

		isiZulu (5)
RR 10	Portuguese (5)	SASL (4) English (5)
RR 11	Sesotho sa Leboa (5)	SASL (4) Sesotho (5) English (5) isiZulu (5)
RR 12	SASL (4)	SASL (4) isiXhosa(4)
RR 13	isiZulu (1)	SASL (4) English (4)
RR 14	isiZulu (3)	SASL (3) isiZulu (3) English (3)
RR 15	isiXhosa (2)	SASL (3) English (3)
RR 16	Setswana (4)	SASL (4) Setswana (4) English (4)
RR 18	Sesotho sa Leboa (4)	SASL (3)

		Sesotho (4)
RR 19	Setswana (5)	SASL (4) Setswana (5)
RR 21	isiZulu (4)	SASL (4) isiZulu (4) English (4)
RR 22	Sesotho sa Leboa (3)	SASL (3) English (4)
RR 23	isiXhosa (4)	SASL (4) English (5)

Table 5: Self-reported language proficiencies

0= Very Bad 1= Bad 2 = OK 3 = Good 4 = Very Good 5 = Excellent

---

Category 3: Gender

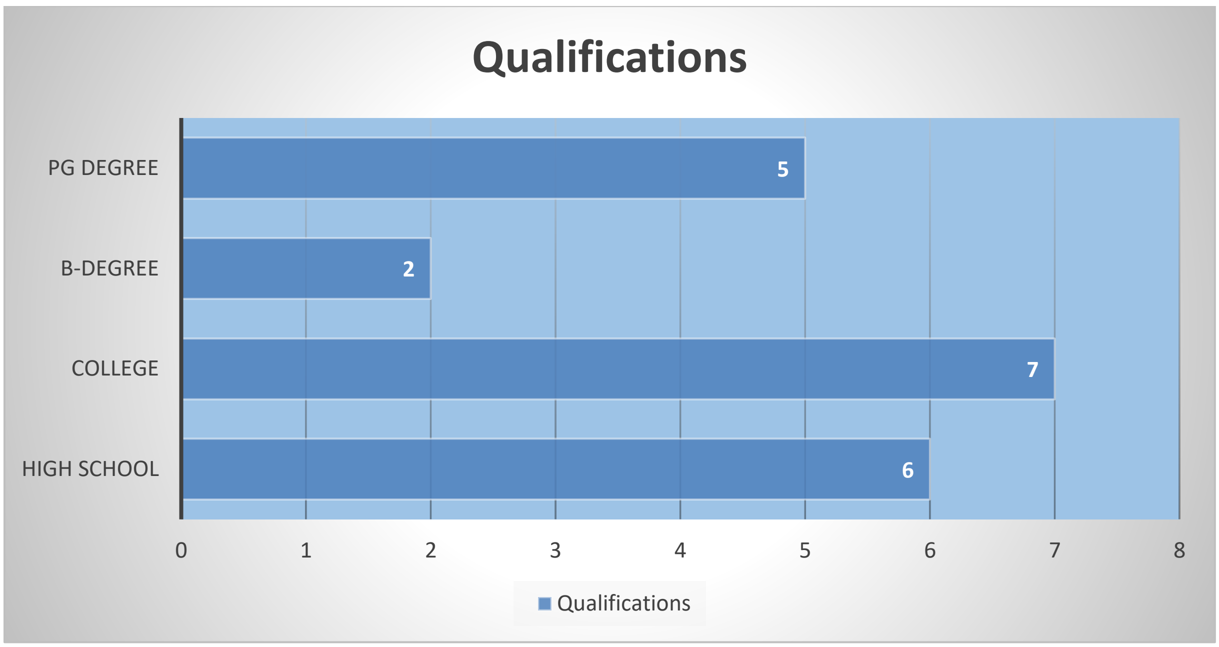
The sample showed that most SASL interpreters are female, as is consistent with gender represention reflected globally for the profession of sign language interpreters. Historically, the profession of sign language interpreters has been dominated by women (Burch, 2000; MacDougall, 2012). This demographic is further supported by the RID annual report 2018, which states that out of a combined membership of 10 000 certified interpreters, 87% are female (RID, 2018). In the immediate past WASLI 2019 conference, on the issue of gender diversity, Napier, presented that women dominate the field of sign language interpreting at a national level, but the same demographic appears to be underrepresented on an international level, where the WFD-WASLI list of accredited International Sign (IS) interpreters reflects 63% male candidates, but more women (CODA+, 2019). Haualand (2019) tweeted: “The field of sign language interpreting is totally dominated by women at the national level, but women are hugely under-represented at the international level. Also, Deaf education is dominated by females, but at international level an abundance of men" (Haualand, 2019). The female majority also reflects in a study on profiling international sign interpreters, where out of a sample of 108, 45.4% were male and 52.8% were female (De Wit et al., 2021). This study did not explore the reporting of other genders that fall in the lesbian, gay, bisexual, transgender, intersex, queer/questioning, asexual LGBTIQA+ range of identities.

Category 4: Qualifications and Training

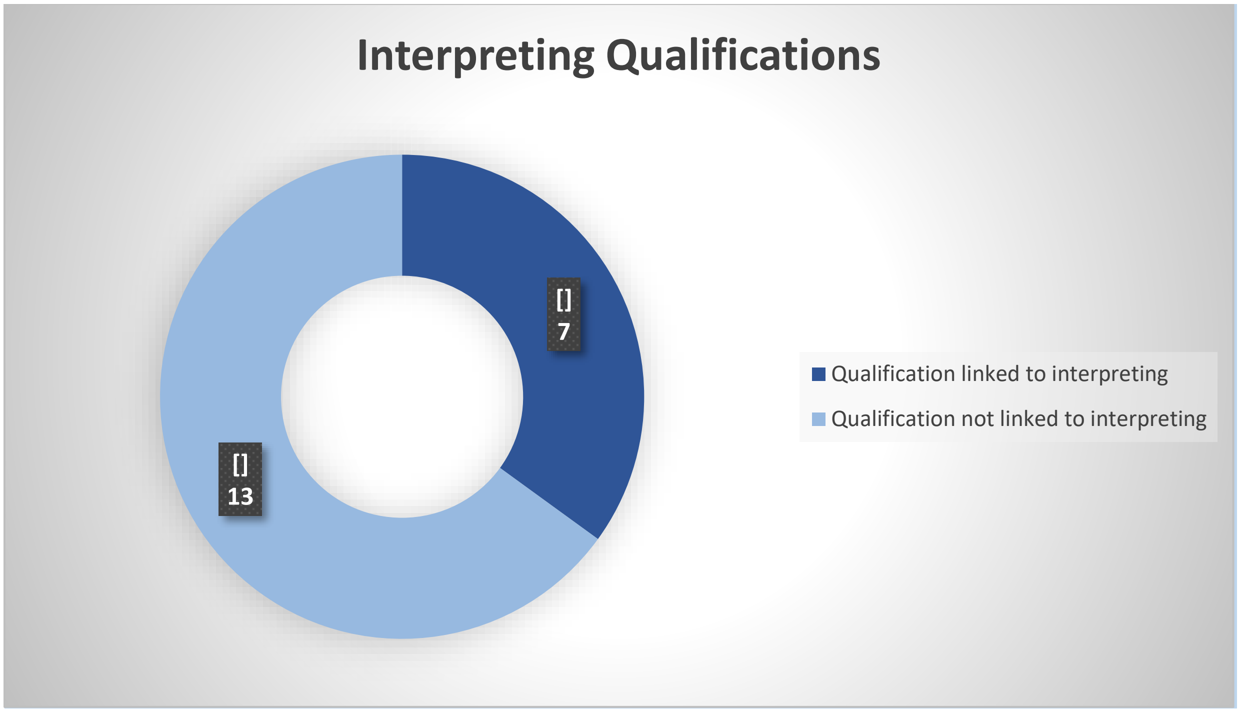
Seven of the respondents have a qualification that is not linked to interpreting. Six out of the seven reported college-level training (NQF level 5) in fashion design, computer science, creative writing and public administration. One respondent has a BA degree (NQF level 7) in Public Administration. Seven respondents had qualifications ranging from diploma to postgraduate degrees, linked to language practice (SASL and English language combination) SASL linguistics or both. Of interest were the six respondents, who reported education at NQF level 4 (Grade 12). These respondents hold no tertiary degree qualification based on the requirement as stated in the South African Language Practitioner's Council Act (SALPCA), a degree qualification to practise as an interpreter in SA, specifically a degree in any language practice field as stated in the literature.

The training indicated differed from workshops, entry-level short courses to postgraduate training at Honours degree level. This situation of various levels of training and practice norms in SASL interpreting impacts directly on the professional status of SASL interpreters, in that there is no consistent standard maintained for training and practice requirements.

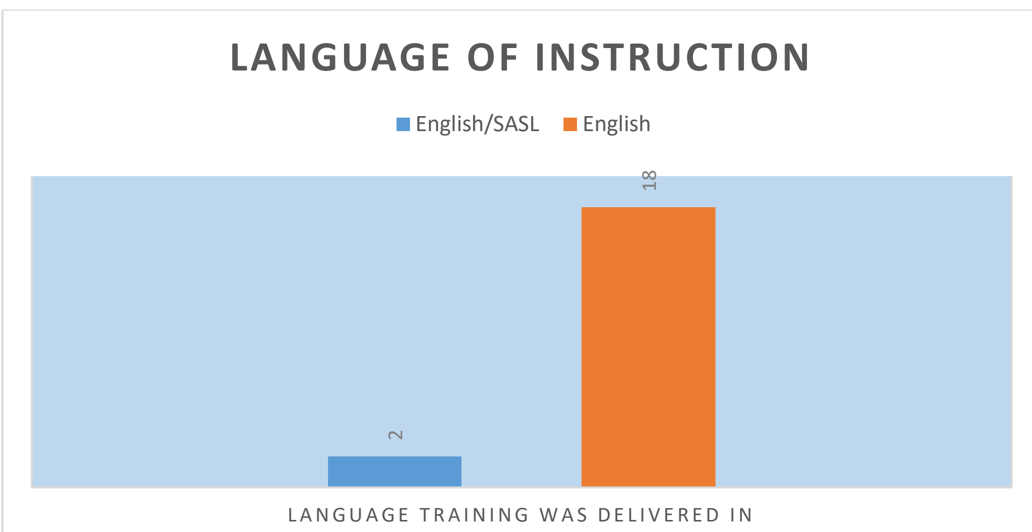
Eighty percent of respondents indicated that the training they received was delivered in English, and twenty percent indicated that training was received both in English and SASL. Fifty percent respondents stated that they did not have an opportunity to engage with their learning (materials and facilitators/lecturers) in their native language. This sample presents that SASL interpreters receive training in English. Hence, they are not confident to interpret into their native language or other spoken languages (see the correlation between Section A: Question 3 & 5 of the questionnaire). This finding is tested in the PET brain analysis, linking native language to number of cognitive areas activated (Section C - Tables 4.5 and 4.6). The data in this section, with reference to the LoLT support the self-reported language proficiency ratings for SASL and spoken languages, where there is an inconsistency in the self-reported data, versus the data collected in the experiment. The inconsistency is presented, where the interpreters report high ratings for spoken language/s and SASL, they only interpret into English which is not their L1, but the LoLT in interpreter training. As stated previously, only nine of 20 respondents interpreted into English only, despite having listed other languages in the higher ranges.



Graph 4: Qualification categories



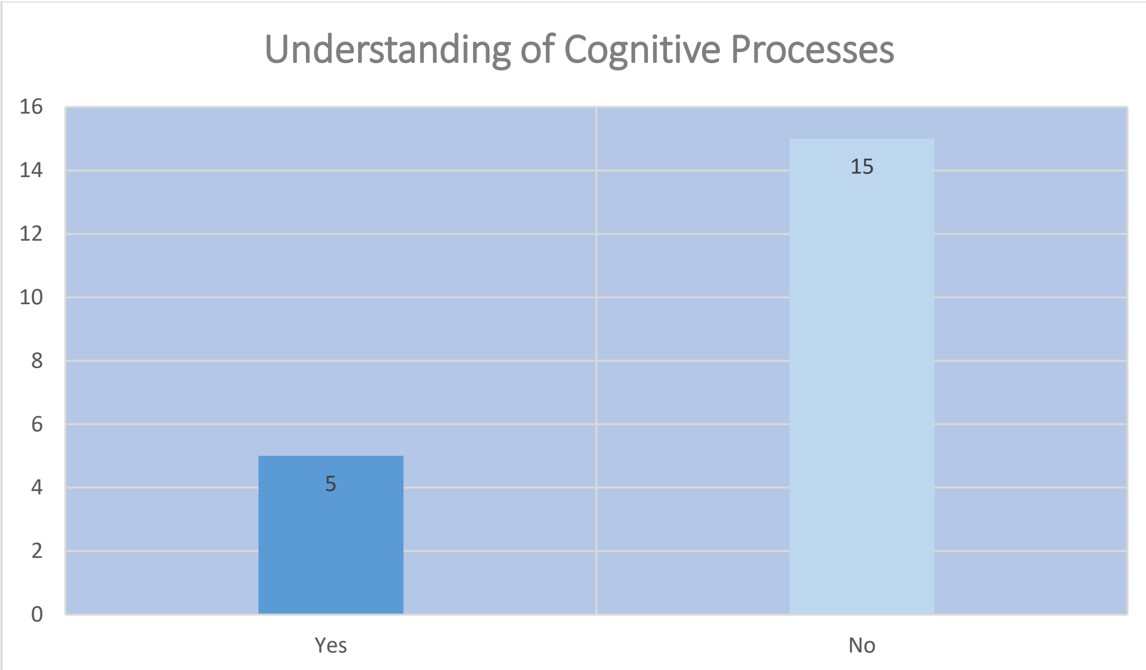
Graph 5: Qualifications linked to interpreting



Graph 6: Interpreter training language of instruction

Category 5 – Understanding of Cognitive Processes during Interpreting

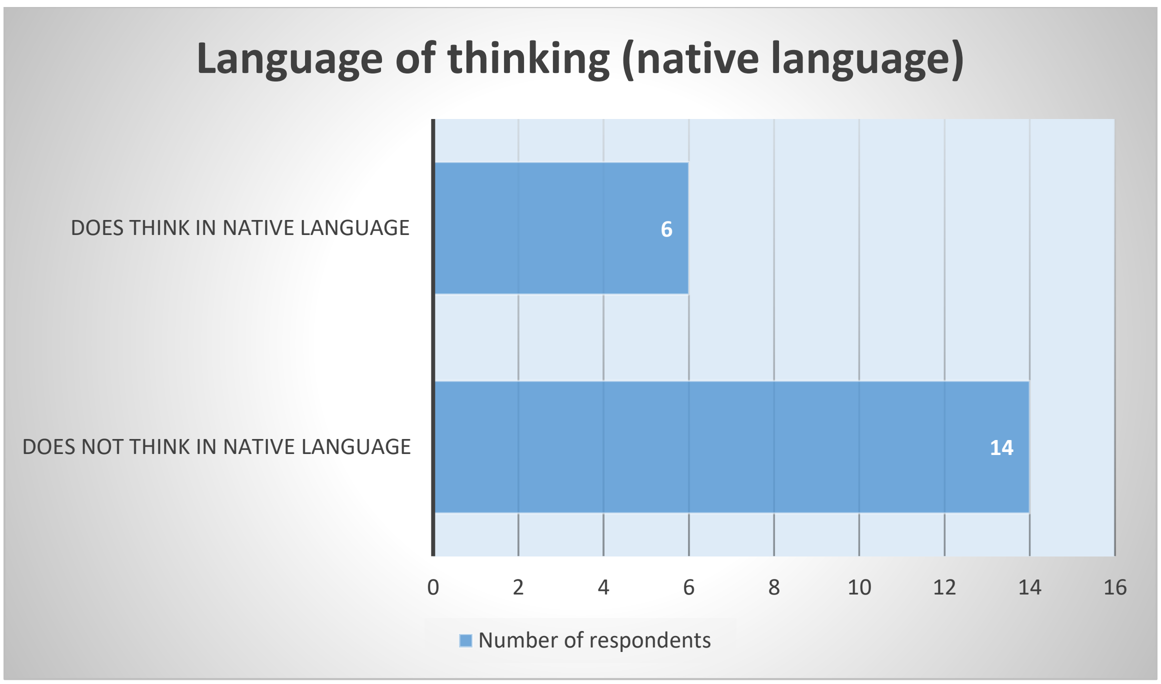
In response to Question 2, 25% of respondents reported that they did not know what transpires in their brain during interpreting, and are thus not aware of the cognitive processes actively engaged or required for interpreting. Practising as a professional interpreter requires an understanding of the trade of interpreting. One of these aspects is the cognitive functions and how possibly to manipulate strategies to enhance the proficiency of the interpreter. Cognitive functions are detailed in, for example, the effort model and tightrope hypothesis (Gile), which are inherent to basic interpreter training modules, both formal and *ad hoc*. There are, therefore, a gap in interpreter training programmes (inclusive of workshops and entry-level short courses), because they do not cover the processe of cognition and its importance in the effective delivery of an interpreting product as it relates to plurilingual settings. Therefore, interpreters are not trained or coached into understanding cognition, where the linguistic repertoire and interpreting strategy as an equilateral system. The understanding of cognition as it relates to neuroscience and its implication on cognitive functions during interpreting is critical. Coaching interpreter trainees on neuro functions and its link to interpretation functions could enable an understanding of interpreter cognitive function concerning language regions in the brain. Furthermore, this understanding can sharpen the employment of linguistic and interpretation coping strategies in the functioning of an interpreter in plurilingual assignments.



Graph 7: Understanding of Cognition during Interpreting

5.1 A) Thinking in Native language vs not thinking in native language

Of the respondents, 30% reported that the language they first think in, meaning the language they use to decode cognitively, is their native language. In contrast, it is evident that, when comparing the proficiency ratings of L1 and other languages in the linguistic repertoire for example, the language the interpreter respondents think in (self-reported) is not always their native language. Those respondents who listed a language other than English as their L1 interpreted into English and did not use of their L1. This could point to the LoLT, where interpreter respondents mainly learn how to interpret from sign to spoken language in English and not in other official languages. This self-reported evidence of language of thinking could not be empirically correlated with the evidence of the voice recording (interpretation into spoken language/s). Further, it could not be established in PET analysis precisely because of English was not listed as the L1. In addition, the ABC language classification cannot be applied here, since the interpreter respondents mostly do not interpret into their A language and instead they interpret into what can be classified as a D/E language (English). Furthermore, the interpreter respondents that do translanguage mostly interpret into their A language pointing to evidence of using their holistic linguistic repertoire to facilitate communication. There is no conclusive evidence of the languages respondents think in and in what language/s they produce the interpretation when the source language is SASL. What the evidence does point to are incidences of ‘interference’, where translanguaging is evident. In this project I do not refer to translanguaging as interference, but rather point to it as an interpreting strategy based on praxis. In a situation where the interpreter employs translanguaging strategies the holistic linguistic, semiotic repertoire is activated to ensure the communicative intent is achieved. The graph below indicates respondents who reported that they think in their native language and those who do not.

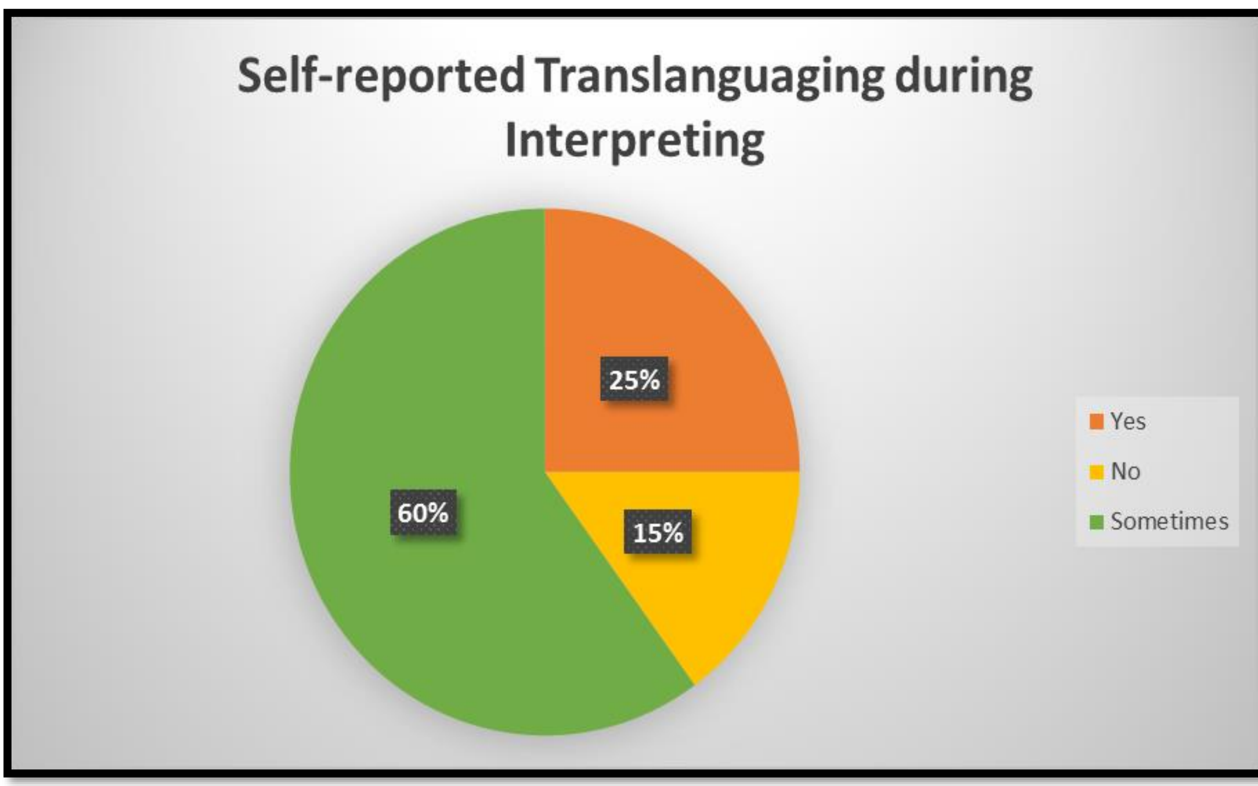


Graph 8: Language of thinking in native language *versus* not thinking in native language

Category 6: Translanguaging

The majority of respondents, 60%, confirmed that they sometimes do translanguage while interpreting, as reported in the questionnaire responses. However, evidence from the ELAN analysis shows that only 45% of respondents used translanguaging strategies in the experiment. Respondents reported on the absolutes of Yes (five out of 20) and No (three out of 20) to the question of translanguaging. When deciphering this information, it can be seen from the sample that interpreters do translanguage (45% from the sample), although not the majority. It is also evident that respondents who have an English home language foundation (L1), are generally conversant in English, and are educated mainly in English do not translanguage.

Illustrated below are the respondents who reported that they do and those who do not translanguage, and those who indicated that they occasionally translanguage.

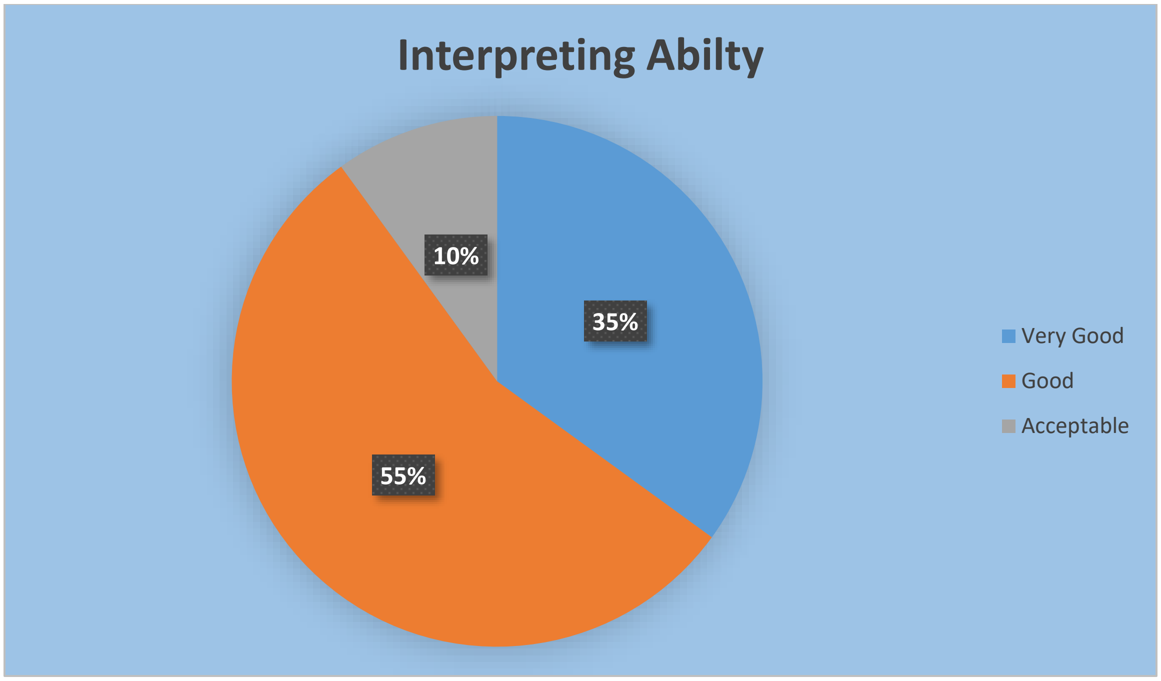


Graph 9: Translanguaging

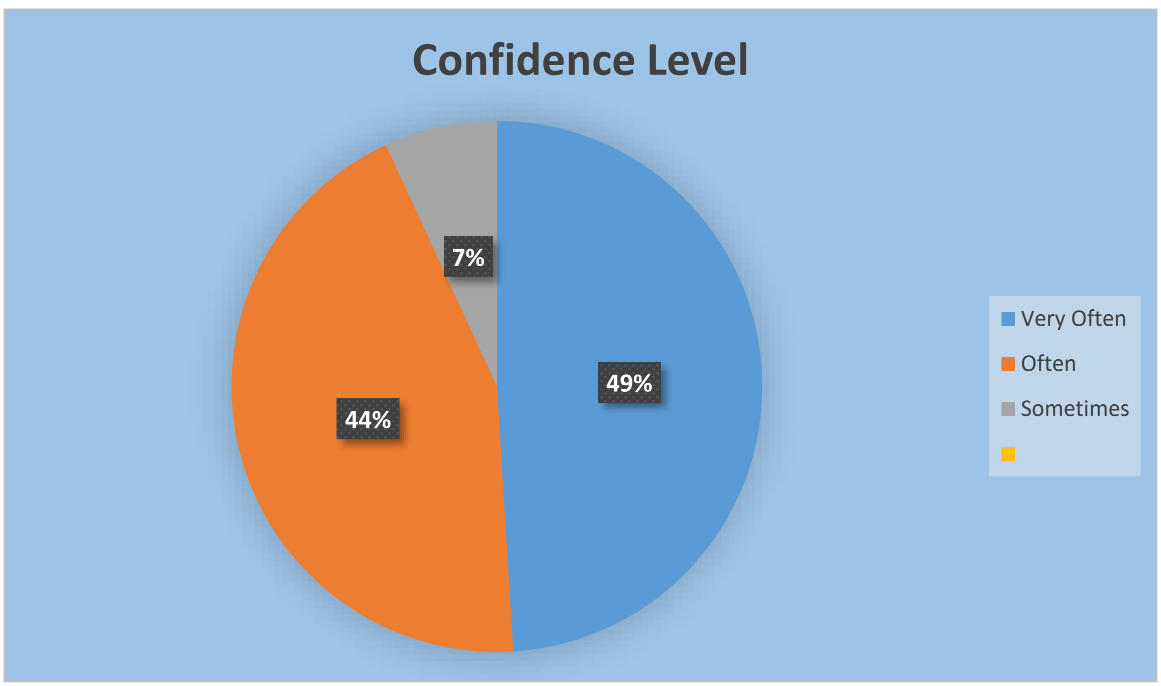
Category 7: Self-perception of ability to interpret from sign to spoken language/s

This category presents evidence of the interpreter respondents self-reported ability to interpret from sign to spoken language/s when responding to Questions 1, 2 and 4. It is evident from the data that the respondents can interpret from SASL to spoken languages (see Likert scale for this Question: 3 - Good). From this response, it can be assumed that SASL interpreter respondents are competent to interpret in the direction from sign to spoken language/s as self-reported. The confidence level when interpreting from sign to spoken language is reported in the upper level of the Likert scale as 4 - Good. This contrast with observations in the literature review (Nicodemus and Emmorey, 2015 and Haug and Audeoud, 2013), where interpreter respondents reported more confidence in the direction spoken to sign language, while the respondents in this study reported the opposite that they had more confidence in interpreting in the direction from sign to spoken language.

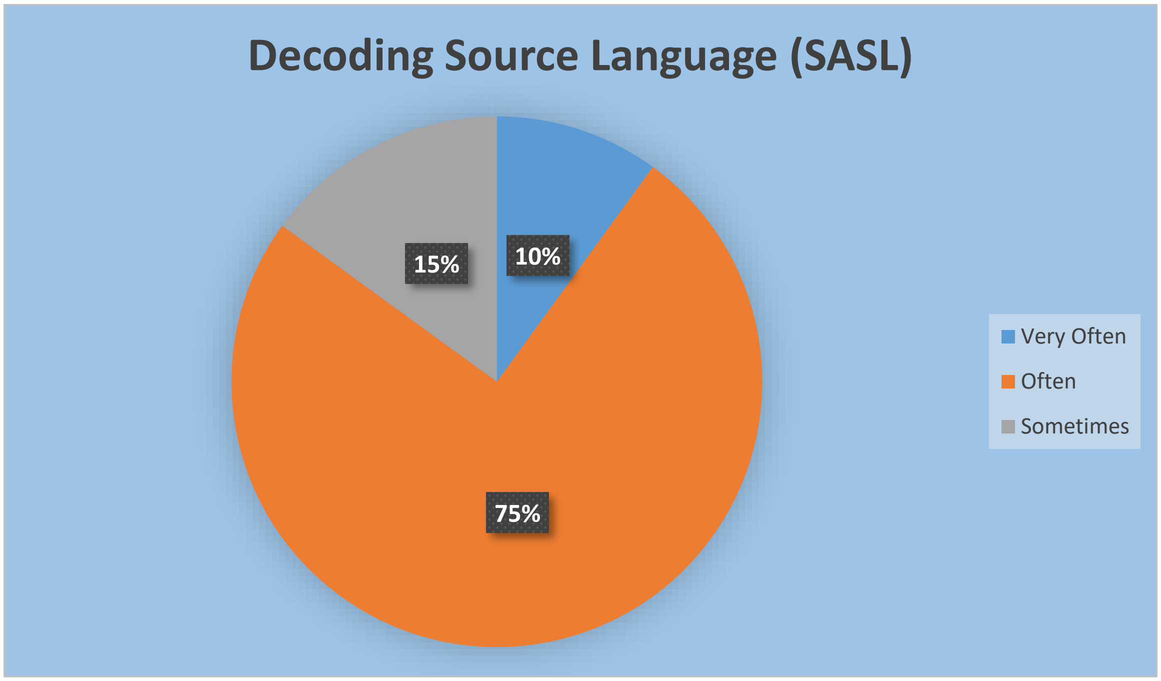
The data points to the fact that decoding the source text is often not a challenge for interpreting respondents (3 - Often). Although respondents reported that decoding is not a problem for them, the response on their knowledge of what cognition (decoding) entails gives a disjointed picture. When examining responses to Category 7, it is evident that 75% of the respondents do not know what occurs in their brain during interpreting. Understanding the term decoding could be attributed to training and knowing the models of, for example, the effort model (Gile, 1995) as a process. The intrinsic operations of cognition and its effect on decoding is not known by the interpreter respondents as self-reported in the questionnaire when asked if they know what happens cognitively during interpreting. It is expected that an interpreter must be aware of the various processes required when interpreting, specifically cognitive processes, to render a faithful and accurate interpretation (Seleskovitch and Lederer, 1984; Wilcox and Schaffer, 2005; Gile, 2018; Cokely, 1992; Mizuno, 2005; Kohn and Kalina, 1996 and Setton, 1999). Understanding the cognitive operation of SASL interpreting by rendering a diamesic interpretation and appreciating the mode of input and output can enhance the functionality of the interpreter.



Graph 10: Self-rating on ability to interpret from SASL to spoken language (Question 1)



Graph 11: Confidence level to interpret into a spoken language (Question 2)



Graph 12: Ability to decode SASL (Question 4)

SECTION B

5.2.1 Section B (i): Amberscript Analysis of Interpretation (Voice Recordings)

In this section, the interpreting product related to lexicon and semantic decisions on how to structure and present the source text is analysed. This section also examines how the respondent's interpretation differs against the guide interpreting text that served as a benchmark to highlight where translanguaging occurs. The tables below present samples of translanguaging across isiZulu, Afrikaans, Sesotho and Setswana.

Transcript1 - isiZulu	
Source Language (Video 01:10-01:18) I WORK LONG TIME FOUR YEARS START 2016 I've been working there for the past 4 years. I started in 2016.	SASL Source Language English guide interpretation
Respondent rendition So *ngisebenze iminyaka emine* [12]since 2015. So, I have worked for four years since 2015	Translanguaging interpretation English back translation

Table 6: Transcription sample translanguaging isiZulu/English (RR01)

Transcript 2- isiZulu	
Source Language (Video 03:28-03:55) ME ENJOY A LOT LIKE WHY ME KNOW DO WHY FINISH PAST EXPERIENCE KNOW HOW ME CHALLENGE WHAT EDUCATION	SASL Source Language

[12] Italics indicates translanguaging lexicon during interpretation.

PRODUCTION LINK WORK IMPLEMENT EDUCATION DEVELOP ENJOY ME LEARN EXPERIENCE A LOT I really enjoy my job, mainly because I have quite a bit of experience in what I do, so I know how to do it what I must do. I have some challenges, education and production are two different worlds, do need to work together so it can develop. And I've been learning a lot, I have gained a lot of experience through this process.	 English standard interpretation
Respondent rendition So *ngiyawuthanda umsebenzi wami kakhulu ngoba ngiyazi ukuthi emuva i-experience yami empilweni iyangisiza ukuthi ngiyenze umsebenzi wami ngikhululekile. So ieducation ne production ziyasebenzisan*a and I try to incorporate two to improve the education they have right now. So, I love my job a lot because I know that my past experience helps me perform my job with ease. Education and production complement each other, and I try to incorporate the two in order to improve the education they have now.	 Translanguaging interpretation English back translation

Table 7: Transcription sample translanguaging isiZulu/English (RR02)

Transcript 3- Setswana	
<u>Source Language (Video 06:00-06:05)</u> THERE ME WORK LONG YEARS HOW MANY FOURTEEN YEARS I've been working there a long time, a total of fourteen years.	SASL Source Language English standard interpretation
<u>Respondent rendition</u> *Ke nale ngwaha ke bereka ko teng*, I think its fourteen years *ntse ke bereka ko teng.* I have been working there for a year, I think it's fourteen years since I started working there.	Translanguaging interpretation English back translation

Table 8: Transcription sample translanguaging Setswana/English (RR18)

Transcript 4- Setswana	
<u>Source Language (Video 06:49-06:58)</u> PAPER HAVE SAY TEN BOX OPEN LOOK FIVE MISSING FIVE ME FIX SO Sometimes the order says that ten items were delivered, but upon opening they only find five items, which means five items are now missing.	SASL Source Language English standard interpretation
<u>Respondent rendition</u> Okay *kodi shopong ba re fonela ba re kgopela hore re kgopela hore le direng jana, re tlhoka di pampiri tse ding jana, so ha re checker re bone*	Translanguaging interpretation

hore okay sharp, hora hore honale mistake tse ditswang kosi shopong. Ha re kreya di pampire re tshwantse re kreye milato ebe ten so hora hore mo boxing mo ra checker, and if ele hore five yoyotle ayi teng then re tswella pele ra checker ra di confirmer hore azang ra kreya tse five, then radi busetsa moraho.	
Okay so we get calls from the shops requesting us to assist them with certain paperwork and so we check and realise any kind of mistake from the shop. When we find the papers we search for cases and there needs to be 10 items of which if an entire five items is not there, we continue to check and to confirm that we never received the other 5 and then we return them.	English back translation

Table 9: Transcription sample translanguaging Setswana/English (RR 19)

Transcript 5- Sesotho	
<u>Source Language (Video 01:10-01:18)</u>	
SECOND PRODUCTION PRODUCTION WHAT YES SET UP RESOURCES RESOURCES THIS SCHOOL SUPPLY ME BUSINESS DO WHAT EDIT SUBTITLING FILMING ETC.	SASL Source Language
Secondly, I also do production work. I develop resources. These resources are then given to	English standard interpretation

schools. With production I do editing, subtitling, filming, etc	
<u>Respondent rendition</u> And the second one *e ke i dirang ke hore* I do production of resources, *ke yetsa business eo ya ho editor, filming and editing*. And the second job I do is production of resources. I am in the business of editing, filming and editing.	 Translanguaging interpretation English back translation

Table 10: Transcription sample translanguaging Sesotho/English (RR18)

Transcript 6- Afrikaans	
<u>Source Language (Video 17:26-17:42)</u> STAFF ROUNDTABLE SIT DISCUSS BUDGET TABLED ALL TOGETHER YES YES OPPOSE DEBATE ARGUE AFTER WORK TOGETHER THIS ME ENJOY. We would around the table, we debate, we discuss. You know have ideas and the relationship we built. Some say no, let's debate this, let's discuss this and after a possible conflict even we then resolve it and the relationship we built through that is amazing and working together like that was absolutely amazing.	 SASL Source Language English standard interpretation

Respondent rendition *As ek onderhandelinge doen met my span is dit vir my lekker as almal saamwerk en dis ook] even [lekker vir my as mense nie saamstem op n sekere punt nie.* When I am in negotiation with my team it is a pleasure when everyone works in harmony but it is also even enjoyable for me when people don't agree on specific point.	 Translanguaging interpretation English back translation

Table 11: Transcription sample translanguaging Afrikaans/English (RR03)

Transcript 7- Afrikaans	
Source Language (Video 17:43-17:54) END DAY ALWAYS GOOD TOGETHER WORK ALL TOGETHER RESPECT RESPECT THIS I ENJOY. We had mutual respect for each other, through the whole process and that's what I really enjoyed about the personal relations.	 SASL Source Language English standard interpretation
Respondent rendition *En om te kyk dat almal wanneer ons saamwerk dat daar is]mutual respect for everyone in the office.*	 Translanguaging interpretation

And to see to it that when everyone works together that there is mutual respect for everyone in the office.	English back translation

Table 12: Transcription sample translanguaging Afrikaans/English (RR03)

The presentation of translanguaging incidents comparing the respondent's interpretation to that of the guide interpretation in the tables above confirms the observation that language involves processes of meaning-making by situational consideration of the linguistic environment and its unique variables such as translanguaging (Kusters et al., 2017). In this specific experiment, the presentation of translanguaging on a syntactic level is seen by code-blending and code-switching and conforms to definitions provided in chapter 2 (III) on Translanguaging (Backus, 2000; Garcia and Wei, 2014; Wei, 2018 a, b). Wei (2011) mentions a pivotal moment, where a decision is made to either follow or flout the norms of language use. The incidents of translanguaging were not followed up in order to source the reasons why the interpreter respondents used translanguaging strategies. Given the interpreting brief as a variable, it could influence the decision to interpret in various languages. On the other hand, if the interpreter is not trained to handle their linguistic repertoire in an interpreting task cognitively and linguistically, they will revert to the default of interpreting in the language in which they were trained, which in this experiment was English.

5.2.1 Section B (ii): ELAN Analysis of Translanguaging

In this section, the ELAN annotator, a time-aligned video transcription tool was used to specifically analyse translanguaging incidents specifically across the sample. The interpreting product related to lexicon and semantic decisions on how to structure and present the target text was analysed, as well as where the respondent's interpretation indicated translanguaging strategies by linguistic categories.

The source text SASL video file and the interpretation voice note file were uploaded as EAF files and aligned to create a single synchronised file. The following tiers were created:

- The 1st tier indicates the *Interpretation* where the interpreter translanguages. The annotations reflect all incidences of translanguaging across the complete interpretation.

- A 2nd parent tier, *Code Switching*, was created. This tier presents annotations across an individual respondent's interpretation. Code-switching is evident, where respondents present random changes in the interpretation, where there is a natural fluctuation of spoken languages from one language to another. In the example of the Afrikaans/English interpretation: [En om te kyk dat almal wanneer ons saamwerk dat daar is *mutual respect for everyone in the office*.] (English - and to see to it that when everyone works together that there is mutual respect for everyone in the office).

- A 3rd child tier, *Code Mixing*, was created, which refers to the parent tier of code-switching. The linguistic type created in the 3rd tier denotes the linguistic data of incidents where the interpreter specifically uses another spoken languages' lexical rule, specifically lexical borrowing by substitution. The lexical borrowing can be seen in changes from the source text to the spoken language(s) used. It presents itself on morphological, syntactic and phonetic levels. An example is evident in the Sesotho interpretation: [And the second one *e ke i dirang ke hore* I do production of resources, *ke yetsa* business *eo ya ho edita*, filming and editing.] (English-and the second job I do is production of resources. I am in the business of editing, filming and editing). In this example, there is a syntactic change, where English and Sesotho morphological structures are presented. Phonological changes are evident in the audio rendition of the interpretation where accents differ for the English and Sesotho sections.

- The 4th tier, *Lexical Borrowing* was analysed to highlight incidences of the adoption of individual words from English. Here, the interpreter used lexical borrowing as a translanguaging interpreting strategy. An example of lexical borrowing in the annotations is: University (English) *e-university (isiZulu) and Dorp (Afrikaans) *edoropo (isiZulu).

- The 5th tier, *Semantic Equivalence*, was analysed to highlight the respondents rendition of the target text. In this tier, interpretations were analysed against equivalences of style and rhythm of the signs used in the SASL source text. An example of semantic equivalence is in the interpretation of facial expressions and mouth morphemes, where the interpreter presents uncountable nouns (for example- a lot) as: *hengse lot* (Afrikaans), *kakhulu* (isiZulu), *haholo* (Sesotho), *thata* (Setswana) for the phrase in SASL [WORK-MINE-ENJOY-FULL].

- The 6th tier, *Semantic Shift*, was analysed for incidences of word form and meaning changes specifically where the interpreter employs the strategy of chunking down. Incidences of a semantic shift is evident in the use of the isiZulu word (*i-budget*). In the SASL source text the term is signed as finances and the interpreter changes the word to budget by using the interpreting strategy of chunking down. There is a change of form in the word budget to *i-budget* and a change in meaning contextually.

- The 7th tier, *Colloquial Expression*, was analysed for incidences where the interpreters use general expressions associated with African Bantu-languages that do not consistently occur in the source language, SASL. Examples of expressions such as [*hayi*], [*eeh*], [*yoh*] in isiZulu and [*nou*] in Afrikaans are evident in the annotations.

- The 8th tier, *Socio-Cultural correction*, is highlighted where the interpreter effectively uses a translanguaging strategy by making reference to a culturally correct term in the target language, even though the term is not politically correct according to the human-rights framework on disability. This is evident in the use of [Deaf TALK CANNOT] in the source text, SASL, and subsequent rendition in isiZulu by interpreting [Deaf TALK CANNOT] as, "*e E-Deaf baningi khona abantu abangakhulumi*" (English: E-Deaf has a lot of people who cannot speak). In isiZulu, the term used to refer to Deaf people is "*isithulu*", however, the interpreter understands the cultural dynamics between the Deaf and hearing communities, thus aiming to create a culturally and politically accepted rendition, by stating (those who cannot talk) [*abantu abangakhulumi*].

Below is an example of tiers created.

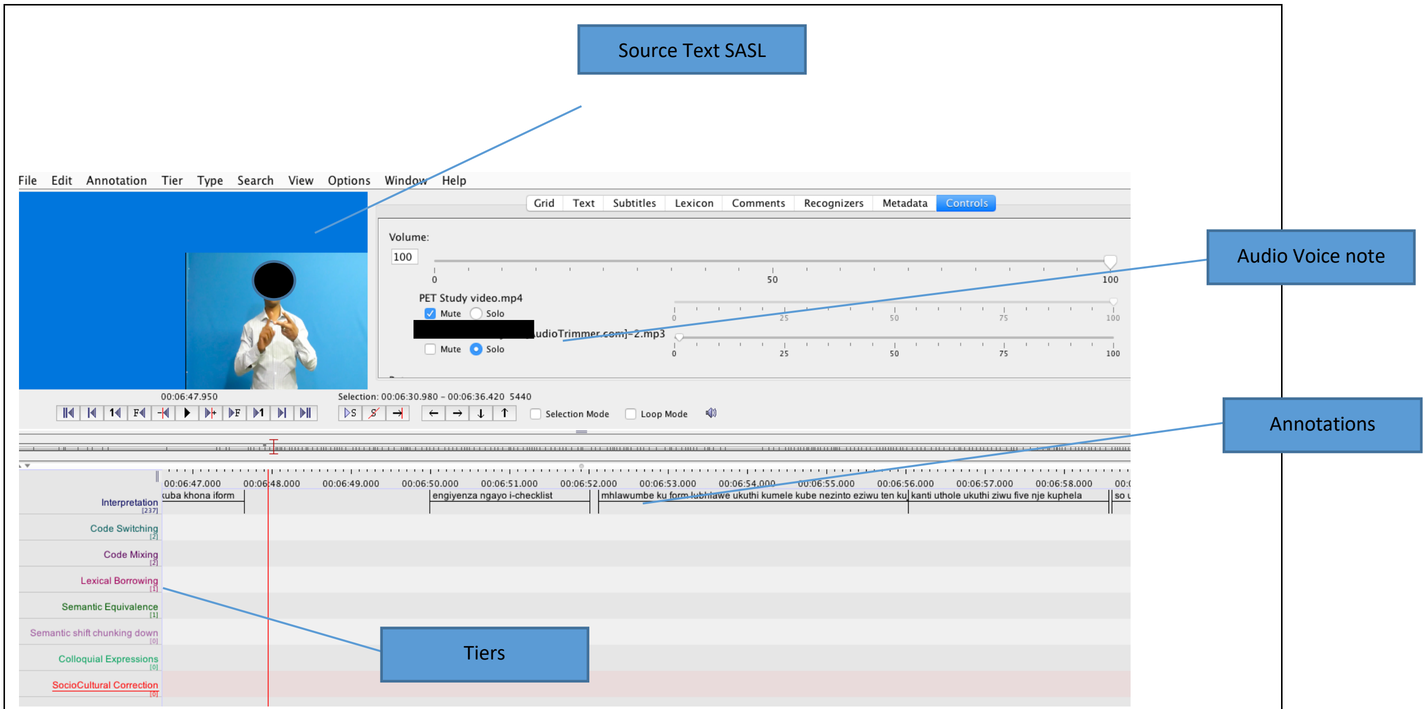
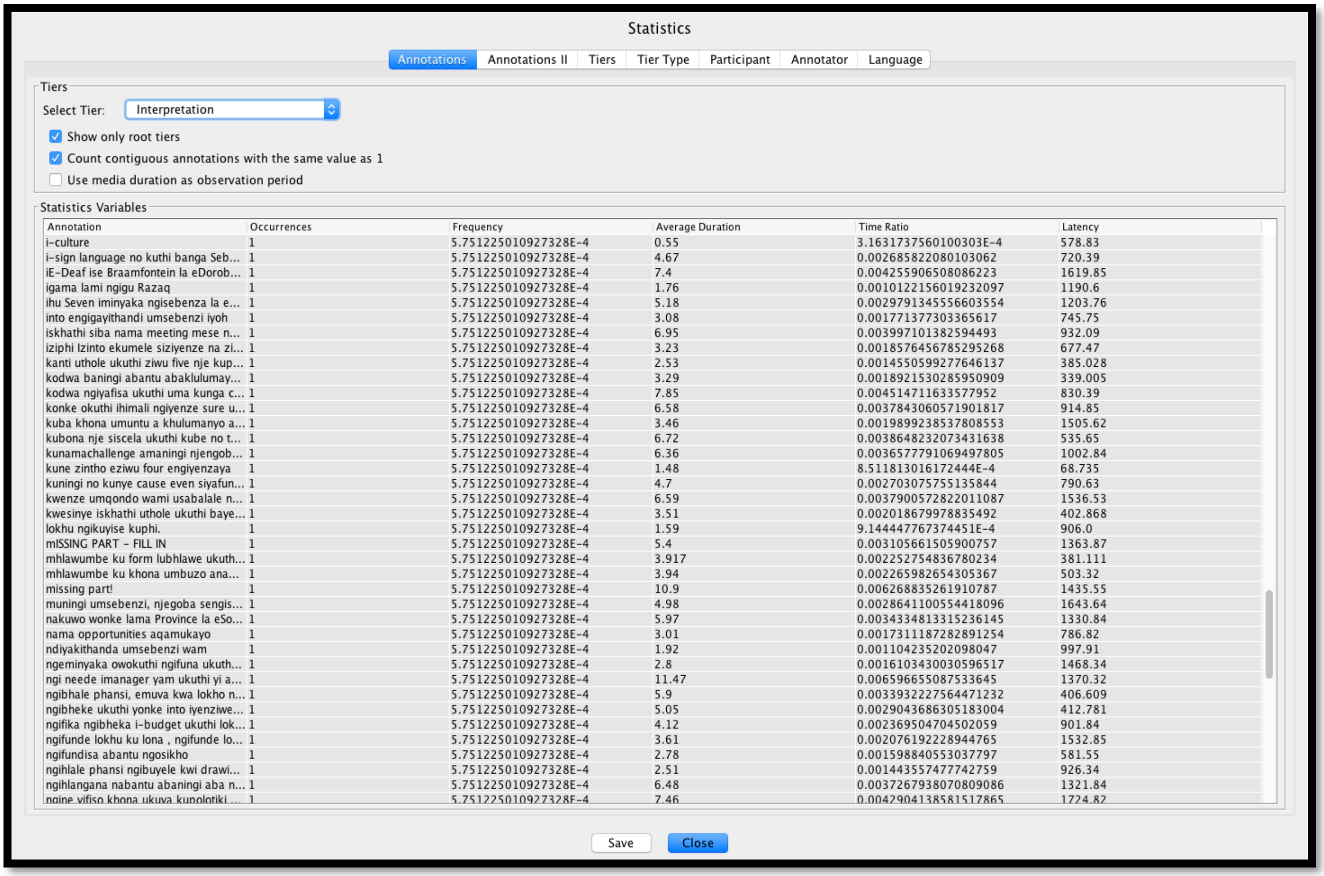


Figure 21: ELAN tiers

Subsequently, individual ELAN files for all 20 respondents were created following the same analysis and tiers as described above. It was found that only nine respondents interpreted into languages other than English (see examples of translanguaging interpretation frequency in isiZulu/English and English/Afrikaans below).


Statistics

Annotations | Annotations II | Tiers | Tier Type | Participant | Annotator | Language

Tiers

Select Tier: Interpretation

Show only root tiers

Count contiguous annotations with the same value as 1

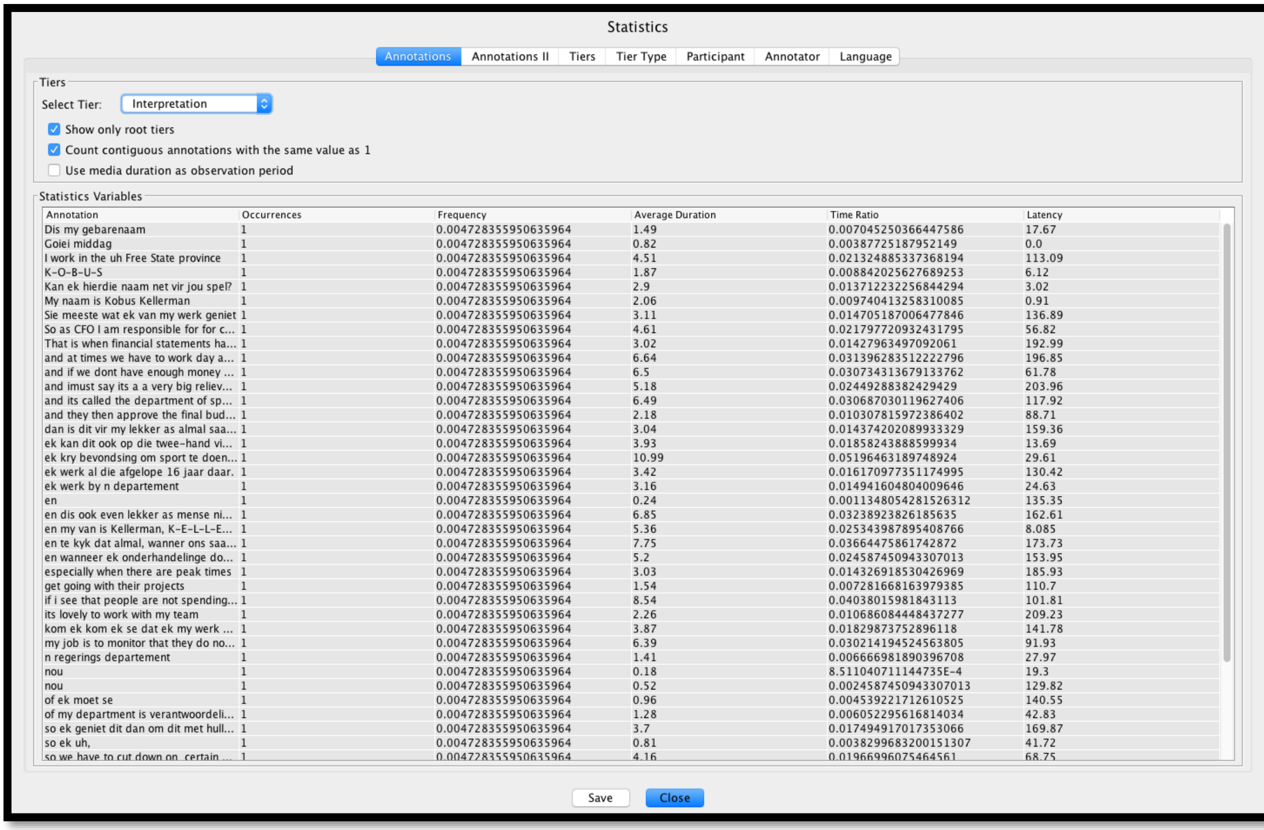
Use media duration as observation period

Statistics Variables

Annotation	Occurrences	Frequency	Average Duration	Time Ratio	Latency
i-culture	1	5.751225010927328E-4	0.55	3.1631737560100303E-4	578.83
i-sign language no kuthi banga Seb...	1	5.751225010927328E-4	4.67	0.002685822080103062	720.39
iE-Deaf ise Braamfontein la eDorob...	1	5.751225010927328E-4	7.4	0.004255906508086223	1619.85
igama lami ngigu Razaq	1	5.751225010927328E-4	1.76	0.0010122156019232097	1190.6
ihu Seven iminyaka ngisebenza la e...	1	5.751225010927328E-4	5.18	0.0029791345556603554	1203.76
into engigayithandi umsebenzi iyoh	1	5.751225010927328E-4	3.08	0.001771377303365617	745.75
iskhathi siba nama meeting mese n...	1	5.751225010927328E-4	6.95	0.003997101382594493	932.09
iziphi Izinto ekumele siziyenze na zi...	1	5.751225010927328E-4	3.23	0.0018576456785295268	677.47
kanti uthole ukuthi ziwu five nje kup...	1	5.751225010927328E-4	2.53	0.0014550599277646137	385.028
kodwa baningi abantu abaklulumay...	1	5.751225010927328E-4	3.29	0.0018921530285950909	339.005
kodwa ngiyafisa ukuthi uma kunga c...	1	5.751225010927328E-4	7.85	0.004514711633577952	830.39
konke okuthi ihimali ngiyenze sure u...	1	5.751225010927328E-4	6.58	0.0037843060571901817	914.85
kuba khona umuntu a khulumanyo a...	1	5.751225010927328E-4	3.46	0.0019899238537808553	1505.62
kubona nje siscela ukuthi kube no t...	1	5.751225010927328E-4	6.72	0.0038648232073431638	535.65
kunamachallenge amaningi njengob...	1	5.751225010927328E-4	6.36	0.0036577791069497805	1002.84
kune zintho eziwu four engiyenzaya	1	5.751225010927328E-4	1.48	8.511813016172444E-4	68.735
kuningi no kunye cause even siyafun...	1	5.751225010927328E-4	4.7	0.002703075755135844	790.63
kwenze umqondo wami usabalale n...	1	5.751225010927328E-4	6.59	0.0037900572822011087	1536.53
kwesinye iskhathi uthole ukuthi baye...	1	5.751225010927328E-4	3.51	0.002018679978835492	402.868
lokhu ngikuyise kuphi.	1	5.751225010927328E-4	1.59	9.144447767374451E-4	906.0
mISSING PART - FILL IN	1	5.751225010927328E-4	5.4	0.003105661505900757	1363.87
mhlawumbe ku form lubhlawe ukuth...	1	5.751225010927328E-4	3.917	0.002252754836780234	381.111
mhlawumbe ku khona umbuzo ana...	1	5.751225010927328E-4	3.94	0.002265982654305367	503.32
missing part!	1	5.751225010927328E-4	10.9	0.006268835261910787	1435.55
muningi umsebenzi, njegoba sengis...	1	5.751225010927328E-4	4.98	0.0028641100554418096	1643.64
nakuwo wonke lama Province la eSo...	1	5.751225010927328E-4	5.97	0.0034334813315236145	1330.84
nama opportunities aqamukayo	1	5.751225010927328E-4	3.01	0.0017311187282891254	786.82
ndiyakithanda umsebenzi wam	1	5.751225010927328E-4	1.92	0.001104235202098047	997.91
ngeminyaka owokuthi ngifuna ukuth...	1	5.751225010927328E-4	2.8	0.0016103430030596517	1468.34
ngi neede imanager yam ukuthi yi a...	1	5.751225010927328E-4	11.47	0.006596655087533645	1370.32
ngibhale phansi, emuva kwa lokho n...	1	5.751225010927328E-4	5.9	0.0033932227564471232	406.609
ngibheke ukuthi yonke into iyenziwe...	1	5.751225010927328E-4	5.05	0.0029043686305183004	412.781
ngifika ngibheka i-budget ukuthi lok...	1	5.751225010927328E-4	4.12	0.002369504704502059	901.84
ngifunde lokhu ku lona , ngifunde lo...	1	5.751225010927328E-4	3.61	0.002076192228944765	1532.85
ngifundisa abantu ngosikho	1	5.751225010927328E-4	2.78	0.001598840553037797	581.55
ngihlale phansi ngibuyele kwi drawi...	1	5.751225010927328E-4	2.51	0.001443557477742759	926.34
ngihlangana nabantu abaningi aba n...	1	5.751225010927328E-4	6.48	0.0037267938070809086	1321.84
ngine vifiso khona ukuva kupolotiki ...	1	5.751225010927328E-4	7.46	0.0042904138581517865	1724.82

Save | Close

Figure 22: Statistics on the frequency of translanguaging according to ELAN tier described - isiZulu/English



Statistics

Annotations | Annotations II | Tiers | Tier Type | Participant | Annotator | Language

Tiers

Select Tier: Interpretation

Show only root tiers

Count contiguous annotations with the same value as 1

Use media duration as observation period

Statistics Variables

Annotation	Occurrences	Frequency	Average Duration	Time Ratio	Latency
Dis my gebarenaam	1	0.004728355950635964	1.49	0.007045250366447586	17.67
Goiei middag	1	0.004728355950635964	0.82	0.00387725187952149	0.0
I work in the uh Free State province	1	0.004728355950635964	4.51	0.021324885337368194	113.09
K-O-B-U-S	1	0.004728355950635964	1.87	0.008842025627689253	6.12
Kan ek hierdie naam net vir jou spel?	1	0.004728355950635964	2.9	0.013712232256844294	3.02
My naam is Kobus Kellerman	1	0.004728355950635964	2.06	0.009740413258310085	0.91
Sie meeste wat ek van my werk geniet	1	0.004728355950635964	3.11	0.014705187006477846	136.89
So as CFO I am responsible for for c...	1	0.004728355950635964	4.61	0.021797720932431795	56.82
That is when financial statements ha...	1	0.004728355950635964	3.02	0.01427963497092061	192.99
and at times we have to work day a...	1	0.004728355950635964	6.64	0.031396283512222796	196.85
and if we dont have enough money ...	1	0.004728355950635964	6.5	0.030734313679133762	61.78
and imust say its a a very big reliev...	1	0.004728355950635964	5.18	0.02449288382429429	203.96
and its called the department of sp...	1	0.004728355950635964	6.49	0.030687030119627406	117.92
and they then approve the final bud...	1	0.004728355950635964	2.18	0.010307815972386402	88.71
dan is dit vir my lekker as almal saa...	1	0.004728355950635964	3.04	0.014374202089933329	159.36
ek kan dit ook op die twee-hand vi...	1	0.004728355950635964	3.93	0.01858243888599934	13.69
ek kry bevondsing om sport te doen...	1	0.004728355950635964	10.99	0.05196463189748924	29.61
ek werk al die afgelope 16 jaar daar.	1	0.004728355950635964	3.42	0.016170977351174995	130.42
ek werk by n departement	1	0.004728355950635964	3.16	0.014941604804009646	24.63
en	1	0.004728355950635964	0.24	0.0011348054281526312	135.35
en dis ook even lekker as mense ni...	1	0.004728355950635964	6.85	0.03238923826185635	162.61
en my van is Kellerman, K-E-L-L-E...	1	0.004728355950635964	5.36	0.025343987895408766	8.085
en te kyk dat almal, wanner ons saa...	1	0.004728355950635964	7.75	0.03664475861742872	173.73
en wanneer ek onderhandelinge do...	1	0.004728355950635964	5.2	0.024587450943307013	153.95
especially when there are peak times	1	0.004728355950635964	3.03	0.014326918530426969	185.93
get going with their projects	1	0.004728355950635964	1.54	0.007281668163979385	110.7
if i see that people are not spending...	1	0.004728355950635964	8.54	0.04038015981843113	101.81
its lovely to work with my team	1	0.004728355950635964	2.26	0.010686084448437277	209.23
kom ek kom ek se dat ek my werk ...	1	0.004728355950635964	3.87	0.01829873752896118	141.78
my job is to monitor that they do no...	1	0.004728355950635964	6.39	0.030214194524563805	91.93
n regerings departement	1	0.004728355950635964	1.41	0.006666981890396708	27.97
nou	1	0.004728355950635964	0.18	8.511040711144735E-4	19.3
nou	1	0.004728355950635964	0.52	0.0024587450943307013	129.82
of ek moet se	1	0.004728355950635964	0.96	0.004539221712610525	140.55
of my department is verantwoordeli...	1	0.004728355950635964	1.28	0.006052295616814034	42.83
so ek geniet dit dan om dit met hull...	1	0.004728355950635964	3.7	0.017494917017353066	169.87
so ek uh,	1	0.004728355950635964	0.81	0.0038299683200151307	41.72
so we have to cut down on certain ...	1	0.004728355950635964	4.16	0.01966996075464561	68.75

Save | Close

Figure 23: Statistics on the frequency of translanguaging according to ELAN tier described – English/Afrikaans

The results of ELAN analysis confirm that for a coherent message to be produced, several cognitive, linguistic and interpreting operations must complement each other. In the analysis, interpreter respondents can arrive at an understanding of the SASL text by grammatical identification, morphological identification, semantic representation, syntactical structure, and processing of prosodic features to construct a coherent interpretation. This finding confirms Dabrowska's (2012) work, which found that linguistic features must be operationalised effectively in order to produce a coherent message. In addition, the analysis presents evidence of extensive translanguaging strategies. The translanguaging interpreting strategies, as seen in the above comparative plot are in line with observations by Garcia and Wei (2014): "…translanguaging shares some components of code-switching, but in addition, presents the use of additional language resources and meta-linguistic awareness based on the context and communicative event". The translanguaging strategies observed in the study is insertion, alternation and congruent lexicalisation conform to the three processes of translanguaging highlighted by Muysken (1997).

Below tables indicate the isiZulu words mostly used across the isiZulu respondents as per the ELAN analysis.

Interpretation	**English word**	**Translanguaging strategy**
Ama budget	budget	Lexical borrwing
i-budget	budgte	Lexical borrwing
aba-deaf	deaf	Lexical borrwing
e-University	university	Lexical borrwing
i-supervisor	supervisor	Lexical borrwing
i-meeting	meeting	Lexical borrwing
i-culture	culture	Lexical borrwing
i-company	company	Lexical borrwing
Krya (Afrikaans Kry)	To get	Lexical borrwing
Tronkong (Afrikaans Tronk)	jail	Lexical borrwing
ngespeed	Quickly (speedily)	Lexical borrwing

Table 13: Lexical borrowing in isiZulu

English word	**Grammatical Function**
So	Subordinating conjunction
Then	adverb used in the contect of 'in addition' and 'next':

Table 14: Subordinating conjunctions

Interpretation	**English Equivalent**	**Grammatical function**
Hayi	oh no	Colloquial Expression
He-eh	no	Colloquial Expression
Hu-uh	no	Colloquial Expression
Gori haai man	Like really? (sarcasm)	Colloquial Expression
Ho so, so	Not good, not bad	Colloquial Expression
Oraait	ok	Colloquial Expression
Haai gaekitsi man	I'm at a loss for words!	Colloquial Expression

Table 15: Colloquial expressions in isiZulu, Afrikaans, Setswana and Sesotho

Interpretation	**Socially Correct term**
Setholo (*Deaf and Dumb)	Semumu
Abakhulamayo (*who cannot talk)	Deaf
Ha ba utlwi/ ga ke utlwi (*those/he/she who cannot hear)	Deaf

Table 16: Cultural Correction

Interpretation	**Semantic Shift**
Hobaning – Sesotho / Seswana(*why)	Used in the context of changing the expression to a rhetorical question instead of a conjunction because.
“finished to experience”	Already experienced or from my experience, semantic shift from SASL (I EXPERIENCE FINISH)

Table 17: Semantic shifts

With reference to monitoring output during interpreting, a component not analysed in this study, only one (1) respondent made reference to an interpreting error and corrected the mistake (see ELAN annotation 00:28:07).

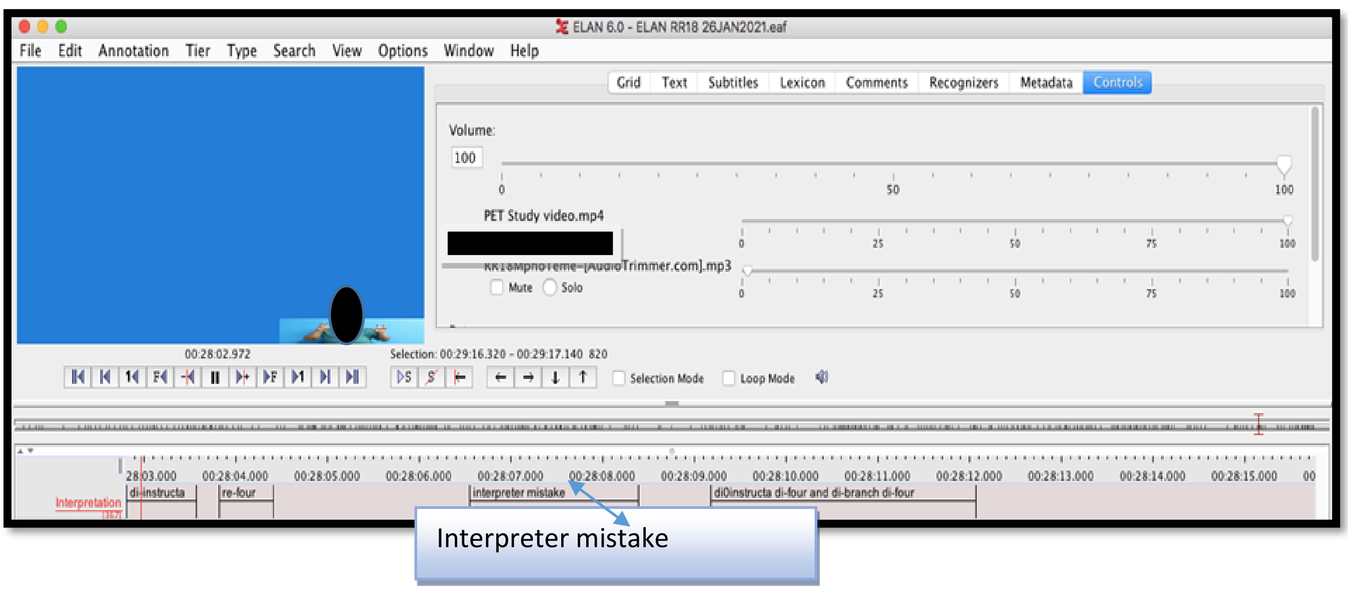


Figure 24: Interpreter Mistake

This singular incident in the data aligns with fMRI evidence that growing up with two or more languages and the cognitive demands of attentively ‘monitoring’ the specific features of the various languages and language control (Abutalebi and Green, 2016) presented in the left lower parietal cortex (Mechelli et al., 2004). Mahendra et al. (2003) present evidence of the basal ganglia in repair and revision incidences. The incidence of monitoring and self-correction links to the phonological loop which according to implicated the left posterior inferior frontal gyrus (pIFG) and anterior supramarginal gyri (aSMG) (Deschamps et al., 2020). In this study, looking at the participant in isolation, there was a change in the left inferior frontal cortex but not exclusively. Other sites in the temporal cortex were seen.

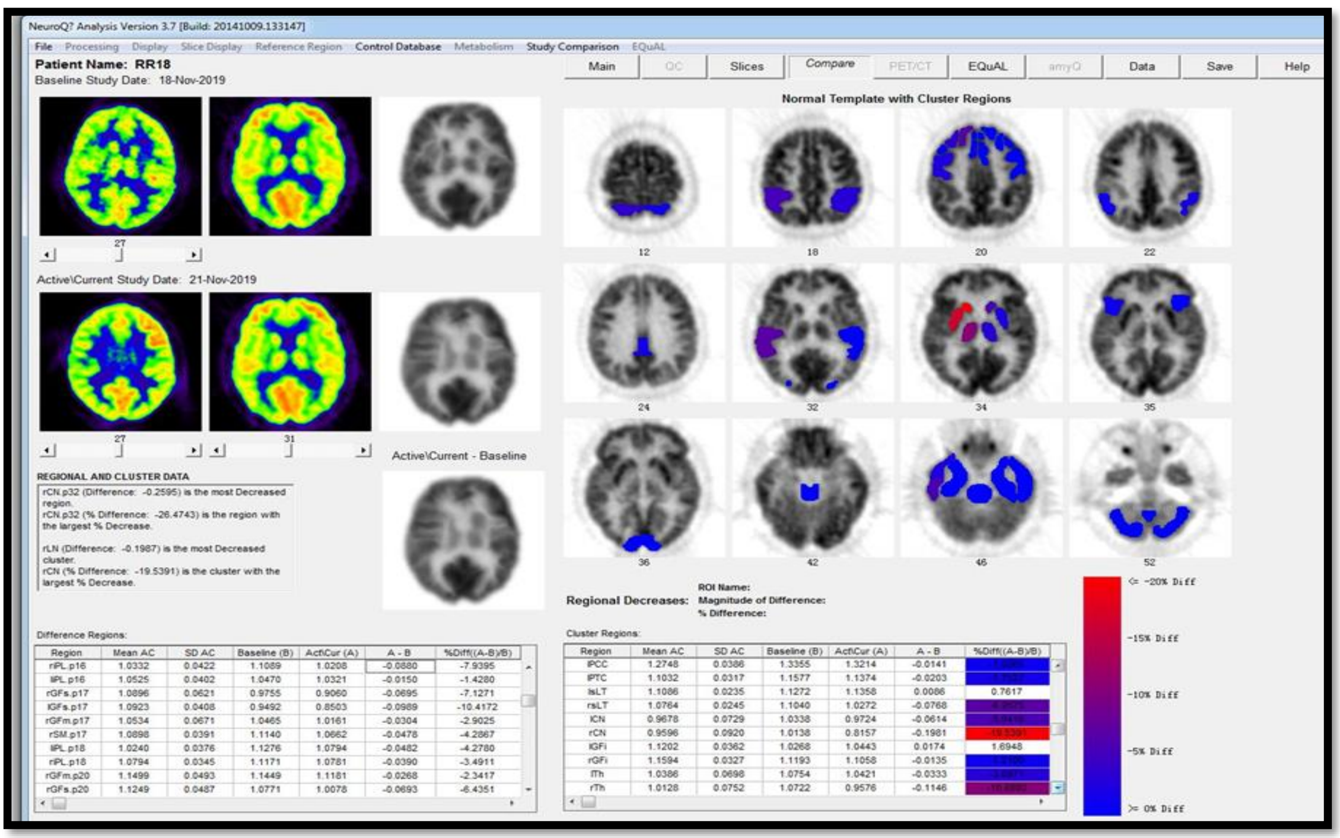


Figure 25: Areas of activation during monitoring and self-correction (RR 18).

SECTION C

5.2.1 Section C: PET brain imaging analysis

NeuroQ^{TM} software was used to analyse the cognitive activity of the respondents under PET baseline and activation imaging. NeuroQ^{TM} software analyses 47 regions of the brain (See table 3).

After running raw data into this specialised brain imaging analysis software (NeuroQ^{TM}), numerous results of automated analysis and quantification of relative brain activity in the above-mentioned regions are generated. An example of summarised brain region analysis in an individual respondent at baseline is displayed below.

Figure 26: RR 12 Baseline imaging showing brains regions 37 - 47. Summary of brain regions 1 - 36 in different result pages similar to the above is not displayed here.

All raw data were analysed both for baseline as described above and in post activation as described below.

Figure 27: RR 12 activation imaging showing brain regions 37 - 47. A summary of brain regions 1-36 in different result pages similar to the above is not displayed here.

In addition, the software allows for direct comparison of all automated data that are generated from baseline and activation analysis. Due to the myriad of data created in NeuroQ^{TM} for all 20 respondents for both baseline and activation imaging, only those areas showing the most significant metabolism are analysed and discussed.

An example of a comparison between baseline-and activation imaging is seen below for some brain regions.

Figure 28: RR 12 comparison imaging baseline and activation in few brain regions.

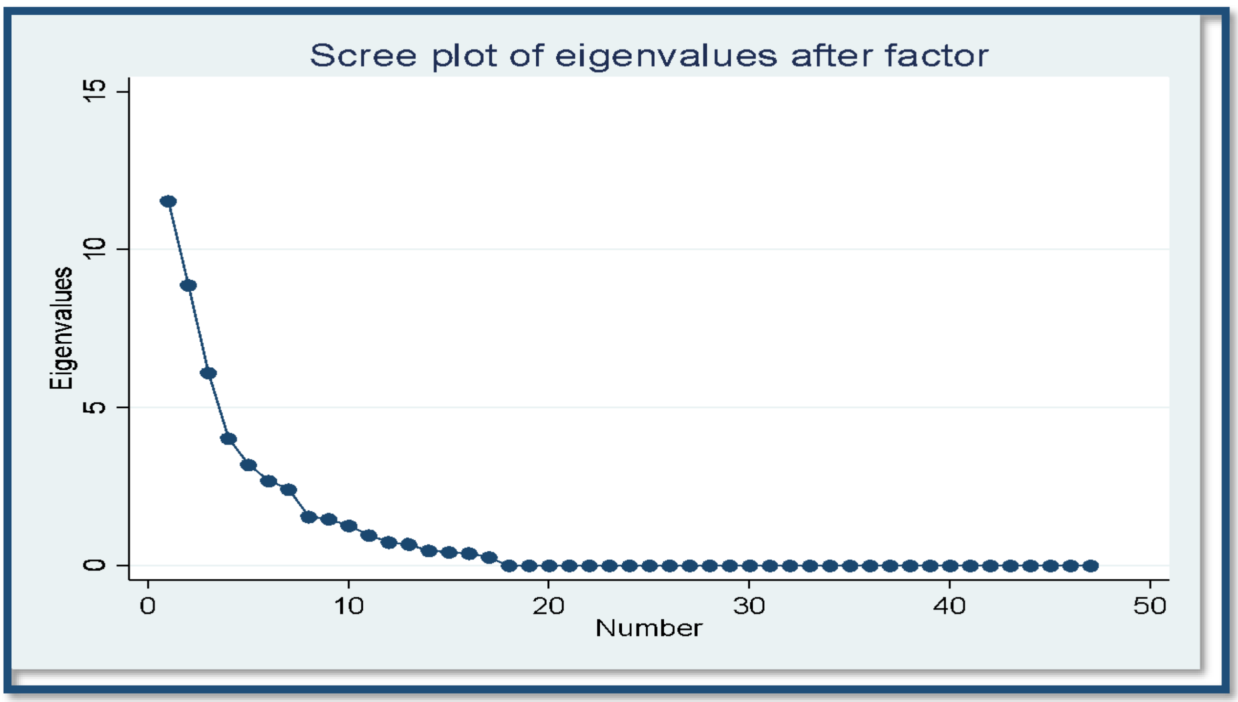
A summary of brain comparison of other regions is not displayed here.

Rattle (R) statistical software package was used for further analysis of the data generated from NeuroQ™. Due to the large number of data produced from the software in the different brain regions, the principal component analysis (PCA)[13] was first applied to summarise the content of

[13] Jolliffe and Cadima (2016) defines principal component analysis as "Principal component analysis is a technique for reducing the dimensionality of such datasets, increasing interpretability but at the same time minimizing information loss" (Jolliffe and Cadima, 2016: 1).

the large dataset and identify the most significant findings. PCA identified brain activation in 17 regions with the expected scree plot [14] shown below.

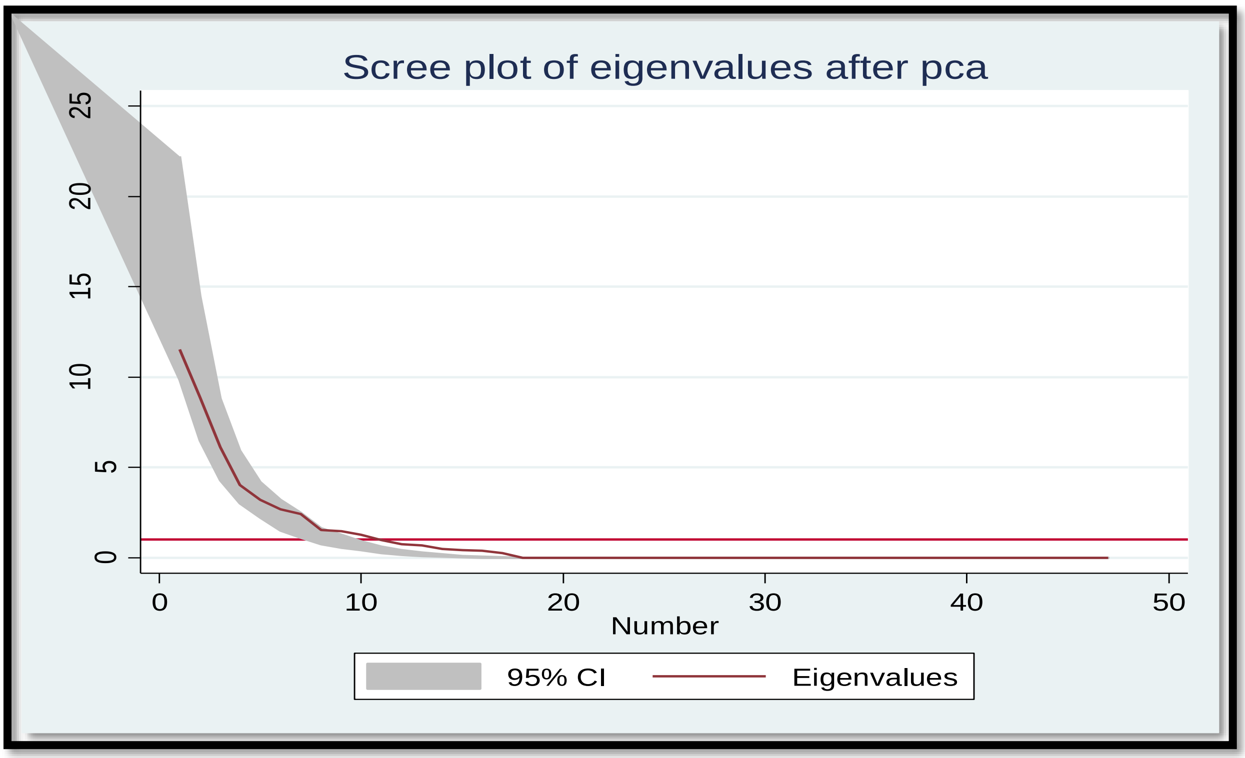
The scree plot was generated BY factor analysis of the principal components. While the PCA captures the essence of data in a few principal components that show the most variation in the entire dataset, the scree plot is used to check if PCA works well in given data. In this study, the ideal curve is obtained as seen in the scree plot. The number of principal components is provided in the X-axis and the amount of variation on the Y-axis. As noted already, 17 principal components show the most variation during brain activation.



Graph 1: Scree plot shows the eigenvalues after factor analysis from the 17 brain regions.

[14] A scree plot according to Irribarr (2018) is "A screenplot is a graphical tool used in the selection of the number of relevant components or factors to be considered in a principal components analysis or a factor analysis" (Irribarr, 2018:2).

The horizontal line in the scree plot after PCA (Graph 2) represents the cut-off of variation at value=1. Therefore, it separates the most representative components from the rest of the data. In this scree plot, the horizontal line separates the 17 components mentioned above (within the shaded part of the curve). In 10 above the value of 1 and 7 below the value of 1. In other words, of the 47 brain regions analysed, only 10 show the most variation that was seen during brain activation.



Graph 2: Scree plot of eigenvalues with 95% confidence interval.

Below are the most significant outcomes from the statistical analysis are discussed.

5.2.1.1 Baseline and Activation Comparisons

A paired T-test was performed to compare the baseline to activation studies. Each of the brain regions as seen in Table 3 were analysed on two occasions of imaging namely baseline and activation. The paired T-test was thus used for the comparison of the two images. After correction, the areas remained significant. The Benjamini-Hochberg correction was applied with the outcome in a new table. The changes are made in Table 18 that shows the brain regions names in full with more statistics.

Brain region	Mean (95% Confidence Interval)	P value
Right Primary Visual Cortex (rPVC)	0.44 (-0.041 to 0.97) 0.98 (0.541 to 1.409)	0.0308
Left Primary Visual Cortex (lPVC)	0.39 (0.007 to 0.755) 0.92 (0.479 to 1.368)	0.0140
Right inferior Lateral anterior Temporal Cortex (riLAT)	-0.380 (-0.359 to 0.283) -0.410 (-0.041 to -0.779)	0.0126
Left anterior Medial Temporal cortex (lMAT)	0.081 (-0.508 to 0.345) -0.512 (-0.944 to -0.080)	0.0009
Right inferior Lateral Posterior Temporal Cortex (riLPT)	-0.383 (-0.585 to -0.180) -0.760 (-1.106 to -0.414)	0.0211

Table 18: Brain regions with significant change from baseline to activation comparison.

After correction with the use of Benjamini-Hochberg for multiple comparison, all these regions still show significant difference from baseline to activation studies, except for one that just shows only a marginal significant difference in Table 19 below:

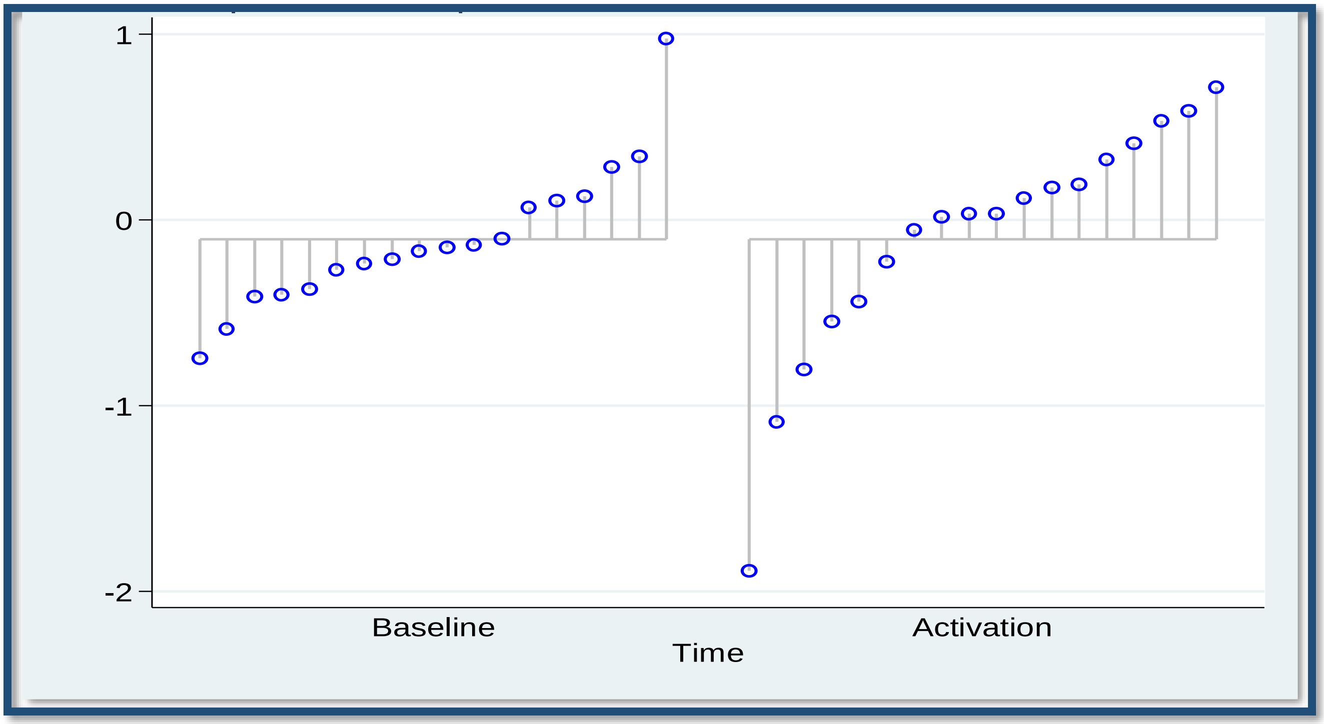
Brain region (after Benjamini-Hochberg correction)	P value
Right Primary Visual Cortex (rPVC)	0.0468
Left Primary Visual Cortex (lPVC)	0.0145
Right inferior Lateral Anterior Temporal Cortex (riLAT)	0.0395
Left anterior Medial Temporal cortex (lMAT)	0.0533*
Right inferior Lateral Posterior Temporal Cortex (riLPT)	0.0288

Table 19: Benjamini-Hochberg multiple comparison of brain regions.

**Marginal difference*

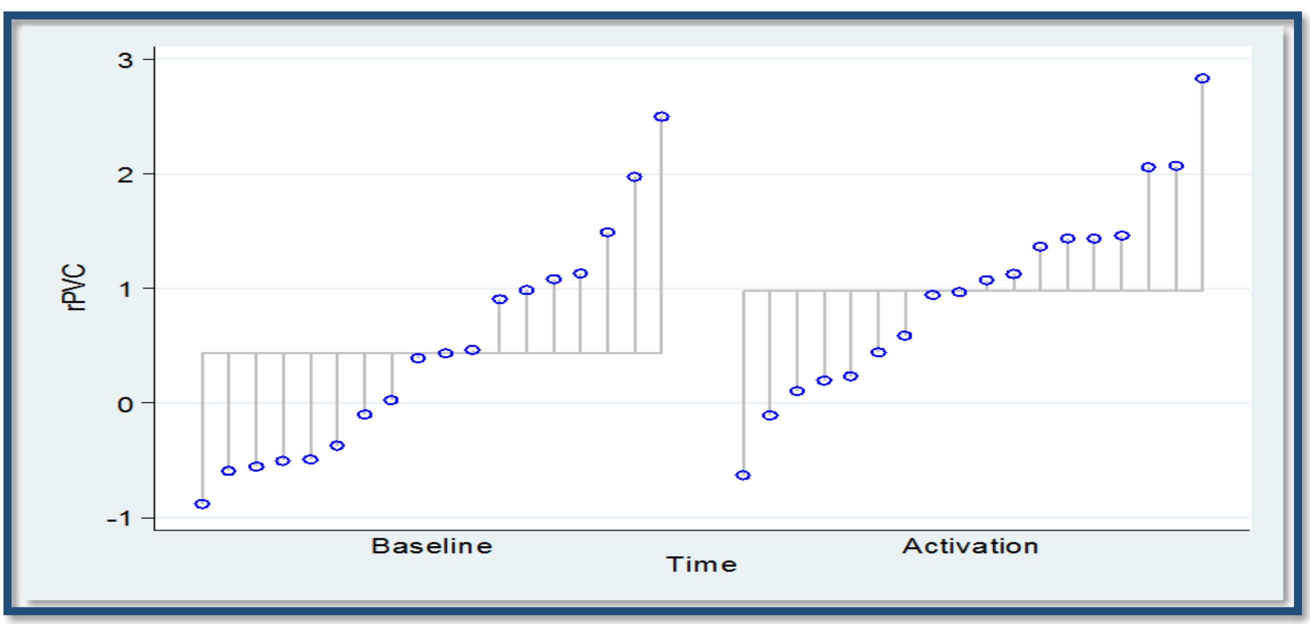
Considering the count measured in each brain region as a numerical value, the deviation plots were used to represent changes before and after activation. In the deviationplots, each graph represents a deviation of the count in the described brain region such as rGFs, from baseline (vertical spikes in the left of the graph) to activation (vertical spikes to the right of the graph) for the most significant regions. Since only a limited number of brain regions showed differences from baseline to activation, deviation plots for visual perception of the differences between the two events.

The plots show the measure of dispersion of the means of brain metabolism at baseline and during activation with their ranges. Each vertical spike with a small circle at the end represents the scale of deviation from 1 to 99 percentiles range, from means across participants at baseline and during activation. In Graph 15 below for example, at baseline, the mean and range =-0.106 (-0.745 to 0.974) and during activation, mean and range= -0.107 (-1.889 to 0.715) for the rGFs area.

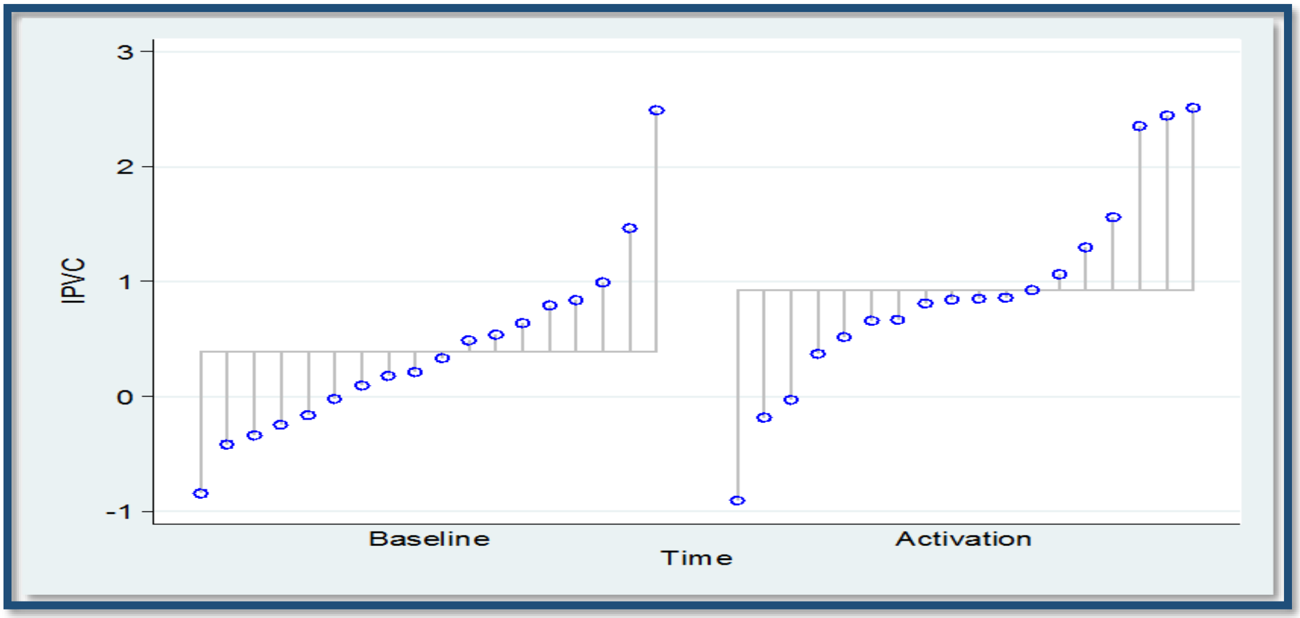


Graph 15: Baseline and activation comparison of rGFs.

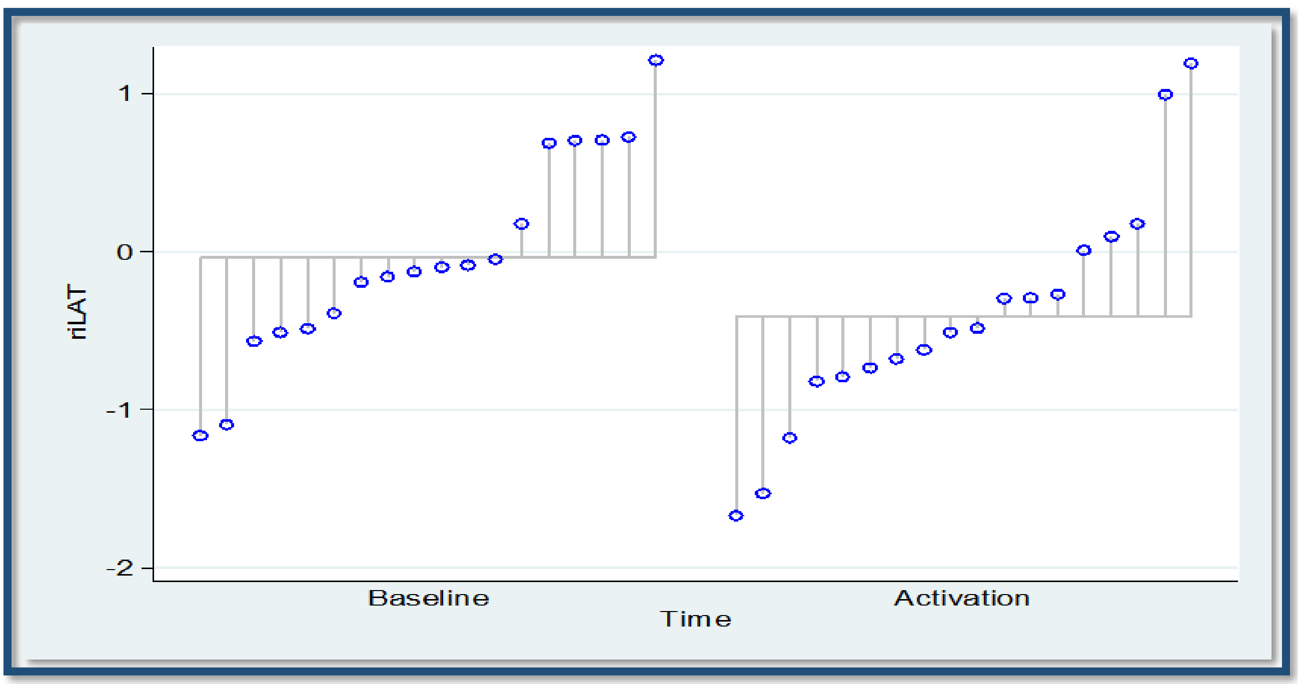
The deviation plots were generated for each brain region at baseline and during activation and can be found in Appendix L. Below are deviation plots for the most significant areas only:



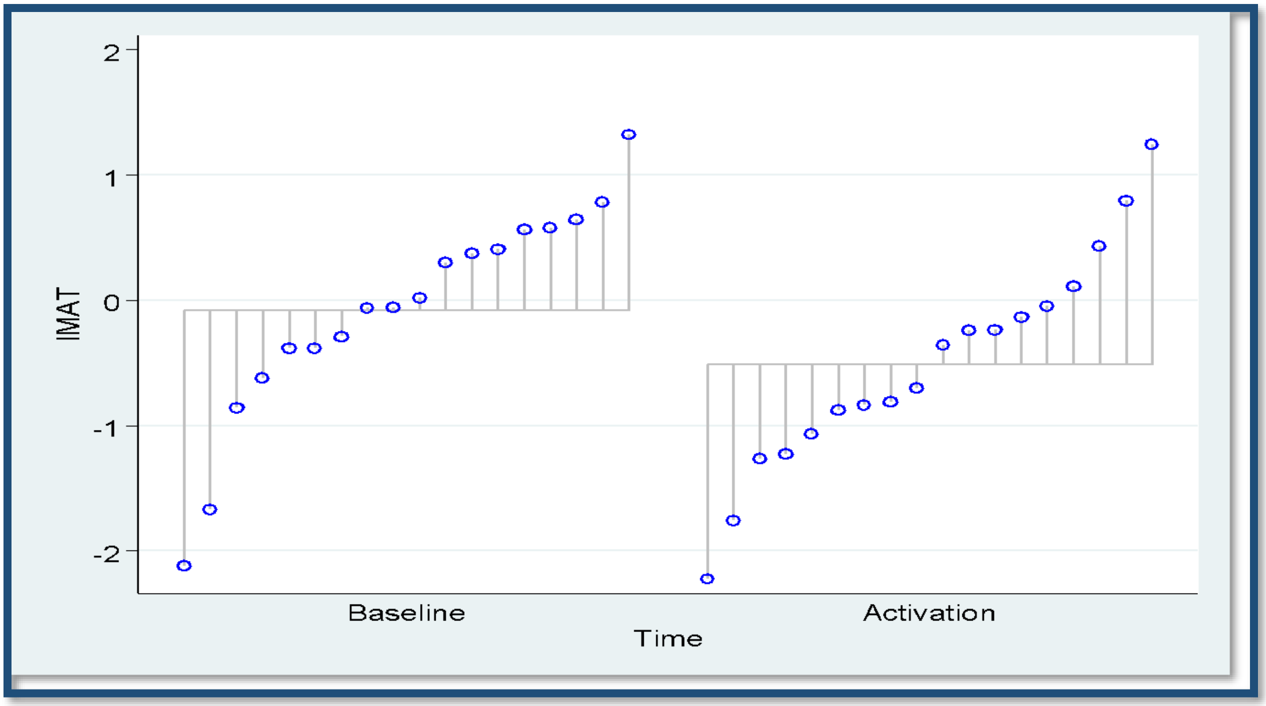
Graph 16: Baseline and activation comparison of rPVC.



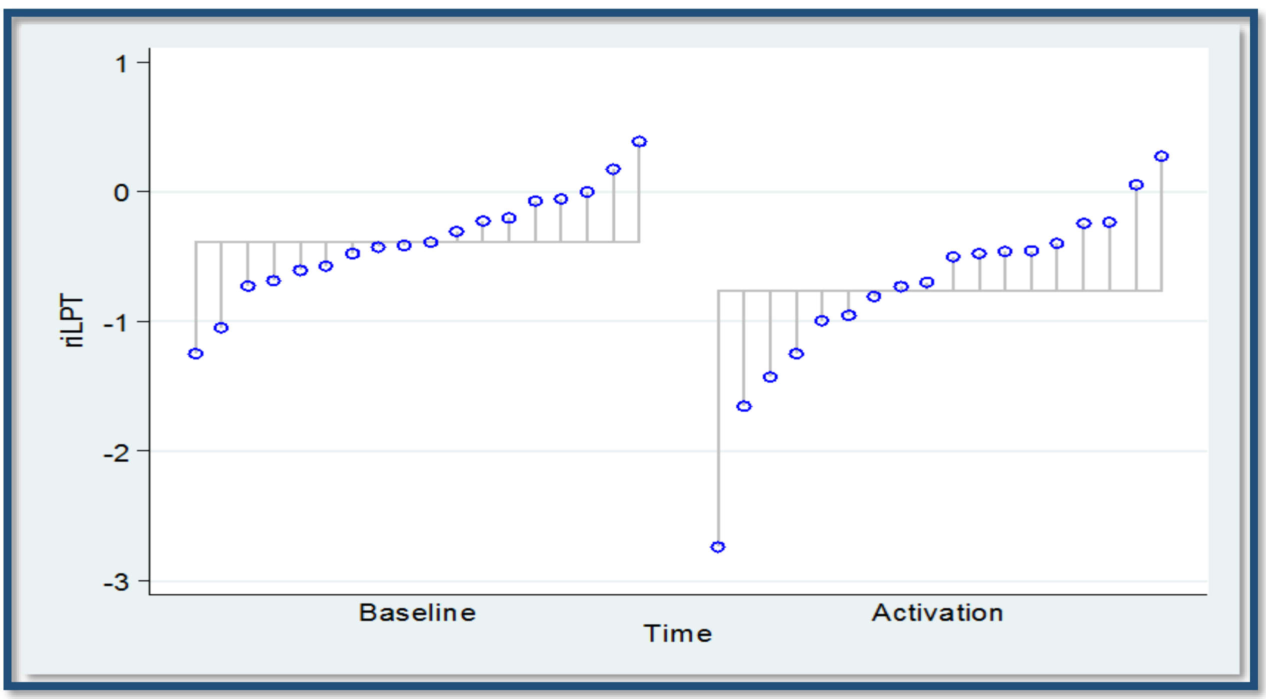
Graph 17: Baseline and activation comparison of lPVC.



Graph 18: Baseline and activation comparison of riLAT.



Graph 19: Baseline and activation comparison of lMAT.

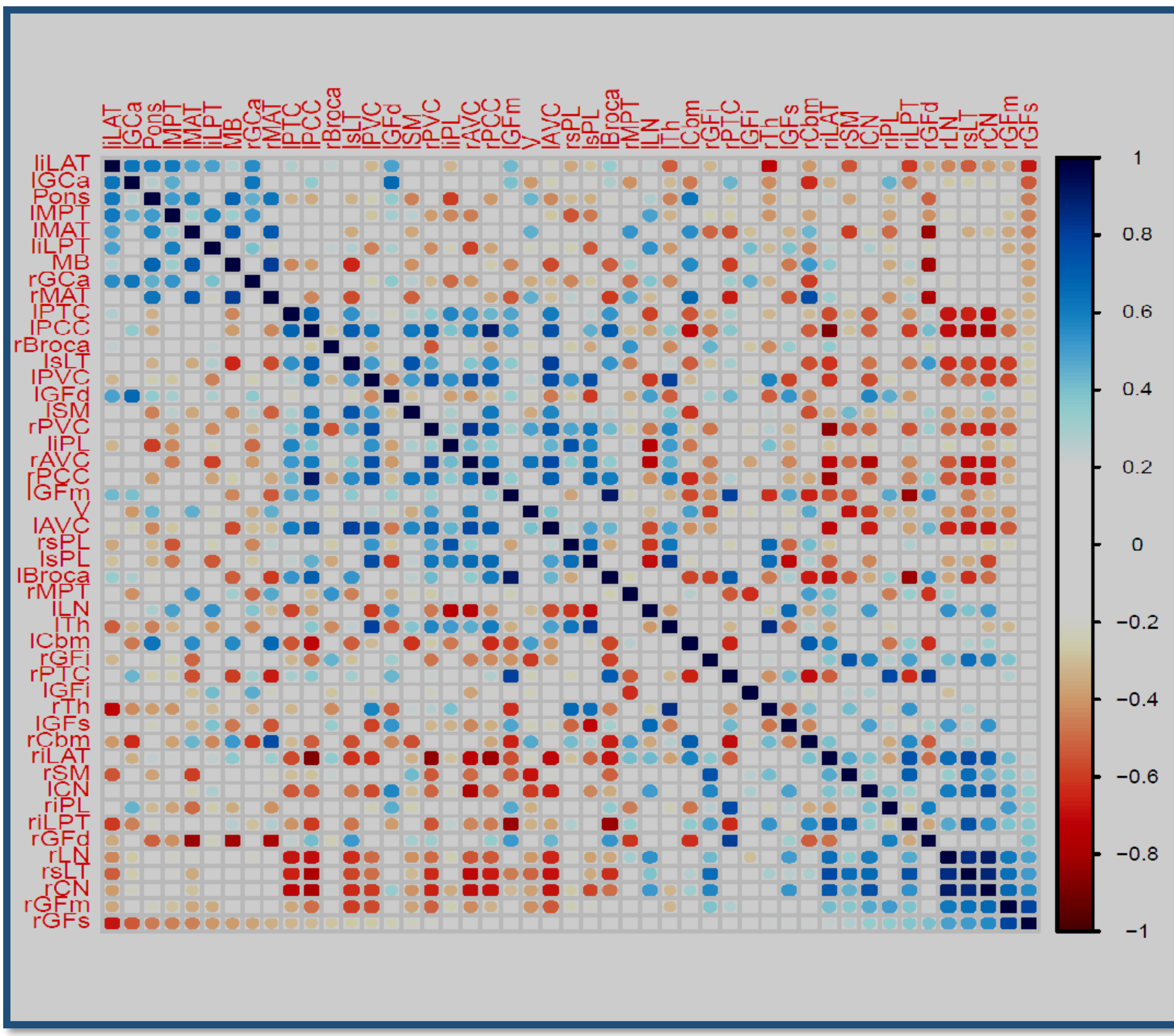


Graph 20: Baseline and activation comparison of riLPT.

5.2.1.2 Correlation of all brain regions post activation

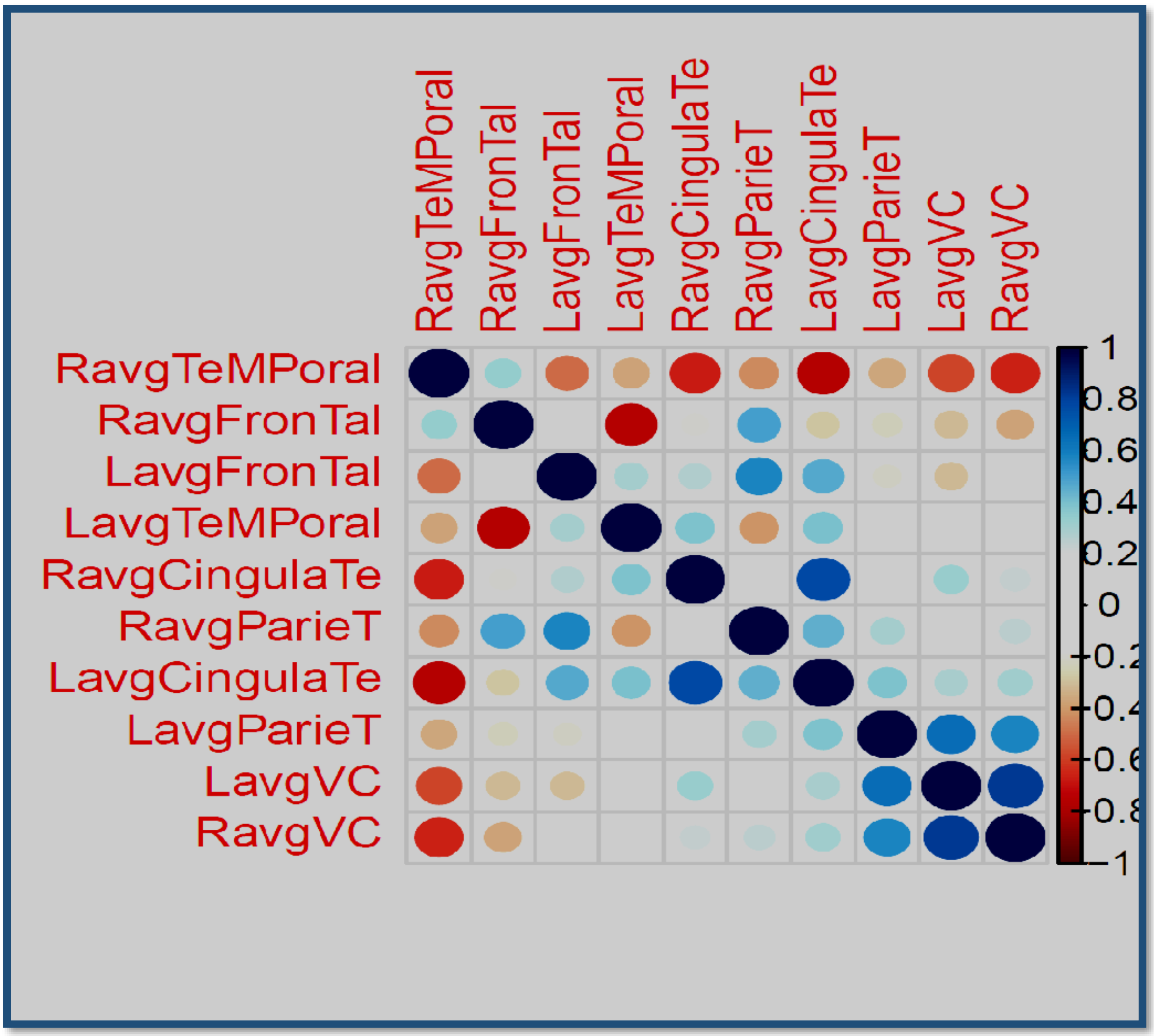
All brain regions were correlated with each other in post-activation using Pearson to get the R-value. A dendrogram of hierarchical clustering of the brain regions was generated to show the brain regions that are more closely linked. The specific brain regions that were more linked than others are reflected below. In addition, the significance of association between brain regions in activation brain imaging, was measured using Pearson correlation. Below are the generated correlation plots for all brain regions in Graph 21:

i) Overall brain activation



Graph 21: Correlation plots showing the association of brain regions during activation.

In this study, every time high metabolism occurred in a particular region, there was also high metabolism in another region. This means that there is a correlation between the two regions. Correlation in this regard does not mean causality it simply shows a relationship. Causation is the relationship between cause and effect (Rohrer, 2018). Brain cluster region activation is illustrated below in Graph 22:



Graph 22: Correlation plot showing the association of brain cluster regions during activation.

Although each brain region and each brain cluster region showed the expected very high correlation to itself (black dots), only a few clusters demonstrated meaningful correlation to one another. There was a reasonable correlation between the right parietal cluster and the right frontal cluster (r=0.51) and between the right parietal cluster and the left frontal cluster (r=0.56). The left parietal cluster showed a high correlation with the left visual cortex (r=0.65) whereas its correlation with the contralateral right visual cortex was reasonable (r=0.59).

5.2.1.3 Correlation of brain regions with biographical data (Section A – Questionnaire)

Data from the brain reflects the metabolism in each region. All generated brain analysis data in post-activation were correlated with biographical and professional data of the questionnaire (section A). The significance of the correlations are seen in the tables below:

a) Significant changes when correlated with Category 1- Language of thinking in native language were seen in:

b)

Brain Region	P-Value
left Parietotemporal Cortex (lPTC)	(p=0.0352)
right inferior lateral anterior Temporal Cortex (riLPT)	(p=0.0352)
left superior Parietal Cortex (rsPL)	(p=0.0193)

Table 20: Brain regions and p-values when thinking in native language.

The biographical data regarding language proficiency in native and other languages were independently reported at the time of recruitment and completing the questionnaire. As previously stated, the language proficiency is self-reported by the respondents and not formally tested with a language aptitude instrument. The task of interpreting from SASL into spoken language/s was administered to see which language the respondents interpret as reported that they think in their native language. As seen from the analysis in Section A, the language in which respondents said they think in (native language) is not the language in which they produced the interpretation (see Graph 8).

c) Significant changes when correlated with thinking in English were seen in:

Brain Region	P-Value
left Primary Visual Cortex (lPVC)	(p=0.0107)
right inferior lateral anterior Temporal Cortex (riLAT)	(p=0.0195)
left anterior Medial Temporal Cortex (lMAT)	(p=0.0010)

Table 21: Brain regions and p-values when thinking in native language.

This table presents regions of significant activation when respondents self-reported that they think in English.

d) Significant changes when correlated with qualifications for interpretation and no qualifications were seen in:

i) Qualifications

Brain Region	P-Value
left mid Frontal Cortex (lGFm)	(p=0.0156)
right superior lateral Temporal Cortex (rsLT)	(p=0.0313)

Table 22: Brain regions and p-values linked to interpreters with qualifications.

ii) No Qualifications

Brain Region	P-Value
right Primary Visual Cortex (rPVC)	(p=0.0143)
left Primary Visual Cortex (lPVC)	(p=0.0386)
left anterior Medial Temporal Cortex (lMAT)	(p=0.0063)
right inferior lateral anterior Temporal Cortex (riLPT)	(p=0.0386)

Table 23: Brain regions and p-values linked to interpreters without any interpreting qualifications.

The brain regions for trained versus untrained interpreters differ in that those with training have to use less cognitive areas thus less cognitive strain during the process of interpreting.

c). Significant changes when correlated with thenumber of years of experience in interpretation were seen in

i) More than five years experience

riLAT (p=0.0107)

ii) Less than five years experience

Brain Region	P-Value
right Primary Visual Cortex **(rPVC)**	p=0.0352
left Primary Visual Cortex **(lPVC)**	p=0.0359
left anterior Medial Temporal Cortex **(lMAT)**	p=0.0078
right anterior Medial Temporal Cortex (rMAT)	p=0.0352
right inferior lateral anterior Temporal Cortex **(riLPT)**	p=0.0352

Table 24: Brain regions and p-values linked to interpreters with less than five years of interpreting experience.

The evidence presented points to increased cognitive activity in more regions for respondents with less than five years of experience than in those with more than five years of experience. Interpreters with more experience have less cognitive strain when compared to those with less experience.

d). Significant changes when correlating understanding of cognitive processes during interpreting were seen in:

i) Understanding of cognition during interpreting
None.

ii) Not understanding of cognition during interpreting

Brain Region	P-Value
right Primary Visual Cortex (rPVC)	p=0.0287
left anterior Medial Temporal Cortex (lMAT)	p=0.0065
right inferior lateral anterior Temporal Cortex (riLPT)	p=0.0287

Table 25: Brain regions and p-values linked to interpreters' understanding of cognition during the interpreting process.

e).Significant changes were seen in English *versus* plurilingual respondents at baseline and activation imaging:

i) Plurilingual (SASL, English plus other spoken language/s)

Brain Region	P-Value
right inferior lateral anterior Temporal Cortex (riLAT)	p=0.0264
left anterior Medial Temporal Cortex (lMAT)	p=0.0073
right inferior lateral anterior Temporal Cortex (riLPT)	p=0.0202

Table 26: Brain regions and p-values linked to plurilingual interpreters with less than five years of interpreting experience.

ii) English only (bilingual SASL and English)
None

In this section of the PET brain study, functional brain activation analysis based on ^{18}F-FDG PET data was performed. Glucose is known to be fundamental for brain metabolism, and ^{18}F-FDG as explained in previous chapters, is an analogue of glucose. Its metabolism reflects local brain activity in a way that it can be used for analysis of functional brain connectivity (Watabe and Hatazawa, 2019). Passow et al. (2015) showed how close local metabolic activity of the brain was with its functional connectivity in a study that compared FDG-uptake and blood oxygen level-dependent (BOLD) signals. They concluded that ^{18}F-FDG- PET was a reliable tool for analysing functional connectivity in the brain. In a different study, Yu et al. (2018) reported on the usefulness of ^{18}F-FDG- PET brain imaging in predicting response to vagus nerve stimulation or activation brain study.

Most activation PET brain imaging studies are aimed at evaluating changes in glucose metabolism during tasks. Therefore, they usually require a separate imaging session for both rest and task activation conditions (Chiaravalloti et al., 2019). In clinical practice, the two brain PET imaging studies are performed 20-40 minutes after a bolus ^{18}F-FDG injection. The bolus method may provide a quantitative, qualitative or both, measurement of glucose metabolism after stimuli. PET studies use a bolus injection of ^{18}F-FDG for mapping the functional cortical metabolic responses to several different stimulations that may include visual, auditory, cognitive tasks, and even drug administration to assess brain activation (Chiaravalloti et al., 2019). In this study, a two-day protocol for ease of feasibility and confidence in comparing them was used. As described in the methodology section of the study, on the first day, ^{18}F-FDG PET brain imaging was performed to assess resting brain metabolism (baseline) and, on the second day (almost a week a part), imaging was acquired during completion of a task described in previous chapters to stimulate the brain (activation).

It is generally advised that the activation PET imaging studies be analysed quantitatively over a qualitative visual analysis of images (Chiaravalloti et al., 2019). In this study, a well-known software programme, NeuroQ™, was used to analyse the potential changes in brain metabolism.

Numerous studies have used ^{18}F-FDG-PET imaging to evaluate glucose metabolic changes to respond to stimuli of different types. Most relevant studies on PET imaging with FDG in different types of tasks are available in Chiaravalloti et al. (2019). There are studies looking at task-related procedures, such as word repetition and word association, during lexical decision or after learning a complex visuospatial/motor task that also used FDG-PET (Nenov et al., 1994; Schreckenberger et al., 1998). In word association studies, FDG increased metabolism was noted in the left prefrontal cortex, the left frontal operculum (Broca's area), and the left insula, indicating the involvement of these areas in associative language processing. However, in the course of word repetition, highly significant negative correlations were noted between the left prefrontal cortex, the contralateral cortex areas and the ipsilateral posterior cingulum (Schreckenberger et al., 1998).

In the current study, significant changes were noted in the following areas when comparing baseline (resting brain PET imaging) to activation studies:

1. Both primary visual cortex (p=0.0308)

2. Left anterior medial temporal cortex (p=0.0009)

3. Right inferior lateral anterior temporal cortex (p=0.0126)

4. Right inferior lateral posterior temporal cortex (p=0.0211).

Activation in both the rPVC and lPVC points to the primary cortical region of the brain, visual area 1 (V1), Brodmann area 17, or the striate cortex. The visual cortex is the first cortical area of the visual system that receives external information visually. Neurons with receptive properties in the primary visual cortex respond by receiving, integrating, and processing information in the visual scene. This finding agrees with Hubel (1995), who suggested that the right frontal areas of the brain are activated during sign language comprehension (Corina and Knapp, 2006 and Jeannerod, 2006). The activation ties in with the motor-cognition theoretical framework that says cognition is constructed from action and perception informed by sensory and motor brain mechanisms (Pulvermüller et al., 2014). The activation of the parietal cortices is by mirror neurons to integrate visual information that gives way to the action, which in this study is the interpreting function (Rizzolatti and Sinigaglia, 2010). This finding corroborates Yeung and Werker (2013) that action-perception links for manual, mouth actions and visual and acoustic perceptions confirm linguistic-articulatory action schemas. The linguistic-articulatory schema is this seen in interpreter respondents in this study by the reception of the SASL visual text, which is processed cognitively giving effect to activation of the mouth and acoustic perceptions to produce the interpreting product in the target language(s) and monitoring the acoustic feedback of the interpretation.

Activation of the riLAT, lMAT and riLPT is associated with processing auditory information and encoding memory. The medial temporal lobe consists of the amygdala and hippocampus entorhinal, perirhinal, and parahippocampal cortices (Strange and Dolan, 2006). Based on detailed studies of cortical connectivity, the neocortex processes information from all sensory modalities. Processing of information to the multimodal association cognitive areas becomes more elaborate or complex, as seen in the output of the interpreting product, whereby the interpreter respondents produce semantically intelligible interpretations in all languages in their linguistic repertoire.

The interpreter respondents in this study had to activate an interpreting process called monitoring, which means listening to their output. This process implies that the interpreter had to simultaneously 'listen' to the source text (visual input, seeing the SASL text), and listen to the interpreting output, the target text. All of the 20 interpreter respondents scored their SASL skill at the higher end of the Likert scale, 3-5. This rating represents language proficiency in SASL rated as good [3], very good [4] and excellent [5]. Self-reported language proficiency borders on the higher scales, between 3 and 5, indicating that the respondents believe their language proficiency across their linguistic repertoire ranges from good to excellent. This confirms that SASL is established in the respondents' linguistic profile and thus part of their long-term memory linked to language learning.

Given the conditions of the experiment, this study utilised a Siemens MRI machine with noise levels affecting the signal-to-noise ratio (SNR). Despite the SNR affected by the noise of the Siemens machine and the air conditioning system, the respondents could process lexical and syntactic input from the source text. The results from this study provide evidence in support of noisy-channel models of sentence comprehension. Turning to the findings of sentence processing in noisy environments, Gibson et al. (2013) confirm that language processing mechanics in cognitive systems are aptly designed to recover intended meaning from noisy utterances. Activation of the riLAT and lMAT regions are implicated in processing semantic information and confirms the findings of Binder et al. (1997); Lambon Ralph and Patterson (2008); Visser, Jefferies and Ralph, (2009); Chen et al. (2017), Binney et al. (2010) and Mion et al. (2010).

These findings of the five most significant cognitive areas activated in this study indicate the role of the primary visual cortex in the perception of sight and processing visual inputs. The findings support the Action Perception Circuit (APC) as part of the motor cognition theory in that lexical and semantic processing is critical to rendering a linguistically socio-culturally fitting interpretation. Furthermore, the activation of the five areas is supported by the Action Control Theory (ACT) linked to cognitive, perceptual and brain sciences. The theory states: "…speech comprehension and production are governed by control processes" (Green and Abutalebi, 2013:515), which this study confirmed by analysing the cognitive areas activated, while interpreting language from source to target text. The hypothesis confirmed in the ACT presents different interactional contexts of bilingual conversational exchanges and the demand placed on language control, which adaptively alter cognitive-control capacities. The interpreter respondents in this study present incidences of translanguaging pointing to adaptive control mechanisms in that the cognitive areas activated are implicated in language processing and the interpreting product is altered for the communication situation.

Several PET imaging studies have been performed on healthy subjects during tasks to assess brain metabolic response to several kinds of stimuli in physiological conditions. In activation PET imaging done to evaluate task-related changes in the visual cortex, increased glucose metabolism was noted during a visual task in the human primary and associative visual cortex, as one increased the complexity of visual scenes (Chiaravalloti et al., 2019). Therefore, stimulation of the primary visual cortex in the current study agrees with the published literature. Changes noted in temporal areas indicate the role of this brain region in language perception and processing. The significant change noted in the left anterior medial temporal cortex may be explained by the hypothesis that this specific area of the brain is associated with the processing of new information (Kagan, 2005). This finding is supported, as participants were watching the source text SASL video for the first time as part of the study. Thus, an element of learning new information was involved. If this finding can be reproduced in studies with a larger number of participants or a well-designed multicenter study, it may become an interesting starting point to explore improving cognition of individuals with difficulty in processing and learning new information such as those with Alzheimer's dementia. For interpreter training, the finding points to improving cognition in applying of translanguaging strategies as part of the usefulness of the holistic linguistic repertoire of a plurilingual interpreter to produce a linguistically and culturally relevant interpretation from source to target text. Consequently, studies that may focus on better understanding of this cerebral area have the potential to offer a breakthrough niche for clinically relevant brain research. Cross-disciplinary collaboration between language practice studies and neuroscience could provide insight into the cognitive processing of languages simultaneously.

Changes in the right inferior lateral anterior and posterior temporal regions, both being in the non-dominant cerebral hemisphere, may indicate the role of these regions in the process of learning and remembering non-verbal information (Queens' University, 2017). In this study, it points to SASL probably being perceived in a similar way as art, such as drawing or conducting music. These findings in my research concur with an early day brain functional study by Schreckenberger et al. (1998) that used activation PET imaging in healthy subjects with word repetition compared with the word cognitive association to assess hyperactivated cortical areas associated with an intracerebral functional network of language and cognitive processes. Both studies demonstrate the role of the temporal brain regions involved in language processing.

The figures 29 A and B illustrate images before and after with differences and the compared set with an explanation.

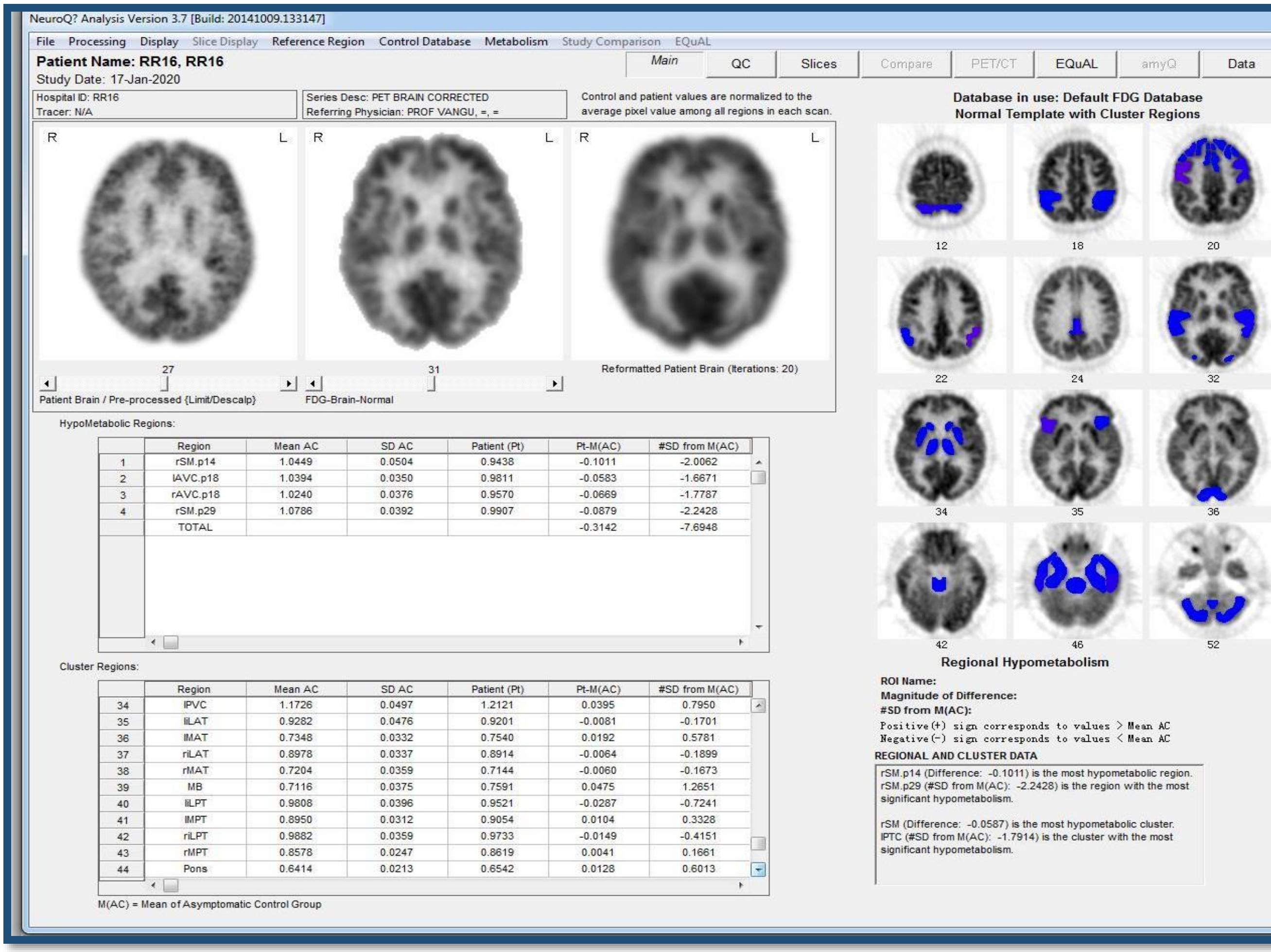

NeuroQ? Analysis Version 3.7 [Build: 20141009.133147]
File Processing Display Slice Display Reference Region Control Database Metabolism Study Comparison EQuAL
Patient Name: RR16, RR16
Study Date: 17-Jan-2020
Main QC Slices Compare PET/CT EQuAL amyQ Data
Hospital ID: RR16
Tracer: N/A
Series Desc: PET BRAIN CORRECTED
Referring Physician: PROF VANGU, =, =
Control and patient values are normalized to the average pixel value among all regions in each scan.
Database in use: Default FDG Database
Normal Template with Cluster Regions
Patient Brain / Pre-processed {Limit/Descalp}
FDG-Brain-Normal
Reformatted Patient Brain (Iterations: 20)
HypoMetabolic Regions:
Region Mean AC SD AC Patient (Pt) Pt-M(AC) #SD from M(AC)
1 rSM.p14 1.0449 0.0504 0.9438 -0.1011 -2.0062
2 lAVC.p18 1.0394 0.0350 0.9811 -0.0583 -1.6671
3 rAVC.p18 1.0240 0.0376 0.9570 -0.0669 -1.7787
4 rSM.p29 1.0786 0.0392 0.9907 -0.0879 -2.2428
TOTAL -0.3142 -7.6948
Cluster Regions:
Region Mean AC SD AC Patient (Pt) Pt-M(AC) #SD from M(AC)
34 lPVC 1.1726 0.0497 1.2121 0.0395 0.7950
35 lLAT 0.9282 0.0476 0.9201 -0.0081 -0.1701
36 lMAT 0.7348 0.0332 0.7540 0.0192 0.5781
37 rLAT 0.8978 0.0337 0.8914 -0.0064 -0.1899
38 rMAT 0.7204 0.0359 0.7144 -0.0060 -0.1673
39 MB 0.7116 0.0375 0.7591 0.0475 1.2651
40 lLPT 0.9808 0.0396 0.9521 -0.0287 -0.7241
41 lMPT 0.8950 0.0312 0.9054 0.0104 0.3328
42 rLPT 0.9882 0.0359 0.9733 -0.0149 -0.4151
43 rMPT 0.8578 0.0247 0.8619 0.0041 0.1661
44 Pons 0.6414 0.0213 0.6542 0.0128 0.6013
M(AC) = Mean of Asymptomatic Control Group
Regional Hypometabolism
ROI Name:
Magnitude of Difference:
#SD from M(AC):
Positive(+) sign corresponds to values > Mean AC
Negative(-) sign corresponds to values < Mean AC
REGIONAL AND CLUSTER DATA
rSM.p14 (Difference: -0.1011) is the most hypometabolic region.
rSM.p29 (#SD from M(AC): -2.2428) is the region with the most significant hypometabolism.
rSM (Difference: -0.0587) is the most hypometabolic cluster.
lPTC (#SD from M(AC): -1.7914) is the cluster with the most significant hypometabolism.

Figure 29: A

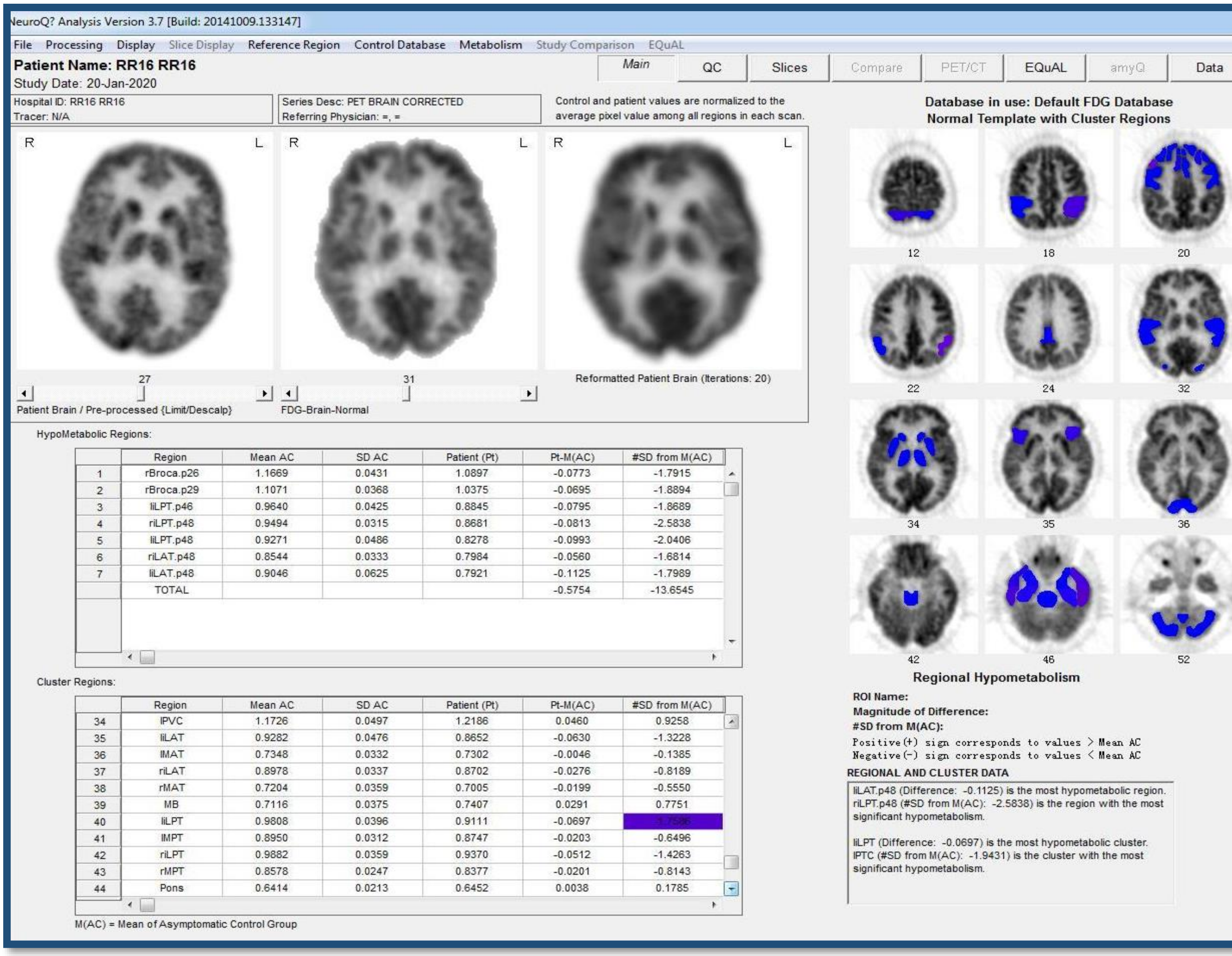

NeuroQ? Analysis Version 3.7 [Build: 20141009.133147]
File Processing Display Slice Display Reference Region Control Database Metabolism Study Comparison EQuAL
Patient Name: RR16 RR16
Study Date: 20-Jan-2020
Main QC Slices Compare PET/CT EQuAL amyQ Data
Hospital ID: RR16 RR16
Tracer: N/A
Series Desc: PET BRAIN CORRECTED
Referring Physician: =, =
Control and patient values are normalized to the average pixel value among all regions in each scan.
Database in use: Default FDG Database
Normal Template with Cluster Regions
R L R L R L
27
31
Reformatted Patient Brain (Iterations: 20)
Patient Brain / Pre-processed {Limit/Descalp}
FDG-Brain-Normal
12 18 20 22 24 32 34 35 36 42 46 52
HypoMetabolic Regions:
Region Mean AC SD AC Patient (Pt) Pt-M(AC) #SD from M(AC)
1 rBroca.p26 1.1669 0.0431 1.0897 -0.0773 -1.7915
2 rBroca.p29 1.1071 0.0368 1.0375 -0.0695 -1.8894
3 liLPT.p46 0.9640 0.0425 0.8845 -0.0795 -1.8689
4 riLPT.p48 0.9494 0.0315 0.8681 -0.0813 -2.5838
5 lLPT.p48 0.9271 0.0486 0.8278 -0.0993 -2.0406
6 riLAT.p48 0.8544 0.0333 0.7984 -0.0560 -1.6814
7 liLAT.p48 0.9046 0.0625 0.7921 -0.1125 -1.7989
TOTAL -0.5754 -13.6545
Cluster Regions:
Region Mean AC SD AC Patient (Pt) Pt-M(AC) #SD from M(AC)
34 lPVC 1.1726 0.0497 1.2186 0.0460 0.9258
35 liLAT 0.9282 0.0476 0.8652 -0.0630 -1.3228
36 lMAT 0.7348 0.0332 0.7302 -0.0046 -0.1385
37 riLAT 0.8978 0.0337 0.8702 -0.0276 -0.8189
38 rMAT 0.7204 0.0359 0.7005 -0.0199 -0.5550
39 MB 0.7116 0.0375 0.7407 0.0291 0.7751
40 liLPT 0.9808 0.0396 0.9111 -0.0697
41 lMPT 0.8950 0.0312 0.8747 -0.0203 -0.6496
42 riLPT 0.9882 0.0359 0.9370 -0.0512 -1.4263
43 rMPT 0.8578 0.0247 0.8377 -0.0201 -0.8143
44 Pons 0.6414 0.0213 0.6452 0.0038 0.1785
M(AC) = Mean of Asymptomatic Control Group
Regional Hypometabolism
ROI Name:
Magnitude of Difference:
#SD from M(AC):
Positive(+) sign corresponds to values > Mean AC
Negative(-) sign corresponds to values < Mean AC
REGIONAL AND CLUSTER DATA
liLAT.p48 (Difference: -0.1125) is the most hypometabolic region.
riLPT.p48 (#SD from M(AC): -2.5838) is the region with the most significant hypometabolism.
liLPT (Difference: -0.0697) is the most hypometabolic cluster.
lPTC (#SD from M(AC): -1.9431) is the cluster with the most significant hypometabolism.

Figure 29: B

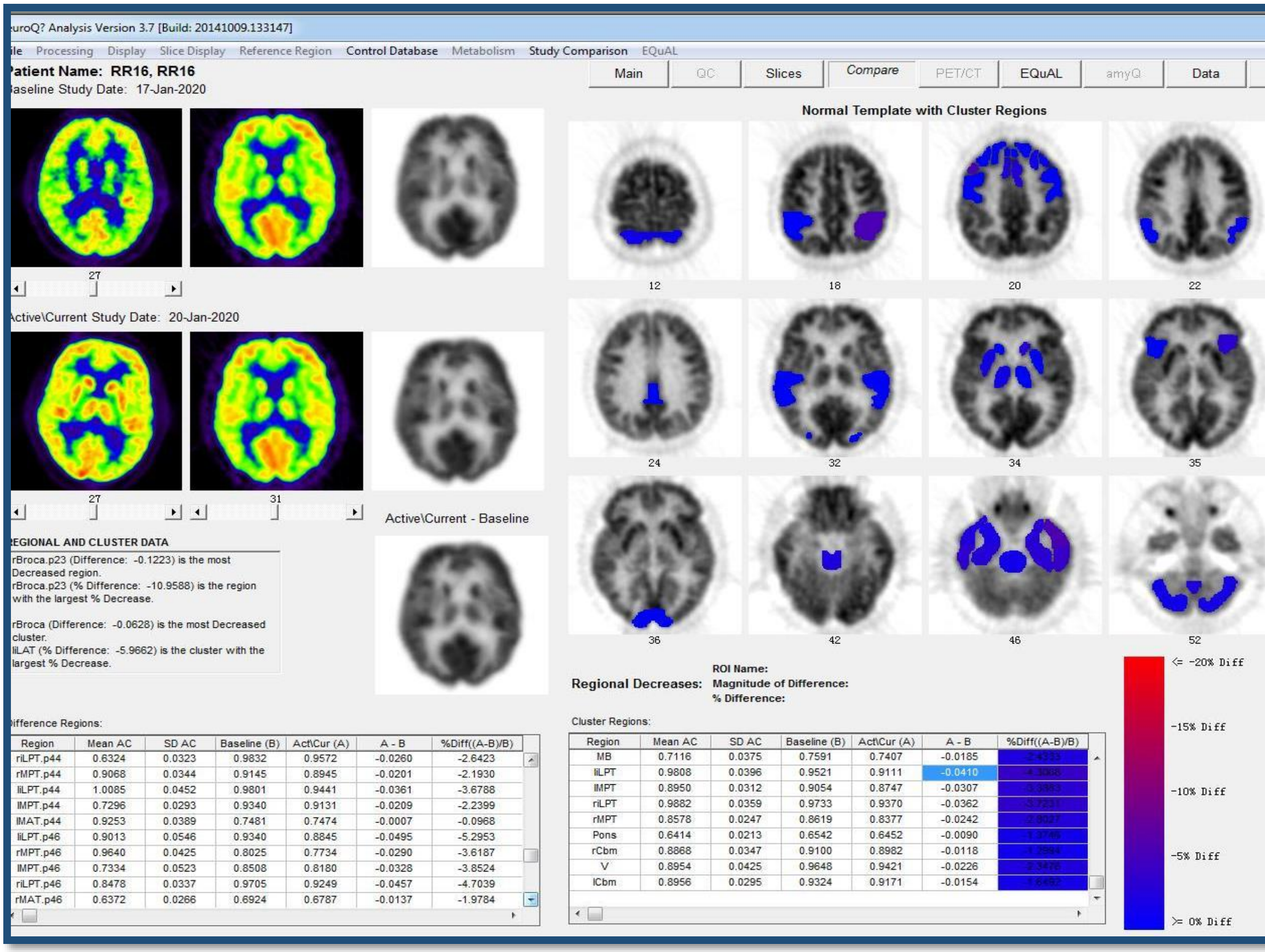

uroQ? Analysis Version 3.7 [Build: 20141009.133147]
ile Processing Display Slice Display Reference Region Control Database Metabolism Study Comparison EQuAL
Patient Name: RR16, RR16
aseline Study Date: 17-Jan-2020
Main QC Slices Compare PET/CT EQuAL amyQ Data
Normal Template with Cluster Regions
12 18 20 22
24 32 34 35
36 42 46 52
Active\Current Study Date: 20-Jan-2020
Active\Current - Baseline
EGIONAL AND CLUSTER DATA
rBroca.p23 (Difference: -0.1223) is the most Decreased region.
rBroca.p23 (% Difference: -10.9588) is the region with the largest % Decrease.
rBroca (Difference: -0.0628) is the most Decreased cluster.
liLAT (% Difference: -5.9662) is the cluster with the largest % Decrease.
Regional Decreases: ROI Name: Magnitude of Difference: % Difference:
ifference Regions:
Region Mean AC SD AC Baseline (B) Act\Cur (A) A - B %Diff((A-B)/B)
riLPT.p44 0.6324 0.0323 0.9832 0.9572 -0.0260 -2.6423
rMPT.p44 0.9068 0.0344 0.9145 0.8945 -0.0201 -2.1930
liLPT.p44 1.0085 0.0452 0.9801 0.9441 -0.0361 -3.6788
lMPT.p44 0.7296 0.0293 0.9340 0.9131 -0.0209 -2.2399
lMAT.p44 0.9253 0.0389 0.7481 0.7474 -0.0007 -0.0968
liLPT.p46 0.9013 0.0546 0.9340 0.8845 -0.0495 -5.2953
rMPT.p46 0.9640 0.0425 0.8025 0.7734 -0.0290 -3.6187
lMPT.p46 0.7334 0.0523 0.8508 0.8180 -0.0328 -3.8524
riLPT.p46 0.8478 0.0337 0.9705 0.9249 -0.0457 -4.7039
rMAT.p46 0.6372 0.0266 0.6924 0.6787 -0.0137 -1.9784
Cluster Regions:
Region Mean AC SD AC Baseline (B) Act\Cur (A) A - B %Diff((A-B)/B)
MB 0.7116 0.0375 0.7591 0.7407 -0.0185
liLPT 0.9808 0.0396 0.9521 0.9111 -0.0410
lMPT 0.8950 0.0312 0.9054 0.8747 -0.0307
riLPT 0.9882 0.0359 0.9733 0.9370 -0.0362
rMPT 0.8578 0.0247 0.8619 0.8377 -0.0242
Pons 0.6414 0.0213 0.6542 0.6452 -0.0090
rCbm 0.8868 0.0347 0.9100 0.8982 -0.0118
V 0.8954 0.0425 0.9648 0.9421 -0.0226
lCbm 0.8956 0.0295 0.9324 0.9171 -0.0154
<= -20% Diff
-15% Diff
-10% Diff
-5% Diff
>= 0% Diff

Figure 29: C

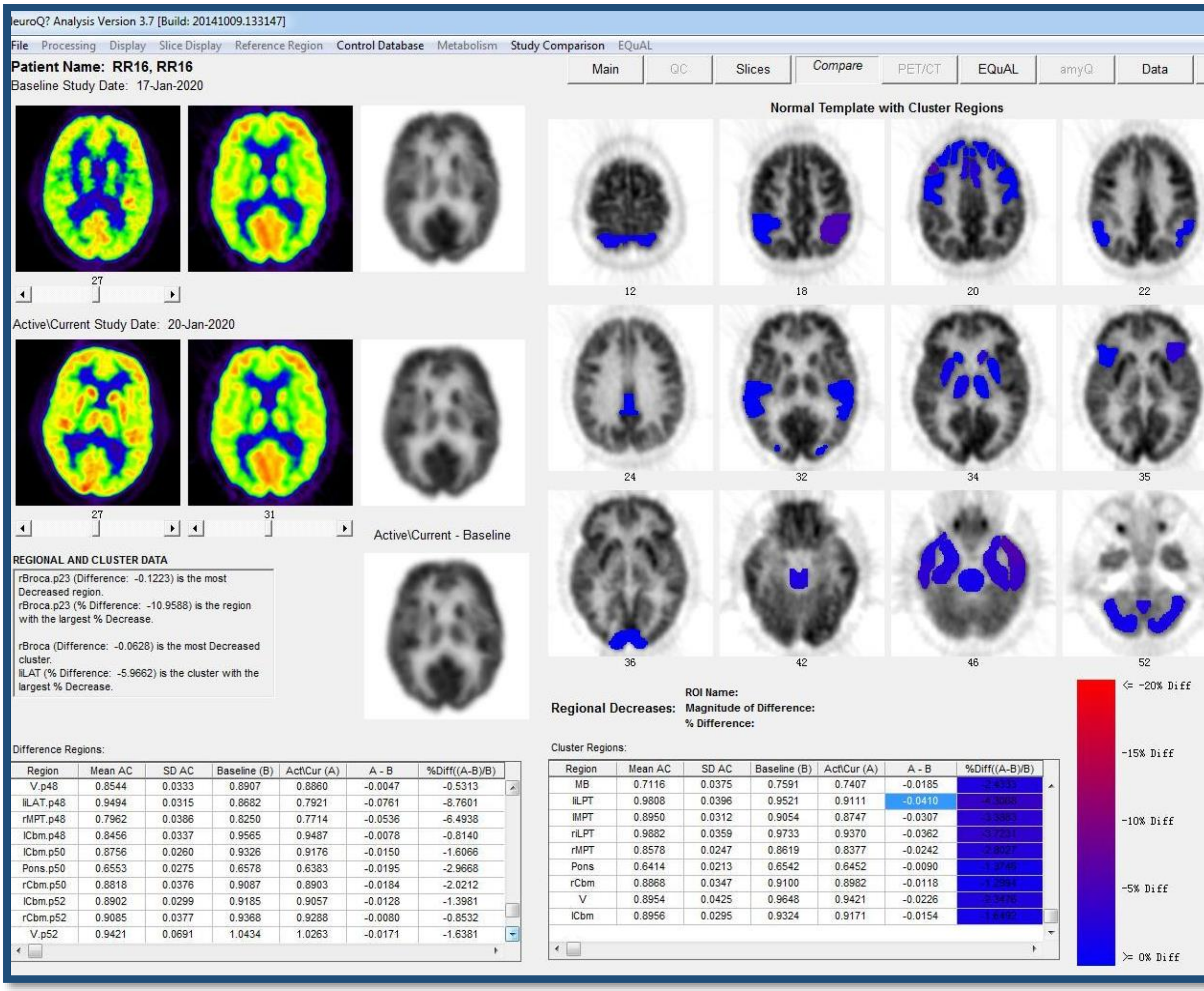


Figure 29 – D

Figure 29 A shows the typical summarised data from a baseline study in participant RR16. The NeuroQ^{TM} looks at brain metabolism region by region based on the analysis of 240 separate brain regions and cluster analysis of 47 volume brain regions. There is a color scale, where blue is considered normal and hypometabolism is defined on changes of the color from blue to red, red representing 30% below the normal mean or 1.65 standard deviation of the cutoff between normal and abnormal metabolism, based on the validation of the NeuroQ^{TM} application. In Figure 30, the 47 cluster regions are displayed in 12 superimposed brain slices (in the right of this figure). The shaded colour from purple to red represents a decrease in metabolism and hypermetabolism is represented by blue as the starting point of normal. The table in the left of the cluster regions in the figure shows the uptake count in each cluster. When the count is not highlighted, it is normal. If abnormal, then the count is highlighted such as in Figure 29 B, where cluster number 40 representing the left inferior lateral posterior temporal cortex shows a decrease in metabolism during activation. In Figure 29 C and Figure 29 D, when a comparison of baseline and activation studies is made by NeuroQ^{TM}, all the differences in metabolism (brain count) are highlighted in the last column of displayed counts within the cluster regions (bottom right of Figures 29 C and D).

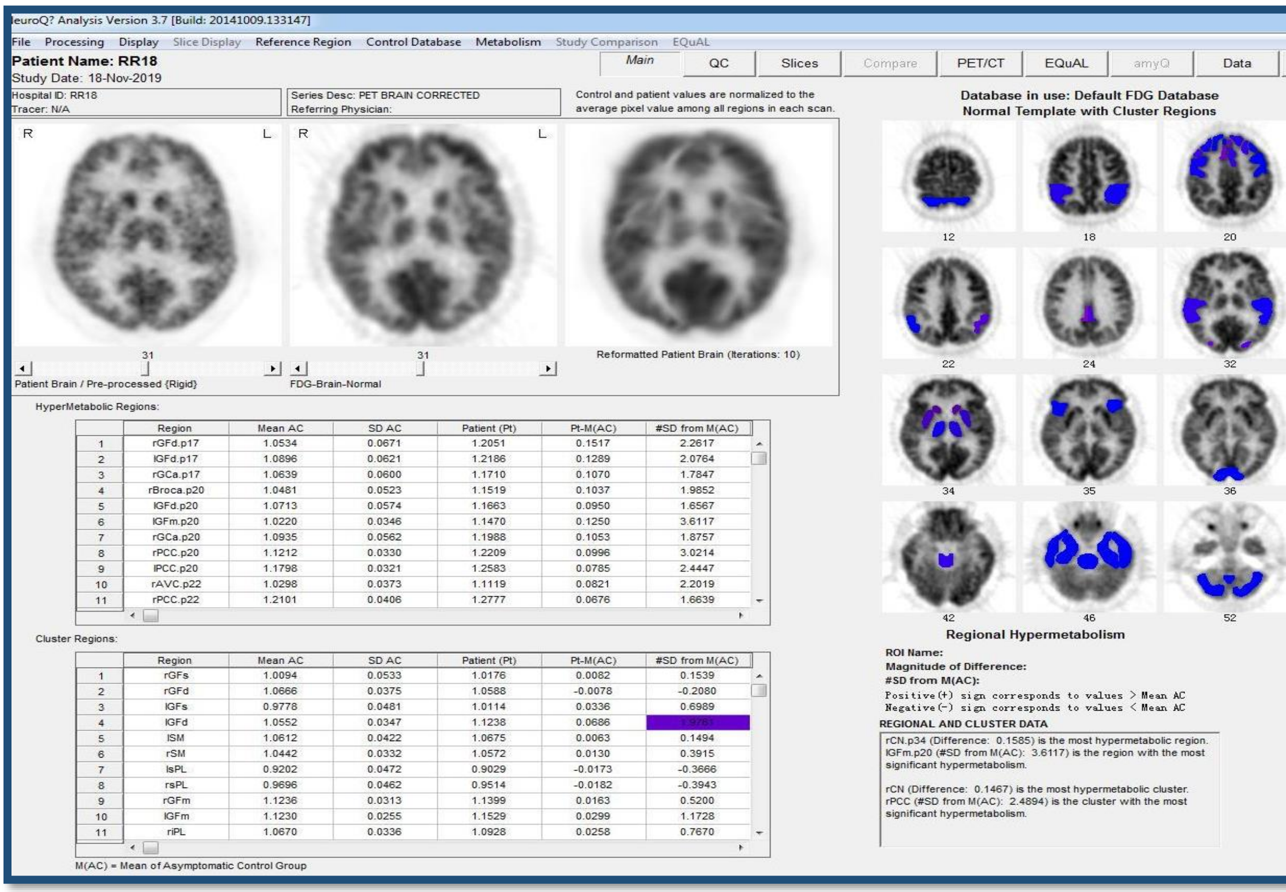


Figure 30: Showing the areas of hypometabolism in A and hypermetabolism in B. Note the change from purple to blue in the 12 superimposed brain images from A to B.

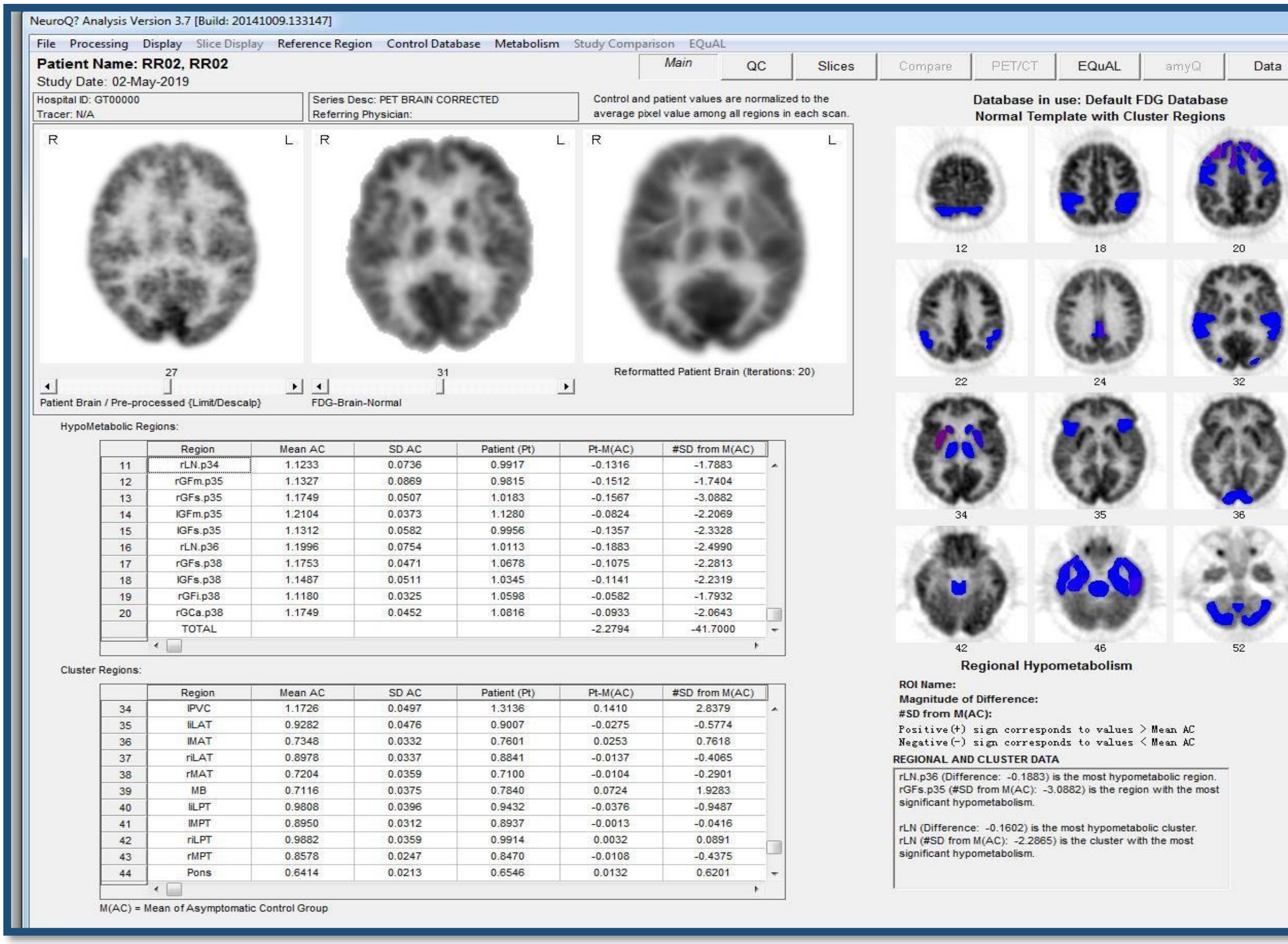


Figure 31 A: Participant RR02 baseline.

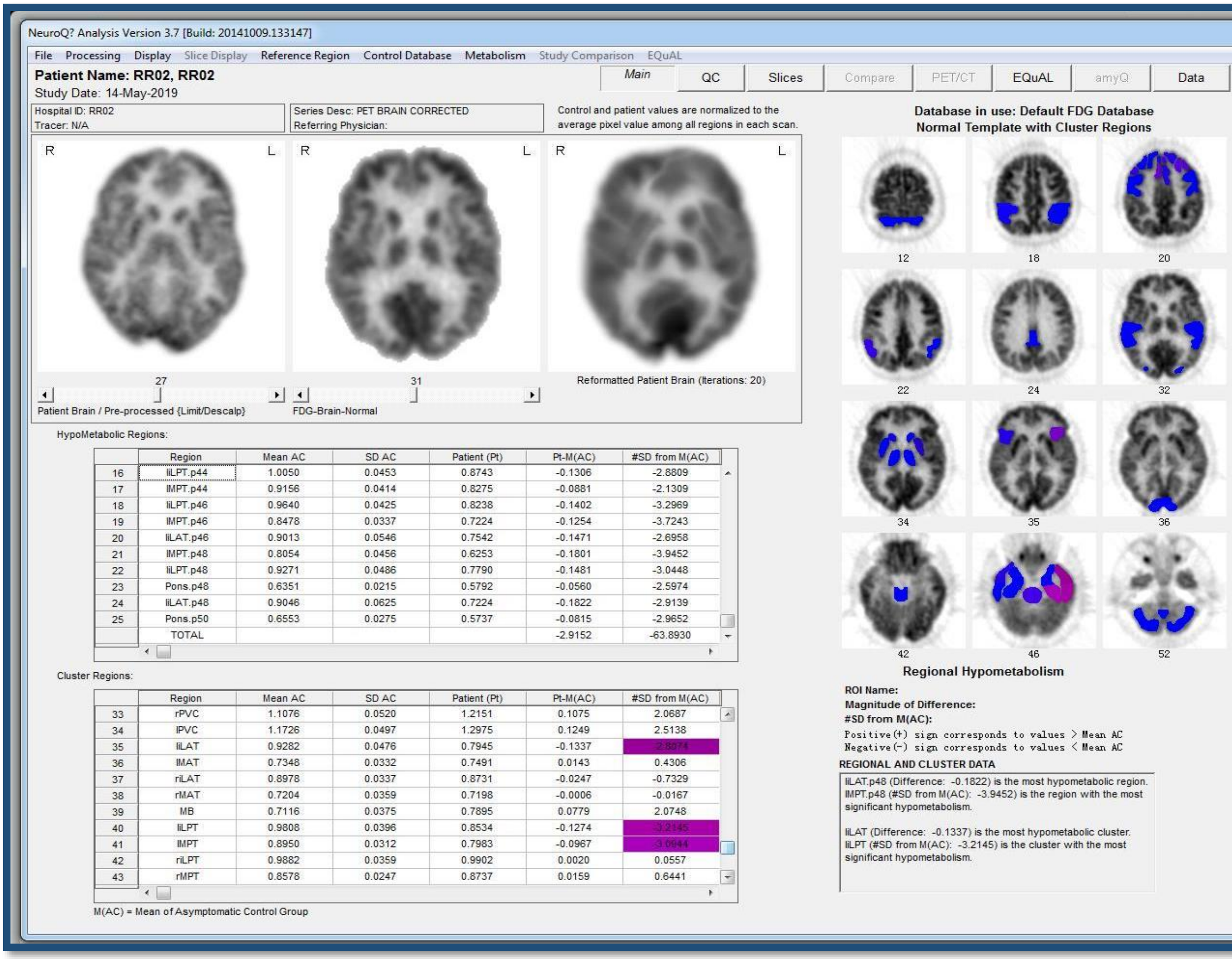


Figure 31 B: Activation in the same participant.

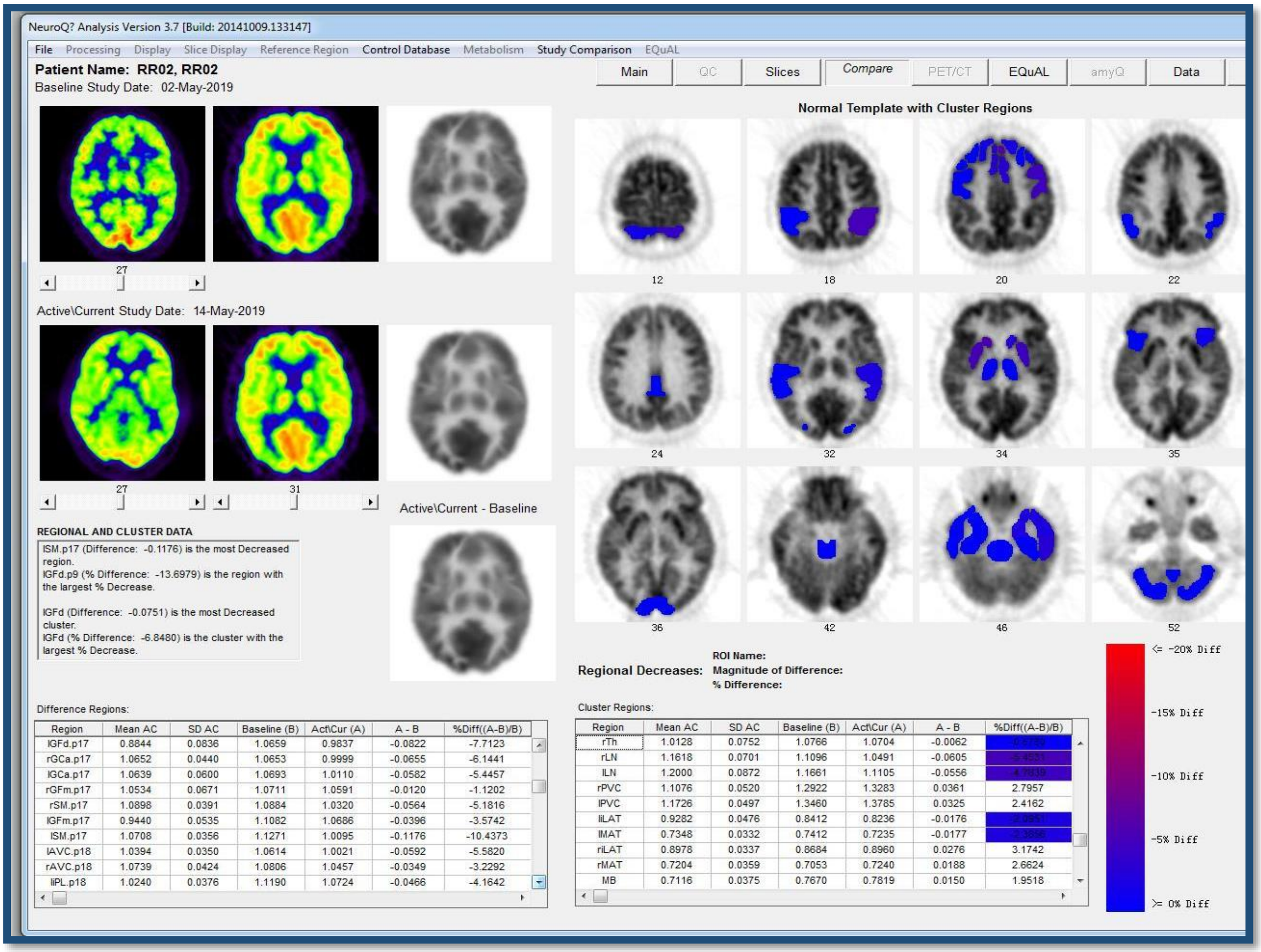


Figure 31 C: Comparison of A and B above.

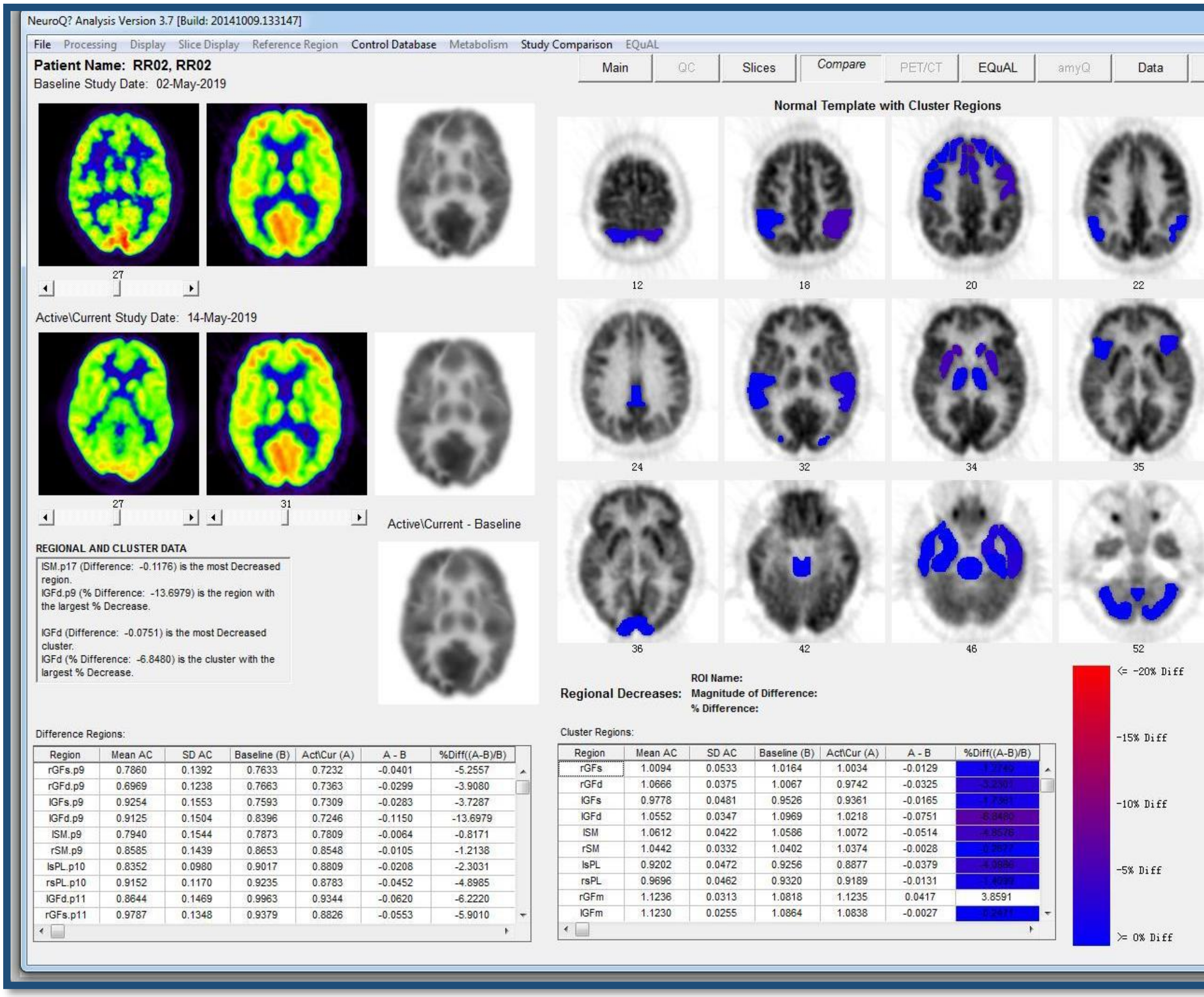
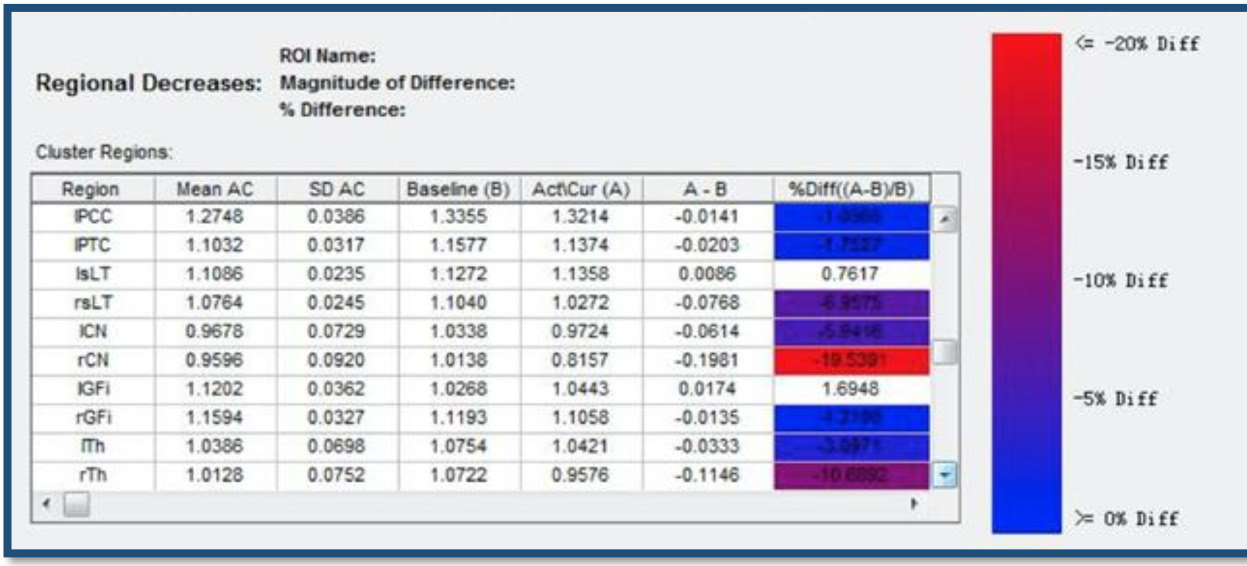


Figure 31 D: Comparison of A and B above for different brain regions.

Figures 31 A, B, C and D above show the brain metabolism in participant RR02 in a similar way, as described for RR16 above. Note the increased metabolism and the hypometabolism in the 12 superimposed brain slices from A to B expressed by colour changes. In the table of brain count within cluster regions in B, the areas of hypometabolism are highlighted in purple. Below the 12 superimposed brain slices is a summary that describes the most affected region/s of the brain from the cluster volumes. Figures 31 C and D again display the differences between baseline and activation studies in participant RR02.

Analysis of caudate metabolism changes of a specific participant as automatically derived from the NeuroQ™ software is shown below in Figure 32



Regional Decreases: ROI Name:
Magnitude of Difference:
% Difference:

Cluster Regions:

Region	Mean AC	SD AC	Baseline (B)	Act\Cur (A)	A - B	%Diff((A-B)/B)
lPCC	1.2748	0.0386	1.3355	1.3214	-0.0141	[illegible]
lPTC	1.1032	0.0317	1.1577	1.1374	-0.0203	[illegible]
lsLT	1.1086	0.0235	1.1272	1.1358	0.0086	0.7617
rsLT	1.0764	0.0245	1.1040	1.0272	-0.0768	[illegible]
lCN	0.9678	0.0729	1.0338	0.9724	-0.0614	[illegible]
rCN	0.9596	0.0920	1.0138	0.8157	-0.1981	-19.5391
lGFi	1.1202	0.0362	1.0268	1.0443	0.0174	1.6948
rGFi	1.1594	0.0327	1.1193	1.1058	-0.0135	[illegible]
lTh	1.0386	0.0698	1.0754	1.0421	-0.0333	[illegible]
rTh	1.0128	0.0752	1.0722	0.9576	-0.1146	[illegible]

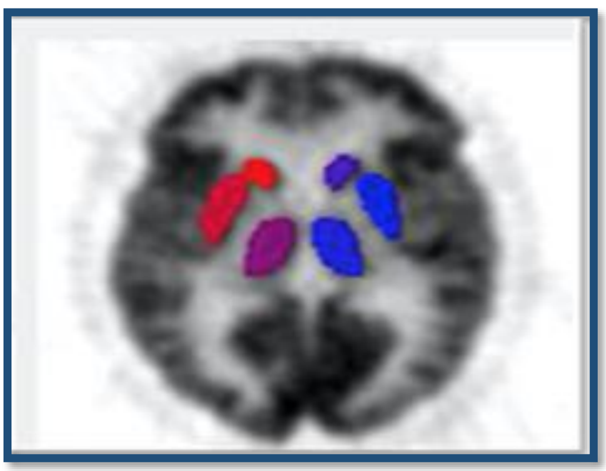


Figure 32: This figure provides analysis of caudate metabolism changes of a specific participant as automatically derived from the NeuroQ™ software

5.2.1.4 Discussion of PET-brain imaging results

The findings of this study emphasise the role of ^{18}F-FDG PET functional imaging in stimulating brain studies. The evaluation of task-related brain activation using ^{18}F-FDG- PET has been recognised as a promising diagnostic tool evaluating of cortical and subcortical activity in healthy subjects during tasks (Chiaravalloti et al., 2019). Similarly, Verger and Guedj (2018) have stated in an editorial paper that the use of ^{18}F-FDG PET brain activation studies contributes to the current renaissance of functional imaging and that is currently the most accurate in vivo method for investigating regional human brain metabolism. The researchers stressed that it should be noted that functional ^{18}F-FDG PET brain activation imaging studies is based on the identification of relative increased metabolism. In addition, the sensitivity of this imaging modality is enhanced by the use of novel techniques in the analysis of data derived from PET functional imaging (Chiaravalloti et al., 2019).

An innovative brain imaging processor for analysis, the NeuroQ^{TM,} was used in the current study. The latter facilitated gathering of data in each of the brain regions examined at rest and during activation, with a bonus, comparing the two studies with its dedicated software.

The changes concerning different biographical entities were analysed and are described below:

1. When experience as a plurilingual SASL interpreter was considered the changes in activation studies were significant in primary visual cortices (p=0.0352), left anterior medial temporal cortex (p=0.0078), right anterior medial temporal cortex (p=0.0352) and right inferior lateral posterior temporal cortex (p=0.03), in those with less than five years of experience, while in those with more than five years of experience, the single change was seen in the right inferior lateral anterior temporal cortex.

2. For respondents with interpreting qualifications, changes were noted in the left mid frontal cortex (p=0.0156) and the right superior lateral temporal cortex (p=0.0313). The respondents with no interpretation qualification showed changes in the primary visual cortex (p=0.0193; in left) and (p=0.0386; in right), left anterior medial temporal cortex (p=0.0063) and right inferior lateral posterior temporal cortex.

These changes, once more, highlight the role of visual cortices for visual inputs and processing and of the temporal regions in language processing. While the temporal areas are linked to language and some visual input processing in general, this study pinpoints the defined anatomical part of the temporal lobe that demonstrates changes during activation. Either the inferior or superior as well as lateral or medial and anterior or posterior region of the temporal lobe, have been involved when respondents interpret the directionality SASL to spoken languages. This finding is significant for future studies in targeting the area involved in different aspects of language and its activation during simultaneous interpreting processing of a sign and spoken language/s with some degree of precision. It is also interesting to note that the changes or activations are seen in both left and right sub-areas of the temporal regions. It was indicated in the text above that the use of the right temporal hemisphere for processing of non-verbal information may be involved as respondents watched an organic SASL video (source text) that was considered to be like 'being similar to gestures while drawing or conducting music'. This finding points to the basic requirement of formal training in interpreting to process language cognitively with less strain on the brain (cognitive load). Less activation of cognitive areas allows the trained interpreter to focus on deeper metalinguistic issues to render a linguistically cultural appropriate interpretation instead of grappling with source text basic understanding, such as in the case of untrained interpreters.

As for the left medial temporal region, the hypothesis that links this particular brain region to processing of new information was mentioned. In these two instances, years of experience and qualification as sign language interpreters, present a pattern from those with less experience or no qualification for interpreting from sign language to spoken language. The activation was noted in the visual and temporal cortices in both of these participants. This finding conforms the observation by Dr. Green in response to the experiments conducted at the University of Geneva, where he states the following:

It could be that as people become more experienced in simultaneous interpretation there's less need for the kind of controlled response provided by the caudate. The caudate plays a role in the control of all sorts of skilled actions. And there's other work showing that as people get more skilled at a task it is not activated as much (Watts, 2016).

In the study, respondents watched the video in the supine position (lying down on the PET machine bed) and voiced what they saw (interpreting from sign to spoken language/s). Since SASL is a complex form of visual-gestural communication that integrates visual information with proprioceptive input that will allow the respondent to perceive that the individuals conducting sign language in the video were standing upright, although the participants were lying down. The activation of these visual and temporal regions may be part of the activation of the brain's higher function, such as the ‘parietal-temporal-occipital associated cortex’ required for such cerebral interconnectivity. This clarifies the initial limitation that presented during the inception of the study, where the real world interpreting setting and the simulated experiment in the MRI machine differs and the impact it could have on the interpreting ability of the respondents. In a real-world setting, during interpreting assignments, interpreters face Deaf (signing) individuals directly.

In respondents with qualifications, the change is noted in the left mid frontal cortex. This seems to imply some degree of planning and an element of coordination of participants’ behaviour. In other words, these skilled sign language interpreters seem not to require the use of higher brain functions but seemed to use their brain for planning what to say and how to structure their interpreting product. The activation of this brain region may indicate the focus or concentration of these respondents on the ability to elaborate thought from the input source language (SASL) to structure the interpreting effort to a linguistic, culturally accurate interpreting product in spoken language/s. This finding is in line with Caplan (2001) and Kotz et al. (2003), who point to the inferior frontal gyrus, specifically Broca’s area for lexical retrieval. In addition, the change during this task may support the finding in the study by Haier et al. (2005), where glucose metabolism was used to assess brain changes after learning a complex visuospatial task. The authors described changes in the left medial frontal area that indicated that presence of brain function even when the brain was engaged in tasks that did not require reasoning. Summarising these findings, one may be tempted to think that the ability of the brain to engage in thinking to produce a thought that will be spoken dominate in individuals who are qualified for SASL interpreting when they are exposed to a visual stimulus of a kind of watching a SASL source text. In contrast, those with qualification may higher brain function, particularly the parietal-temporal-occipital associative area, tend to be able to integrate the complexity of language that incorporate both the visual and proprioceptive inputs.

Although very limited in their number, brain activation studies in healthy participants often look at the association between all brain regions (Alessandrini et al., 2014). In this study, there was a significant correlation between visual cortices and the left parietal region as is seen in the R-values: $r=0.65$ for the left VC, $r=0.59$ for the right VC, $p<0.0001$. The right parietal region also showed an association with both frontal regions (r=0.51 with the right, r=0.59 with the left, p<0.001). This finding agrees with Emmorey (2002) and Horwitz et al. (2003), where left perisylvian regions were activated in sign and spoken languages. This finding further supports the finding in the fMRI study that presented evidence of the lateral prefrontal cortex activated with perceptual context stimuli (Koechlin et al., 2003).

No causality of regional brain association has been described in the literature, but usually, when there is a change in the visual cortex during activation, change is also noted in the left parietal region. The same applies to the change between the left parietal and frontal regions. However, knowing the interconnectivity between most brain areas processing language, the implication of the parietal-temporal-occipital associative cortex, discussed earlier, may be considered as the change in the parietal region was not enhanced as a significant change during activation. This could explain the role of visual chiasma in stimulating other anterior areas of the brain during SASL interpreting by the visual cortex. However, there is no evidence to support this statement, and the secondary research question remains unanswered. Kent (2012) stated the localisation of cognitive functions as they relate to the optic chiasm and its links to visual information and its processing during communication is fragmented. Thus, inconclusive evidence is presented in this study related to the processing of visual stimuli (SASL). I stipulated that the visual chiasma may somehow be involved in processing of information from visual input to the left cerebral area involved with language processing during simultaneous interpreting. This evidence tells me that the region is metabolically altered. The neurological relation of the optic chiasm therefore requires further study.

No significant changes were seen in the analysis of the caudate metabolism. However, mild changes in the metabolism of <5% were seen in the left caudate of half of the participants. Of them participant (RR18) showed a severe change (>20%) in the right caudate and three showed mild change (5%-10%) in the right caudate. This significance of the change in the caudate cannot be explained in the current study, however in other studies it seem to play a role. In a study by Hervais-Adelman et al. (2015), the caudate is prominent in networks that regulate cognition and action. The caudate nuclei is engaged during simultaneous interpreting, according to Hervais-Adelan et al. (2015). In other related studies, the left caudate nucleus is activated in multilingual respondents (Crinion et al., 2006; Abutalebi and Green, 2008 and Garbin et al., 2010). Multilingual language control by direct electrical stimulation and has been shown to be implicated in Wang et al. (2012). The study conducted by Hervais-Adelman et al. (2015), was done on spoken language interpreters, whereas this study focused on sign language interpreters working in a dual modality, spoken and sign language. Furthermore, the Hervais-Adelman et al. (2015) study was done using MRI, and the current study used PET.

The PET brain imaging part of this project could answer the hypothetical questions (primary and secondary research questions) of this thesis. The brain regions that are activated during SASL interpreting from baseline were identified. It was demonstrated that the visual chiasma is somehow indirectly involved in passing information from visual input into the left cerebral area involved with language processing during simultaneous interpreting. The hypothesis of this study can be confirmed based on the predictive statement regarding plurilingual interpreters and incidences of translanguaging during interpreting. Based on the analysis of the results, simultaneous interpreting from SASL into English, Afrikaans, isiZulu, Sesotho and Setswana is directly linked to the cognitive language processing ability and the nexus of translanguaging and linguistic ability of the plurilingual interpreter. The findings confirm that there is no single brain area devoted exclusively to the control of interpretation as stated by Hervais-Adelman et al. (2015).

5.3 Situating the Theoretical Framework in the Findings

The introductory chapter of the thesis set out the theories that underpin the study. The MCT and ACT were discussed in detail in Chapter 3 as part of the theoretical framework of this study. Both theories are restricted to experiments that involve bilingual and multilingual respondents. Experiments were conducted with language tasks involving single language, dual language and dense code-switching. Based on the data analysis, the MCT and ACT can be extended to an interpreting context.

The application of the ACT has been expanded to the context of language use in a communicative situation and not only to language tasks such as the verbal Stroop task and non-verbal Global-Local task. This experiment with plurilingual interpreters highlights that the ACT can be applied to the context of interpreting experiments. The language control mentioned in the ACT hypothesis is confirmed in the application of the ACT to the interpreting experiment in that interpreters adapted their language output and the interpretation product according to the interpreting brief of a plurilingual interview panel at which the interpretation was targeted. Furthermore, the interpreter respondents changed parameters according to their linguistic repertoire by using the three principles of the ACT, namely, identification, decision, and modification in the interpreting process, by identifying the message of the presenter in the SASL text, deciding to interpret in a specific language by using specific lexicon in the spoken language, and modification by various translanguaging strategies, as seen in the ELAN analysis.

The cognition areas identified by the NeuroQ™ software supports the findings of the ACT of specific areas of activation of the parietal cortex in multilingual language interactional contexts and dense code-switching contexts. This study highlights the significant activation of the rPVC, lPVC, riLAT, lMAT and the riLPT.

The adaptive control processes are modified based on the dual-modality interpreting in a plurilingual context of this study by applying the ACT to a diamesic interpretation.

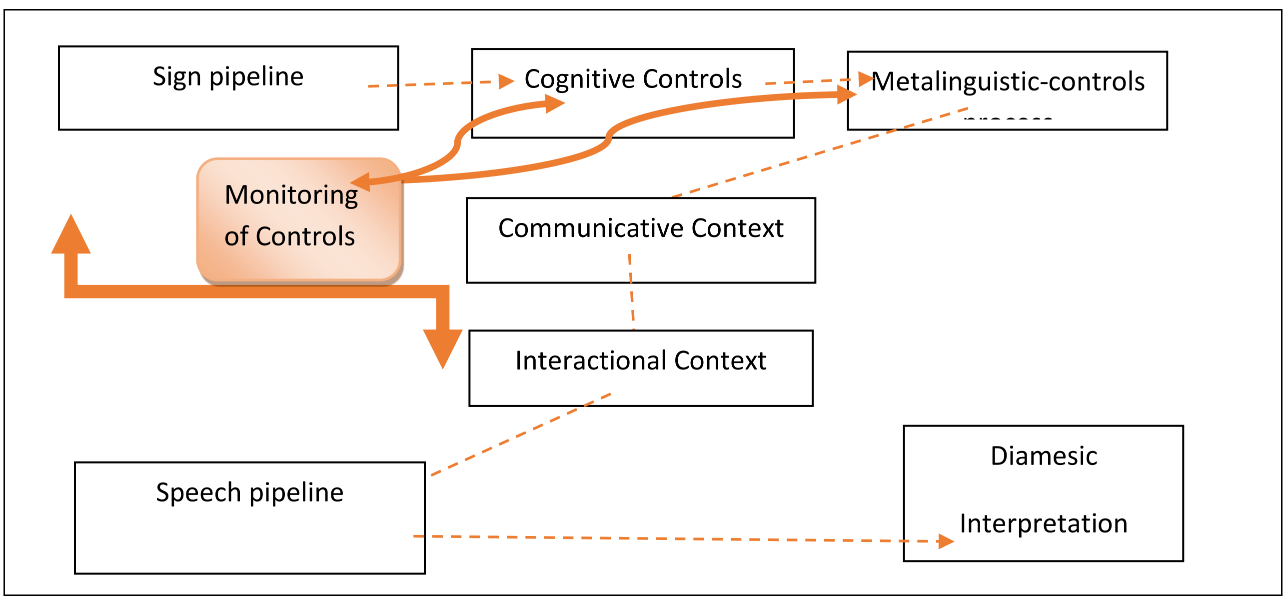


Figure 33: Adapted illustration of the adaptive control process as proposed by Green and Abutalebi (2013).

The adapted illustration of the adaptive control processes in a plurilingual interpreting context are shown above. The illustration expands on that of Green and Abutalebi (2013) in the context of

ACT by adding the modality of a sign pipeline. In addition, this illustration adds the cognitive controls as seen in the cognitive areas activated in the experiment for understanding of the source language, SASL. Furthermore, the illustration extends the context to a communicative context since the goal of the experiment was to render an interpretation into the target languages that formed part of the interpreter's linguistic repertoire. Finally, the addition of the final product is added, a diamesic interpretation. Highlighted in this illustration is the monitoring of controls, which is needed during interpreting because the interpreter must consistently evaluate the controls and the adaptation thereof. Here the interpreter navigates between the modality of audio and visual languages by applying controls as is deemed relevant for the communicative intent in the interactional context.

The MCT is expanded to the context of an interpreting action schema. The MCT describes action stimulated by cognitive mechanisms, because of hearing a language utterance. In this study, the dual modality of the experiment, sign and spoken language(s) extend the MCT to dual-modality context. The action stimulated by cognitive activation is caused by sign language as an input language and action as interpreting into spoken language. This study thus confirms the view that the formation of linguistic-articulatory action schemas is linked to manual, mouth actions and visual and acoustic perceptions. By extension of the comprehension component of motor resonance, this study confirms the visuospatial variable as impacting sense-making during lexical access and processing. In the experiment, interpreter respondents rely on the visual-gestural lexicon of SASL and the vocal-auditory lexicon in their linguistic repertoire to deliver an effective interpreting product.

5.4 Summary of Findings

In many ways, several of the findings in the study agree with previous research. However, there are some remarkable findings in this particular study. This was the first known study to explicitly state the specific cognitive areas prominent in cognitive language processing in plurilingual simultaneous interpreters in a dual-modality. Furthermore, to my knowledge, this is the first study in healthy participants that compares resting brain metabolism to activation brain studies for specifically plurilingual SASL interpreters, working in the direction of sign-to-spoken languages.

While the number of respondents was limited to 20, no published research on brain activation has included more than 30 subjects and usually enrolled fewer than ten respondents. Furthermore, similar to previous studies conducted on spoken language simultaneous interpreters, this study has revealed and confirmed that the caudate plays a prominent role in cognition. As one element of a broader research project, this study sought to explore a phenomenon termed ‘translanguaging repertoire’ in plurilingual interpreting settings. It focused on the cognitive language processing of plurilingual SASL interpreters. The incidence of translanguaging in South African interpreters is not entirely unexpected in this plurilingual context. However, it is still somewhat surprising that there is no formal training offered on translanguaging strategies in interpreting.

In the brain functional imaging section of this thesis, the areas influenced by sign language interpreting during activation were idetified. The brain areas that were more activated during plurilingual interpreting among experienced SASL interpreters and those with less experience were differentiated. In the same way, interpreters who are qualified from those who are not could be separated by looking at the brain areas activated during simultaneous interpreting from SASL to spoken language/s. Future studies with a large number of participants may confirm these findings, with increased power of accuracy to make recommendations. For example, qualification as sign language interpreters would be preferable, because perhaps the task only requires less brain cognitive demand that is linked solely to the pathway of thoughts. In contrast, those with with fewer qualifications require complex cerebral connectivity involved with the complexity of language processing.

The following chapter provides conclusions and recommendations for future studies in the fields of language practice and neuroscience.

CHAPTER 6

Limitations, Conclusions and Recommendations

6.1 Introduction

In the previous chapter, the results of this study were presented and discussed as a basis of empirical evidence to support the answers to the research questions posed in Chapter 1. Here, I present the limitations of the study. Conclusions are drawn from cognitive language processing linked to sign language interpreting. The conclusions are the golden thread ensuring that the aim, objectives, research questions and results of the study are adequately captured. Lastly, this study offers specific recommendations on further research with concerning interpreting and the variables of plurilingualism and translanguaging. A critical juncture is reached at this point, where the pertinent question is: “What do we make of this disquisition about ways in which cognitive language processing during interpreting unfolds in plurilingual sign language interpreters?”

6.2 Limitations

The limitations of this study are as follows:

1. The focus of this study was solely on the direction of SASL to spoken language/s. This interpretation direction does not require the interpreter to use their hands. This decision was made due to the specifications of PET brain scans requiring a subject to lie completely still with no movement while under the scan. If there is movement, it affects the quality of the recording and subsequently the scanning image cannot be used for analysis.
2. The participants’ placement in a supine position in an experimental medical environment could have affect their interpreting output.

3. The timing of the stimulus application presented a limitation because the protocol was developed in such a way that uptake of FDG were first to take place, and the intervention of the SASL video was presented after 15-20min, which in hindsight could have been administered in real time.

4. The project's geographical scope was concentrated in Gauteng Province, South Africa and excluded interpreters in the other eight provinces of the country. The project required the use of PET brain scanning equipment, located on the University of the Witwatersrand medical campus in Johannesburg. It was therefore not possible to conduct the same tests in other provinces.
5. The costs associated with this study meant that the number of participants was restricted (Appendix B). Although the sample size of 20 is not representative of the number of SASL interpreters in the country, no published study on brain activation has included more than 30 subjects and usually enrolled fewer than 10 participants.
6. The option of using an fMRI scanner was not available; therefore, the available PET brain imaging scanner was used (Refer to Table 1 for the justification of the use of PET brain scans in Chapter 3, Theoretical Framework and Methodology.)
7. Transcription software for African languages is not available, so the translanguaging segments were manually transcribed, and linguistic annotation was done using the ELAN annotator.

6.3 Conclusions related to the Study Aim, Objectives and Research Questions

Overall, this study achieved its aims by successfully conducting an empirical investigation of specific neurological areas activated during interpreting from SASL to spoken language, using PET brain imaging. As a culmination of the evidence gathered in this study, the aim of positing a praxeological interpreting model based on translanguaging was achieved.

This study achieved its objective by highlighting the cognitive functions concerning sign language interpreting and, in particular, how they relate to plurilingual, translanguaging sign language interpreters during simultaneous interpreting. The research questions posed were satisfactorily answered by empirical evidence from the data collected. The evidence points to specific brain clusters activated neurologically for lexical and semantic processing from SASL to spoken languages. The findings indicate specific language faculties in the perisylvian region activated neurologically while delivering a simultaneous, diamesic interpreting product. The evidence further suggests the possibility of applying interpreting strategies underpinned by translanguaging in plurilingual settings. Significant areas activated during simultaneous interpreting in plurilingual SASL interpreters are the rPVC, lPVC, riLAT, lMAT and the riLPT. The investigation of the optic chiasm, its activation and role in processing visual stimuli, specifically linguistically structured stimuli such as sign language, have not provided conclusive evidence. Suffice to state that the implication of the parietal-temporal-occipital associative cortex points to the role of visual chiasma in stimulating anterior areas of the brain during sign language interpreting.

This study enriches concepts of plurilingualism and translanguaging in interpreting studies. The concepts are explored by providing a praxis lens to the semiotic resources and translanguaging strategies used by plurilingual sign language interpreters to allow for meaning making towards communicative success. The study provides an entrance into the cognitive processes and sociolinguistic dynamics of co-constructed interpreted meaning, offering a novel understanding of translanguaging and its linkages in the plurilingual interpreter brain. The findings in the experiment open up a new avenue for interpreting study research that draws upon recent developments in translanguaging theory and the variable patterns of language communities' communication functions, specifically translanguaging in Deaf signing communities.

It must be pointed out that, even if some of the evidence presented in this thesis that is deemed inconclusive, this highlights the fact that the vital question of what happens in the interpreters' black box during translanguaging remains a formidable challenge to interpreting scholars and neuro-science scholars alike. Therefore, future studies are encouraged to either double or triple the number of respondents in a single study or multi-centre studies of smaller numbers according to their practicalities. This may confirm the findings of this study or add new insights to what was described in terms of cognitive language processing during simultaneous interpreting. Cognitive functions are interrelated and do not operate in isolation; hence, the interdisciplinary project I undertook between neuroscience and language practice studies (interpreting) is timely in making a scholarly contribution to understanding the holistic neurological operations during interpreting.

In this study, the concept of plurilingualism and how it transpires in interpreting was explored. As stated previously, a praxis model that cocoons plurilingualism in the expression of translanguaging strategies in interpreting is proposed. This model conforms to the views of Moser-Mercer (2010) that cognitive analysis by advanced brain imaging software enables analysis on a granular level, which can assist in the scientific validation of interpreting theory and models.

6.4 The Sankofa Interpreting Model (SIM)

The Sankofa Interpreting Model is a praxeological model embedded in the reflective practice of interpreters in plurilingual, ubuntu translanguaging speech and sign communities. In this model, the communicative exchange between interlocutors is located in the real-life translanguaging phenomena where the interpreter is considered a part of this exchange. In bridging the gap between the speech and sign communities the model reflects the interpreter not only mediating between L1 and L2 to interpret between the source language and the target language, but employing their holistic linguistic repertoire to ensure the communicative aim is achieved by navigating the holistic language use in context. The intent of this model is to synchronise the communication and interpreting values with culturally relevant interpreting practices through understanding of cognition. This interpreting praxis model (IPM) has four facets: linguistic, semiotic repertoire, interpreting theory epistemology, translanguaging situated action, critical reflection and a core construct, identity. Identity, in the Sankofa Interpreting Model, is considered the core of multilanguaging interpreting praxis.

<u>Component A- Linguistic, semiotic repertoire</u>

Taking stock of the unique individual cultural, linguistic, and semiotic repertoire enables the sign language interpreter to be aware of the intersectionality of the meta-linguistics of languages, communicative intent, semiotics of speech and sign communities, and the interpreting dynamics. This awareness gives rise to a profile where there is conscious engagement with aspects of identity as a core construct. Understanding the linguistic, semiotic repertoire provides a positive vector, where the interpreter engages with translanguaging strategies.

Component B - Interpreting Epistemology and Ontology

Interpreting theories remain important in the teaching and learning of interpreting as a profession. Teaching interpreting theory to advance understanding of interpreting processes and models must follow teaching and learning design principles relevant to various interpreting contexts. This is aimed at effectively grooming and guiding market-ready and market-relevant interpreters once they graduate. Incorporating aspects of intersectionality regarding the identity of African sign language interpreters creates a lucrative cross-disciplinary project. By positing an alternative lens, ubuntu translanguaging in interpreting as part of the African plurilingual identity, aims to engage with Sankofa norms in interpreting. Whereas traditional interpreting models view translanguaging as an interpreting error, the Sankofa Interpreting Model (SIM) holds translanguaging as a positive interpreting strategy based on neurological activation evidence in this project. Ubuntu translangugaging is thus a strategy that is part of the identity and linguistic engagement of the African sign language interpreter during multilanguaging communicative exchanges. Therefore, interpreting norms are enhanced by offering an adjusted lens to plurilingual interpreted communicative events. By incorporating ubuntu translanguaging, professional, relational, communication and accountability norms are inclusive of the interpreting practice realities of the African sign language interpreter.

Component C –Ubuntu Translanguaging

Navigating the interpreting setting, specifically decisions made during interpreting, forms part of situated action. Action that is informed by taking into account the organic state of the communicative exchange to produce the message (both source and target language) linguistically, culturally, and socially acceptable, by fetching knowledge from the past, as is embedded in Sankofa. Situated action propels the interpreter's decision-making to a progressive praxis by reading the audience and the communicative intent of the interlocutors the plurilingual sign language interpreter, if and when comfortable with his plurilingual repertoire and identity, engages with ubuntu translanguaging strategies aimed at bridging the gap between speech and sign communities. Activation of the active languages as demonstrated in this experiment is embedded in cognnitve activation of all languages in the linguistic repertoire, without "switching off" any one language.

Component D - Critical reflection, cognition

Critical reflection is posited as part of the SIM to create scope for ontological knowledge in translanguaging interpreting practice. Pausing to reflect on an interpreting situation where the communicative exchange was marked by translanguaging provides the interpreter with a point of reference beyond the traditional view of failing to produce the target language equivalent. The integral view of interpreting as multifarious and organic presents a unique opportunity for translanguaging strategies to be incorporated as part of the ontological knowledge of interpreting. Critical reflection in the praxis model allows the interpreter to consider, plan and adjust the interpreting approach and translanguaging strategies by creating a professional environment where the interpreter can experiment with various translanguaging strategies. These strategies ought to be documented so as to inform future considerations of interpreting models informed by ubuntu translanguaging practices in interpreting. The ability for critical reflection is rooted in cognition of the past, present and future. By understanding cognitive processes linked to interpreting allows for reflection and deep thought processes on the praxis and application of interpreting strategies.

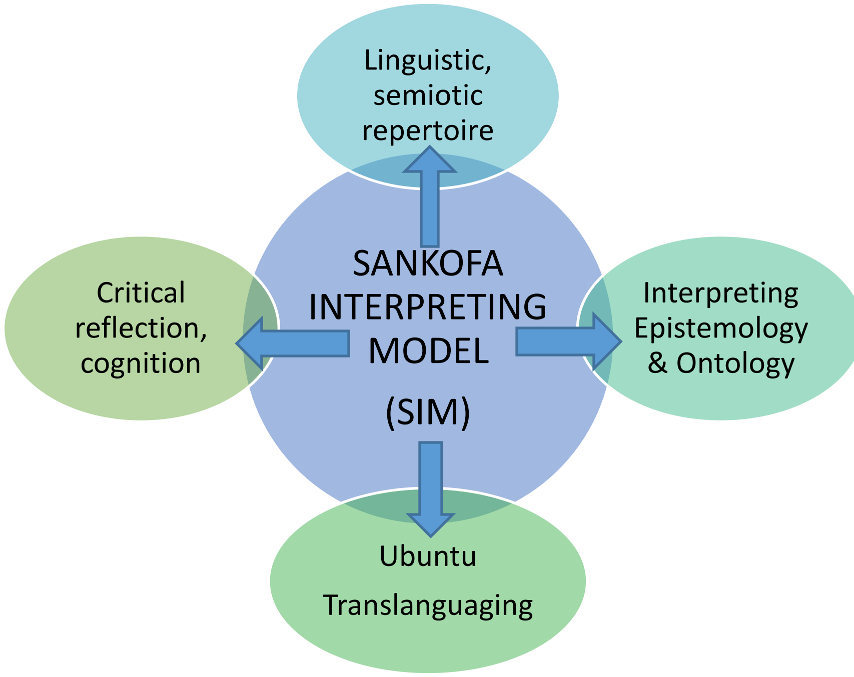


Figure 34: The Sankofa Interpreting Model (SIM)

By applying the theoretical framework of MCT and ACT, this investigation furthers our understanding of the nature of translanguaging in the operative reality of interpreting in plurilingual settings. Evidence presented following the methodological framework supports the predictive hypothesis of the study that states the following: “From sign to spoken language/s, the simultaneous interpreting product is directly linked to the nexus of cognitive language processing and the linguistic repertoire of a plurilingual interpreter.” Indeed, the evidence presents specific cognitive areas activated during simultaneous interpreting. It further highlights incidents of linguistic ability and the use of translanguaging strategies by plurilingual interpreters.

The aim of this study has been realised by conceptualising a praxeological interpreting model, named the Sankofa Interpreting Model (SIM), based on incidences of plurilingualism and translanguaging strategies in the experiment. As stated previously, this model aims to lay the foundation for alternative trajectories in interpreting praxis and pedagogy through the lenses of plurilingualism and translanguaging. The links between societal linguistic repertoires, the education and training of sign language interpreters and their professional lived experience leads me to propose this novel praxeological model in interpreting, where translanguaging becomes a concerted practice in establishing an inclusive model of interpreting practice. The SIM, aims to expand ways of understanding interpreting through an epistemic and ontological lens by interrogating education systems and contexts that have ignored the cultural communicative aspects of multilanguaging. The model proposed is merely based on an interpretive hypothesis and should thus be refined based on testing Ubuntu translanguaging strategies in interpreting.

6.5 Recommendations for Further Research

The following recommendations can be made for future research:

6.5.1 Recommendations specific to the evidence of this study,

- ❖ The extension of this study, based on fMRI brain analysis.
- ❖ A replica of this study on a larger sample.
- ❖ An investigation of the optic chiasm, its activation and role in processing of visual stimuli, specifically linguistically structured stimuli such as sign language.
- ❖ A comparative study that focuses on comparing activation in both interpreting directions, sign to spoken language and spoken language to sign language.
- ❖ A comparative study of cognitive language processing between spoken and sign language interpreters' translanguaging strategies.
- ❖ A replica of this study comparing various levels of translanguaging by having a control and experimental group of trained *versus* untrained interpreters.
- ❖ A follow-up on the translanguaging incidences in interpreting to probe why and at what point interpreters decide to follow or flout the norms of language use prescribed by the ABC language classification.
- ❖ A language aptitude test to verify language aptitude and ability to measure against self-reported proficiency in interpreters to gauge the classification of ABC language classification by fMRI imaging.

6.5.2 Recommendations for other future studies

- Use of a corpus where an analysis can be drawn from natural translanguaging interpreting practice to evaluate the practice and not focus on the clinical aspect of the experiment using PET or fMRI.
- Development of a curriculum for education and training of plurilingual language practitioners in which a symbiotic relationship is forged between curriculum, theory and translanguaging practices that incorporates the market demand for a plurilingual language practitioner.
- Linked to this project, it is imperative for an interpreter to understand the operations of the brain and how the various language faculties operate holistically. This will provide insight into how the various languages in their linguistic repertoire come into operation during translanguaging interpreting strategies. It can further provide room for investigating translanguaging strategies as proposed by the praxeological model.
- Development of assessment tools for plurilingual interpreters as modelled by the assessment tools for the training of interpreters (ASSESSTI) project, by empirical investigation of cognitive language processing (PET/fMRI brain analysis)
- Translanguaging interpreting strategies in multilingual interpreting contexts.
- A review of the ABC working languages classification system for multilingual settings where the interpreter has a functional working knowledge of more than three languages.
- Empirical identification of essential performance features across language groupings from analysis of interpretation performance.
- Development of clear, observable scaling descriptors for language proficiency scales where the plurilingual interpreter has professional working knowledge of more than three languages in or across groupings such as Nguni, Sotho and Tsonga language groupings.
- The classification of working language descriptors taxonomy informed by applicable interpreting models.

- ❖ Recruitment criteria for SASL interpreters to be defined clearly according to language classification, for example, the use of languages in a meeting. Such criteria will inform the employability of interpreters based on their confirmed language aptitude linked to interpreting skill level and interpretation qualification.

6.6 Conclusion

This chapter provided the conclusions for this study. From the conclusion related to the aim, objectives and research questions, it was clear that the predictive hypothesis of the study was confirmed. Recommendations for future research have also been made to conclude this study.

Reference list

Aarons, D & Akach P. (1998). South African Sign Language - one language or many? A sociolinguistic question *Stellenbosch Papers in Linguistics*, Vol. 31, 1998, 1-28

doi: 10.5774/31-0-55

Aboitiz, F. & García, R. (2009). Merging of phonological and gestural circuits in early language evolution. *Reviews in the Neurosciences* 20:71–84.

Aboitiz, F. & García, R. (1997). The evolutionary origin of the language areas in the human brain: a neuroanatomical perspective. *Brain Research Reviews* 25:381–396.

Abu-Krooz, H., Al-Azzawi, Q. & Saadoon, M. (2019). Code Switching and Code Mixing: A Sociolinguistic Study of Senegalese International Students in Iraqi Colleges. Available at: https://www.researchgate.net/publication/330225079_Code_Switching_and_Code_Mixing_A_Sociolinguistic_Study_of_Senegalese_International_Students_in_Iraqi_Colleges/citation/download [Accessed 18 October 2019]

Abutalebi, J & Green, D. (2016). Neuroimaging of language control in bilinguals: Neural adaptation and reserve. *Bilingualism: Language and Cognition, 19*(4), 689-698. doi:10.1017/S1366728916000225

Abutalebi, J., Annoni, J., Zimine, I., Pegna, A., Seghier, M., Lee-Jahnke, H., Lazeyras, F., Cappa, S. & Khateb A. (2008). Language control and lexical competition in bilinguals: an event-related fMRI study. *Cerebral Cortex*. 18:1496–1505.

Ackerman S. (1992) Discovering the Brain. . Washington (DC): National Academies Press (US); 1992. 6, The Development and Shaping of the Brain.

Adom, D., Hussein, E. & Adu-Agyem, J. (2018). Theoretical and Conceptual Framework: Mandatory Ingredients of a quality research. *International Journal of Scientific Research*. 7. 438-441.

Akach, P. (2010). *Application of South African Sign Language (SASL) in a bilingual-bicultural approach in education of the Deaf*. PhD in Humanities, University of the Free State.

Alessandrini, M., Micarelli, A., Chiaravalloti, A. et al. (2016). Involvement of Subcortical Brain Structures During Olfactory Stimulation in Multiple Chemical Sensitivity. Brain Topogr 29, 243–252. https://doi.org/10.1007/s10548-015-0453-3

Alimi, M. & Matiki, A. (2017). Translanguaging in Nigerian and Malawian online newspaper readers' comments, *International Journal of Multilingualism*, 14:2, 202-218, DOI: 10.1080/14790718.2016.1241255

Anderson, S. & Lightfoot, D. (2002). The Language Organ - Linguistics as Cognitive Physiology. Cambridge University Press.

Andrews, E., Frigau, L., Voyvodic, C., Voyvodic, J. & Wright, J. (2013). Multilingualism and fMRI: Longitudinal Study of Second Language Acquisition. *Brain sciences*. 3. 849-76. 10.3390/brainsci3020849.

Anglin-Jaffe, H. (2011). Sign, Play and Disruption: Derridean Theory and Sign Language, Culture, Theory and Critique, 52:1, 29-44, DOI: 10.1080/14735784.2011.621665

Ardila, A. & Bernal, B. (2016). Neuroimaging in language: The contribution of fMRI.

Aronin, L. & O´ Laoire, M. (2012). The material culture of multilingualism. In D. Gorter,

Aronin, L. & Singleton, D. (2012). Multilingualism. Amsterdam: John Benjamins.

Australia's Nuclear Science and Technology Organisation (ANSTO). *Production and use of PET radioisotopes*. (2019). Available from :file:///C:/Users/A0037968/Downloads/Cyclotrons_and_PET_scans%20(1).pdf Accessed: November 2020

Backus, A. (2000). The role of the lexicon in alternational code-switching. Paper presented at 7th *International Conference on Pragmatics*, Budapest.

Bagga-Gupta, S. (2000). Visual language environments: Exploring everyday life and literacies in Swedish Deaf bilingual schools. *Visual Anthropology Review*, 15, 95-120.

Baigorri- Jalón, J. (2005). Conference interpreting in the First International Labor Conference (Washington, DC, 1919). *Meta*. 50. 987-996. 10.7202/011609ar.

Baigorri- Jalón, J. (2018). The history of the interpreting profession. In H. Mikkelson, & R. Jourdenais (Eds.), *The Routledge Handbook of Interpreting* (pp. 11-28). Routledge.

Baigorri-Jalón, J. (2014). From Paris to Nuremberg. The birth of conference interpreting. *International Journal of Translation and Interpreting Research*. 7. 10.12807/ti.107202.2015.r01.

Bancroft, M. (2015). Community interpreting: A profession rooted in social justice. *In The Routledge Handbook of Interpreting* (217-235). Holly Mikkelson and Renée Jourdenais (Eds). New York: Routledge.

Barnali, C. (2017). Code-Switching and Mixing in Communication- A Study on Language Contact in Indian Media. Proceedings of the RAIS Conference: *The Future of Ethics, Education and Research*, 2017, Available from: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3085969

Bauman, H-D. (2008). Listening to Phonocentrism with Deaf Eyes: Derrida's Mute Philosophy of (Sign) Language. *Essays in Philosophy A Biannual Journal*, 9(1) Article 2.

Bavelier, D., Brozinsky, C., Tomann, A., Mitchell, T. & Liu, G. (2001). Impact of early Deafness and early exposure to sign language on the cerebral organization for motion processing, The Journal of *Neuroscience,* Vol. 21, pg. 8931-8942.

Bavelier, D., Dye, M. & Hauser, P. (2006). Do Deaf individuals see better? *Trends in Cognitive Sciences*. Vol. 10, pg. 512-518.

Beacco, J-C. (2005), *Languages and Language Repertoires: Plurilingualism as a Way of Life in Europe*. Council of Europe: Strasbourg.

Becker, M. (2019). "Socialism," in *The Routledge handbook to the history and society of the Americas*, edited by Olaf Kaltmeier, Josef Raab, Michael Stewart Foley, Alice Nash, Stefan Rinke, and Mario Rufer (Abingdon, Oxon: Routledge, 2019), 429-35.

Beeman, M. & Chiarello, C. (1998). Right hemisphere language comprehension: *Perspectives from Cognitive Neuroscience*, Hillsdale, N.J. Lawrence Erlbaum Associates.

Behroozi, M. & Daliri, M. (2012). Software Tools for the Analysis of functional Magnetic Resonance Imaging. *Basic and Clinical Neuroscience*. 3. 71-83.

Benor, S. (2010). "Ethnolinguistic Repertoire: Shifting the Analytic Focus in Language and Ethnicity." Journal of Sociolinguistics 14 (2): 159–183. doi:10.1111/j.1467-9841.2010.00440.x

Berent, G. (2008). *Sign Language—Spoken Language Bilingualism: Code Mixing and Mode Mixing by ASL-English Bilinguals*. 10.1002/9780470756997.ch12.

Binder, J. (1997). Neuroanatomy of language processing studied with functional MRI. *Clinical Neuroscience*, 4: 87–94.

Binder, J., Frost, J., Hammeke, T., Cox, R., Rao, S., & Prieto, T. (1997). Human brain language areas identified by functional magnetic resonance imaging. *The Journal of Neuroscience*, 17(1), 353–362.

Binney, R., Embleton, K., Jefferies, E., Parker, G. & Ralph, M. (2010). The Ventral and Inferolateral Aspects of the Anterior Temporal Lobe Are Crucial in Semantic Memory: Evidence from a Novel Direct Comparison of Distortion-Corrected fMRI, rTMS, and Semantic Dementia. *Cerebral cortex* (New York, N.Y. : 1991). 20. 2728-38. 10.1093/cercor/bhq019.

Bitman, N. & John, N. (2019). Deaf and Hard of Hearing Smartphone Users: Intersectionality and the Penetration of Ableist Communication Norms, *Journal of Computer-Mediated Communication*, Volume 24, Issue 2, 56–72 https://doi.org/10.1093/jcmc/zmy024

Blackledge, A. (2000). Monolingual ideologies in multilingual states: Language, hegemony and social justice in Western liberal democracies. *Sociolinguistic Studies*. 1. 10.1558/sols.v1i2.25.

Block, N. (1995). On A Confusion About a Function of Consciousness. *Behavioral and Brain Sciences*. 18. 10.1017/S0140525X00038188.

Blommaert, J. (2013). *Ethnography, Superdiversity and Linguistic Landscapes. Chronicles of Complexity*. London: Multilingual Matters.

Bludau, S., Eickhoff, S., Mohlberg, H., Caspers, S., Laird, A., Fox, P., Schleicher, A., Zilles, K., & Amunts, K. (2014). Cytoarchitecture, probability maps and functions of the human frontal pole. *NeuroImage*, 93 Pt 2(Pt 2), 260–275. https://doi.org/10.1016/j.neuroimage.2013.05.052

Boden, M. (2006). Mind as Machine. Oxford: Clarendon Press.

Bontempo, K. (2018). Signed Language Interpreting. In H. Mikkelson, & R. Jourdenais (Eds.), *The Routledge Handbook of Interpreting* (pp. 112-128). Routledge.

Bookheimer, S. (2002). Functional MRI of language: new approaches to understanding the cortical organization of semantic processing. *Annual Review of Neuroscience*. 25:151–188.

Boren, E. (2019). Understanding Sustainable Development Goal 4 on quality education from micro, meso and macro perspectives, *International Review of Education*, 65: 277-294.

Botvinick, M. (2008). Hierarchical models of behaviour and prefrontal function. *Trends in cognitive sciences*. 12. 201-8. 10.1016/j.tics.

Brain Map: Temporal Lobes. 22 January 2021. Available from: https://www.health.qld.gov.au/abios/asp/btemporal_lobes Accessed: 23 January 2021.

Brain Wellness Center. (2012). "What is NeuroQ?" Available from: https://youtu.be/kN_3IjWNXMQ Accessed: December 2021

Braitenberg, V. & Schuz, A. (1998). Cortex: Statistics and geometry of neuronal connectivity (2nd ed). Berlin: Springer.

Brandt Line. Royal Geographical Society. Available from: https://www.rgs.org/CMSPages/GetFile.aspx?nodeguid=9c1ce781-9117-4741-af0a-a6a8b75f32b4&lang=en-GB Accessed: June 2019

Braun, A., Guillemin, A, Hosey, L. & Varga, M. (2001). The neural organization of discourse: an H2 15O-PET study of narrative production in English and American sign language. *Brain*; 124(Pt 10):2028-44. doi: 10.1093/brain/124.10.2028. PMID: 11571220.

Brownell, G. (1999). *A History of Positron Imaging*. Physics Research Laboratory, Massachusetts General Hospital Division of Radiological Sciences, Massachusetts Institute of Technology.

Buck, A., Schirrmeister, H., Kühn, T., Shen, C., Kalker, T., Kotzerke, J., Dankerl, A., Glatting, G., Reske, S. & Mattfeldt, T. (2002). FDG uptake in breast cancer: correlation with biological and clinical prognostic parameters. *European Journal of Nuclear Medicine and Molecular Imaging*, 1317-23. doi: 10.1007/s00259-002-0880-8. Epub 2002 Jul 26. PMID: 12271413.

Buckner, R., Koutstaal, W., Schacter, D. & Rosen, B. (2000). Functional MRI evidence for a role of frontal and inferior temporal cortex in amodal components of priming. *Brain* 123: 620–640.

Budner, S. (1962). Intolerance of ambiguity as a personality variable. *Journal of Personality*, 30(1), 29–50

Burch, D. (2000). American sign language interpreters: Diversity in progress. *Journal of Interpretation*, 3-12.

Busch, B. (2012). The Linguistic Repertoire Revisited. *Applied Linguistics* 1–22 Oxford University Press. doi:10.1093/applin/ams056

Busch, B. (2015). Expanding the notion of the linguistic repertoire: On the concept of Spracherleben – the lived experience of language. *Applied Linguistics.* Advance online publication. doi: 10.1093/ applin/amv030

Campbell, R., MacSweeney, M. & Waters, D. (2008). Sign Language and the Brain: A Review, The *Journal of Deaf Studies and Deaf Education*, Volume 13, Issue 1, 3–20, https://doi.org/10.1093/Deafed/enm035

Canagarajah, S. (2009). The plurilingual tradition and the English language in South Asia. *AILA Review*, 22, 5-22.

Canagarajah, S. (2013). Translanguaging in the classroom: Emerging issues for research and pedagogy. *Applied Linguistics Review*, 2,1 –28. doi:10.1515/9783110239331.1

Canagarajah, S., & Liyanage, I. (2012). Lessons from pre-colonial multilingualism. *The Routledge handbook of multilingualism* (pp. 67–83). London: Routledge.

Cao, C., Ma, L. & Xu, Y. (2012). Adaptive Control Theory and Applications. *Journal of Control Science and Engineering.* Volume 2012, Hindawi Publishing Corporation. DOI:10.1155/2012/827353

Caplan, D. (2001). Functional neuroimaging studies of syntactic processing. J*ournal of Psycholinguistic Research*. 30:297–320.

Caplan, D., Alpert, N., Waters, G. & Olivieri, A. (2000). Activation of Broca's area by syntactic processing under conditions of concurrent articulation. *Human Brain Mapping*. 9:65–71.

Carter, M. & Shieh, J. (2010). Electrophysiology. *Guide to Research Techniques in Neuroscience*. Pages 91-118. https://doi.org/10.1016/B978-0-12-374849-2.00004-5

Cenoz, J. & Gorter, D. (2017). *Translanguaging as a Pedagogical Tool in Multilingual Education*. 10.1007/978-3-319-02240-6_20.

Census (2011). Statistics South Africa. Pretoria: StatsSA Available from: https://www.statssa.gov.za/publications/P03014/P030142011.pdf Accessed: May 2019

Chee, M., Soon, C., Lee, H. & Pallier, C. (2004). Left insula activation: A marker for language attainment in bilinguals. *Proceedings of the National Academy of Sciences, U.S.A* 101:15265–15270.

Chen, Y., Chen, K., Ding, J., Zhang, Y., Yang, Q., Lv, Y., Guo, Q., & Han, Z. (2017). Brain Network for the Core Deficits of Semantic Dementia: A Neural Network Connectivity-Behavior Mapping Study. *Frontiers in human neuroscience*, 11, 267. https://doi.org/10.3389/fnhum.2017.00267

Chiaravalloti, A., Micarelli, A., Ricci, M., Pagani, M., Ciccariello, G., Bruno, E., Alessandrini, M. & Schillaci1, O. (2019). Evaluation of Task-Related Brain Activity: Is There a Role for 18F FDG-PET Imaging? *BioMed Research International* Volume 2019 |Article ID 4762404 | https://doi.org/10.1155/2019/4762404

Chimhundu, H. (2002). Adoption and adaptation in Shona. Oslow: ALLEX project.

Chiswick, B. & Miller, P. (2014). International Migration and the Economics of Language, IZA Discussion Papers, No. 7880, *Institute for the Study of Labor (IZA)*, Bonn.

Chomsky, N. (1968). *Language and Mind*. Harcourt Brace Jovanovich, New York. Extended edition 1972.

Chomsky, N. (2000). New horizons in the study of language and mind. Cambridge: Cambridge University Press.

CODA+. WASLI 2019 Paris.18 July 2019. Accessed on 06 October 2019. Available from: https://signsandwords.com/2019/07/18/wasli-2019-paris/

Cokely, D. & Winston E. (2008). Phase I Deaf Consumer Needs Assessment Final Report. Report submitted on behalf of the National Consortium of Interpreter Education Centers, <http://www.interpretereducation.org/wp-con-

Cokely, D. & Winston E. (2009). Phase II Deaf Consumer Needs Assessment Final Report. Report submitted on behalf of the National Consortium of Interpreter Education Centers, <http: //www.interpretereducation.org/wp-con-tent/uploads/2011/06/FinalPhase IIDCReport.pdf.

Cokely, D. (1992). Interpretation: A sociolinguistic model. Burtonsville, MD: Linstock Press.

Collins, C. & Stockton, C. (2018). The Central Role of Theory in Qualitative Research. *Sage*, Vol 17: 1–10. DOI: 10.1177/1609406918797475 journals.sagepub.com/home/ijq

Concha, M., Bianco, I. & Wilson, S. (2012). Encoding asymmetry within neural circuits. *National Review of Neuroscienc*e; 13(12):832-43. doi: 10.1038/nrn3371

Corina, D. & Knapp, H. (2006). "Lexical retrieval in American Sign Language production," in Laboratory Phonology, 8: *Varieties of Phonological Competence*, eds L. Goldstein, D. Whalen, and C. Best (Berlin: Mouton de Gruyter), 213–239.

Corina, D., San Jose-Robertson, L., Guillemin, A., High, J., & Braun, A. (2003). Language lateralization in a bimanual language. *Journal of Cognitive Neuroscience*, 15, 718–730.

Costa, A. & Caramazza, A. (1999). Is lexical selection in bilingual's language specific? Further evidence from Spanish-English bilinguals and English-Spanish bilinguals. *Bilingual Language Cognition*. 2:231--244.

Coste, D., & Simon, D. (2009). The plurilingual social actor. Language, citizenship and education. *International Journal of Multilingualism*, 6(2), 168–185.

Council of Europe. (2001). *Common European framework of reference for languages: Learning, teaching, assessment.* Cambridge, UK: Cambridge University Press. Available at: www.coe.int/t/dg4/Linguistic/Source/Framework_EN.pdf

Courtney, S., Petit, L., Maisog, J., Ungerleider, L., & Haxby, J. (1998). An area specialized for spatial working memory in human frontal cortex. *Science*, 279, 1347–1351.

Cowie, F. (2017). , "Innateness and Language", *The Stanford Encyclopedia of Philosophy*. Stanford University.

Creese, A., & Blackledge, A. (2010). Translanguaging in the Bilingual Classroom: A Pedagogy for Learning and Teaching. *The Modern Language Journal*, 94, 103-115. https://doi.org/10.1111/j.1540-4781.2009.00986.x

Cresswell, J. (1998). Qualitative enquiry and research design: Choosing among the five traditions. Thousand Oaks, CA: Sage.

Crinion, J., Turner, R., Grogan, A., Hanakawa, T., Noppeney, U., Devlin, J.T., Aso, T.,Urayama, S., Fukuyama, H., Stockton, K., Usui, K., Green, D., Price, C. (2006.) Language control in the bilingual brain. *Science*, 312, 1537–1540.

Crosson, B., Ford, A., McGregor, K., Meinzer, M., Cheshkov, S., Li, X., Walker-Batson, D. & Briggset R. (2010). Functional imaging and related techniques: An introduction for rehabilitation researchers. *Journal of Rehabilitation Research and Development*, 47(2), vii– xxxiv.

Cutsuridis, V. (2013). Cognitive Models of the Perception-Action Cycle: A View from the Brain. *Proceedings of the International Joint Conference on Neural Networks*. 10.1109/IJCNN.2013.6706713.

Dabrowska, E. (2012). Different speakers, different grammars: Individual differences in native language attainment. *Linguistic Approaches to Bilingualism*, 2 (3). pp. 219-253. ISSN 1879-9264

DBpedia. *Magnetic resonance imaging (MRI).* Available from: https://dbpedia.org/page/Magnetic_resonance_imaging Accessed: December 2020.

De Klerk, G. (2002). "Mother Tongue Education in South Africa: The Weight of History." *International Journal of Sociology of Language*, 154: 29–46

De Kock, P. (2018). The Brics Brand from economic concept to institution of global governance - Ubuntu Magazine. Available from: https://www.researchgate.net/publication/326628650_P_de_Kock_-_The_Brics_Brand_from_economic_concept_to_institution_of_global_governance_-_Ubuntu_Magazine/citation/download Accessed: June 2019

De Monet, J. & Cardebat D. (2000). Prospects in cognitive neuroimaging: the case of language functions. In: *Handbook of Neuropsychology* (2nd ed.), edited by Boller F and Grafman J. Amsterdam: Elsevier, p. 237–257

De Quadros, R., Lillo-Martin, D., & Chen Pichler, D. (2014). Code-blending in bimodal bilingual development [Sobreposição no desenvolvimento bilíngue bimodal]. *Revista Brasileira de Linguística Aplicada*, 14, 799–834.

De Wit, M & Sluis, I. (2014). Sign language interpreter quality: the perspective of Deaf sign language users in the Netherlands", in: *The Interpreters' Newsletter*, 19 (2014), pp. 63-85.

De Wit, M. (2011). A Sign Language Interpreter in Inclusive Education: The View of Deaf Persons on their Quality of Life, MA Thesis, Edinburgh, Heriot Watt University.

De Wit, M. (2016). Register & kwalificatiesystemen voor tolken: een internationale vergelijking. In Interpres vakblad over tolken gebarentaal, *Interpres Journal for Sign Language Interpreters*) 2016/3.

De Wit, M., Crasborn, O. & Napier, J. (2021). 'Interpreting international sign: mapping the interpreter's profile', *Interpreter and Translator Trainer*. https://doi.org/10.1080/1750399X.2020.1868172

Delso, G., Fürst, S., Jakoby, B., Ladebeck, R., Ganter, C., et al. (2011). Performance measurements of the Siemens mMR integrated whole-body PET/MR scanner. *Journal of Nuclear Medicine*, 52(12):1914–1922.

Deschamps, I., Courson, M., Dick, A. & Tremblay, P. (2020). The phonological loop: is speech special? *Experimental Brain Research*. 238(10):2307-2321. doi: 10.1007/s00221-020-05886-9.

Dewaele, J.-M. & Wei, L. (2013). Is multilingualism linked to a higher tolerance of ambiguity? *Bilingualism: Language and Cognition*, 16(1), 231–240. International Journal of Multilingualism 71doi: 10.1353/sls.2004.0005

Diriker E. (2011). "User expectation surveys: questioning findings and drawing lessons for interpreter training" İ. Ü. Çeviribilim Dergisi, (in English, IU *Journal of Translation Studies*), 1(3), http://www.journals.istanbul.edu.

Dronkers, N. (1996.) A new brain region for coordinating speech articulation, *Nature* 384, 159–161.

Economic and Social Commission for Asia and the Pacific (UN ESCAP). 2017. *Beijing Declaration. Action Plan to Accelerate the Implementation of the Incheon Strategy 2017*. Available from: https://www.unescap.org/sites/default/files/F.%20Beijing_Declaration.pdf

Edwards R., Temple, B. & Alexander, C. (2005). "Users' experiences of interpreters: the critical role of trust", *Interpreting*, 7/1, 77-95.

Eimer, M. (2011). The face-sensitive N170 component of the event-related brain potential. In: Calder, A., Rhodes G, Johnson, M. & Haxby, J. (eds) *The Oxford Handbook of Face Perception*. New York, NY, Oxford University Press: 329–344.

ELAN (Version 6.0) [Computer software]. (2020). Nijmegen: Max Planck Institute for Psycholinguistics, The Language Archive. Retrieved from https://archive.mpi.nl/tla/elan

Elfert, M. (2019).Lifelong learning in Sustainable Development Goal 4: What does it mean for UNESCO's rights-based approach to adult learning and education?. International Review of Education, 65, 537–556. https://doi.org/10.1007/s11159-019-09788-z

Emmorey, K. (2002). Language, cognition and the brain: Insights from sign language research, Mahwah, N.J. Lawrence Erlbaum.

Emmorey, K. & McCullough. (2009). The bimodal bilingual brain: Effects of sign language experience. *Brain and Language*. Vol 109. pp124-132. https://doi.org/10.1016/j.bandl.2008.03.005

Emmorey, K. & Özyürek, A. (2014). Language in our hands: Neural underpinnings of signlanguage and co-speech gesture. In: Gazzaniga M & Mangun GR (eds) *The Cognitive Neurosciences* (5th ed.). Cambridge, Mass., MIT Press: 657–666.

Eurobarometer Report 2012. Available at: https://epale.ec.europa.eu/en/resource-centre/content/eurobarometer-europeans-and-their-languages-2012 Accessed: 13 January 2020

Eze, M. (2010). Intellectual History in Contemporary South Africa. New York: Palgrave Macmillan.

Fabbro, F., Gran, L., Basso, G. & Bava, A. (1990). Cerebral lateralization in simultaneous interpretation. *Brain and language.* 39. 69-89. 10.1016/0093-934X(90)90005-2.

Felder, P. (2019). The Philisophical Approach of SANKOFA: Perspectives on historically marginalized doctoral students in the United States and South Africa. *International Journal of Doctoral Studies*, Vol 14.

Fiez, J., Raife, E., Balota, D., Schwarz, J., Raichle, M., & Petersen, S. (1996). A positron emission tomography study of the short-term maintenance of verbal information. *Journal of Neuroscience*, 16, 808–822.

Fodor, J. (1983). The Modularity of Mind, Cambridge, MA: MIT Press.

Fowler, J. & Ido, T. (2002). Initial and subsequent approach for the synthesis of 18FDG, *Seminars in Nuclear Medicine*, Volume 32, Issue 1,Pages 6-12. https://doi.org/10.1053/snuc.2002.29270.

Frackowiak, R. & Friston, K. (1994). Functional Neuroanatomy of the human brain- Positron Emission Tomography – A new neuroanatomical technique. *Journal of Anatomy*, 184, 211-225.

Freeman, J., Ambady, N., Midgley, K., & Holcomb, P. (2011). The real-time link between person perception and action: brain potential evidence for dynamic continuity. *Social neuroscience*, *6*(2), 139–155. https://doi.org/10.1080/17470919.2010.490674

Friederici, A. & Gazzaniga, M. (2004). The neural basis of syntactic processes, *The cognitive neurosciences*, 3rd Cambridge, MA: The MIT Press(pg. 789-801).

Friederici, A. (2004). Event-related brain potential studies in language. *Current Neurology Neuroscience*, Rep 4, 466–470 (2004). https://doi.org/10.1007/s11910-004-0070-0

Friederici, A., Meyer, M. & Von Cramon, D. (2000). Auditory language comprehension: An event-related fMRI study on the processing of syntactic and lexical information, *Brain and Language*, vol. 75 (pg. 289-300).

Friedner, M. & Kusters, A. (Eds.). (2015). It's a small world: International Deaf spaces and encounters. Washington, DC: Gallaudet University Press.

Fuster, J. (2003). Cortex and Mind: Unifying cognition. Oxford University Press.

Fuster, J. (2004). Upper processing stages of the perception–action cycle. *Trends in Cognitive Sciences*, 8(4):143-145.

Fuster, J. (2008). The prefrontal cortex (4th ed.). London: Academic Press.

Fuster, J. (2009). Cortex and memory: Emergence of a new paradigm. *Journal of Cognitive Neuroscience*, 21, 2047–2072.

Gannon, P., Holloway, R., Broadfield, D. & Braun, A. (1998).Asymmetry of Chimpanzee Planum Temporale: Human like pattern of Wernicke's brain language area Homolog. *Science*,279, 220 – 222.

Garcia, O. (2009). 'Education, multilingualism and translanguaging in the 21st Century' in A. K. Mohanty, M. Panday, R. Phillipson, and T. Skutnabb-Kangas (eds): *Multilingual Education for Social Justice: Globalising the Local*. Orient BlackSwan, pp. 140–58

Garcia, O. & Wei, L. (2014). *Translanguaging: Language, Bilingualism and Education.* Basingstoke, UK: Palgrave Macmillan.

Garcia, O., & Sylvan, C. (2011). Pedagogies and practices in multilingual classrooms: Singularities and pluralities. *The Modern Language Journal*, 95(3), 385–400. Retrieved from http://www.jstor. org/stable/41262374.

Gibson, E., Bergen, L. & Piantadosi, S. (2013). Rational integration of noisy evidence and prior semantic expectations in sentence interpretation. *Proceedings of the National Academy of Sciences*, Vol 110, 20, 8051-8056.

Gile, D. (1990). "Scientific research vs. personal theories in the investigation of interpretation." In *Aspects of Applied and Experimental Research on Conference Interpretation*, Laura Gran & Christopher Taylor (eds), 28–41. Udine: Campanotto Editore

Gile, D. (1991). Methodological Aspects of Interpretation (and Translation) Research. Target. 3. 153-174. 10.1075/target.3.2.03gil.

Gile, D. (1995). Fidelity assessment in consecutive interpretation. *Target*, 7:1, 151-164.

Gile, D. (1995). Interpretation research: A new impetus. Hermes: *Journal of Linguistics*, 14, 15–31.

Gile, D. (2001). Consecutive vs. Simultaneous: which is more accurate?. Tsuuyakukenkyuu - *Interpretation Studies*, 1:1, 8-20

Gile, D. (2005). “Directionality in conference interpreting: A cognitive view”. In R.Godijns & M.Hinderdael (Eds.), Directionality in interpreting: The ‘retour’ or the native?Ghent: *Communication and Cognition*, 9–26.

Gile, D. (2018a). Simultaneous interpreting. *An Encyclopedia of Practical Translation and Interpreting*. Hong Kong: The Chinese University Press. 531-561.

Gile, D. (2018b). The Effort Models and Gravitational Model. Clarifications and Update. 01 June 2018 version. Available at: https://www.researchgate.net/publication/325485989_The_Effort_Models_and_Gravitational_Model_Clarifications_and_Update_01_June_2018_version (Accessed 16 February 2019)

Goldin-Meadow, S., & Brentari, D. (2017). Gesture, sign and language: the coming of age of sign language and gesture studies. *Brain Behavioral Science*. 39, 1–17. doi: 10.1017/s0140525x15001247

Gow, D., Jr. (2012). The cortical organization of lexical knowledge: a dual lexicon model of spoken language processing. *Brain and language*, 121(3), 273–288. https://doi.org/10.1016/j.bandl.2012.03.005

Grabowski, T., Damasio, H., Frank, R., Hichwa, R., Ponto, L. & Watkins, G. (1995). A new technique for PET slice orientation and MRI-PET co-registration. *Human Brain Mapping*. 2, 123-133.

Green, D. & Abutalebi, J. (2013). Language control in bilinguals: the adaptive control hypothesis. *Journal of Cognitive Psychology*. 25, 515–530. doi: 10.1080/20445911.2013.796377.

Green, D., & Abutalebi, J. (2013). Language control in bilinguals: The adaptive control hypothesis. *Journal of cognitive psychology*, 25(5), 515–530. https://doi.org/10.1080/20445911.2013.796377

Greenwood, John. (1999). Understanding the ‘Cognitive Revolution’ in Psychology. *Journal of the History of the Behavioral Sciences.* 35. 1 - 22. 10.1002/(SICI)1520-6696(199924)35:1<1::AID-JHBS1>3.0.CO;2-4.

Groen, M., Whitehouse, A., Badcock, N. & Bishop, D. (2012). Does cerebral lateralization develop? A study using functional transcranial Doppler ultrasound assessing lateralization for language production and visuospatial memory. *Brain and behavior*, 2(3), 256–269. https://doi.org/10.1002/brb3.56

Grosjean, F. (2001). “The bilingual’s language modes,” in *One Mind, Two Languages: Bilingual Language Processing* ed. Nicol J. Oxford: Blackwell; 1–22.

Guba, E. & Lincoln, Y. (1994). Competing paradigms in qualitative research. In N. K. Denzin & Y. Lincoln (Eds.), *Handbook of qualitative research* (pp. 105-117). Thousand Oaks, CA: Sage

Gumperz, J.(1960). ’Formal and informal standards in Hindi regional language area (with C. M. Naim),’ in C. A. Ferguson and J. J. Gumperz (eds): Linguistic Diversity in South Asia, Vol. III. RCAPF-P, pp. 92–118. *International Journal of American Linguistics* 26/3.

Gumperz, J. (1964). ‘Linguistic and social interaction in two communities,’ *American Anthropologist* 66/(6/2): 137–53.

Gumperz, J. (1982). Discourse strategies. New York, NY: Cambridge University Press.

Gutierrez, E., Müller, O., Baus, C. & Carreiras, M. (2012). Electrophysiological evidence for phonological priming in Spanish Sign Language lexical access. *Neuropsychologia*, 50(7): 1335–1346.

Gutierrez, E., Williams, D., Grosvald, M. & Corina, D. (2012). Lexical access in American Sign Language: An ERP investigation of effects of semantics and phonology. *Brain Research,* 1468: 63–83.

Hagoort, P., (2006). On Broca, brain, and binding. In: Grodzinsky, Y., Amunts, K. (Eds.), Broca’s Region. Oxford University. Press, Oxford, pp. 242–253.

Haier, R., Siegel, B. Jr, MacLachlan, A., Soderling, E., Lottenberg, S., Buchsbaum, M. (1992). Regional glucose metabolic changes after learning a complex visuospatial/motor task: a positron emission tomographic study. *Brain Research Bulletin*. 570(1-2):134-43. doi: 10.1016/0006-8993(92)90573-r.

Harrington, F. & Turner, G. (2001). Interpreting Studies & reflections on sign language interpreting. *Interpreting*. 6. 222-226. 10.1075/intp.6.2.09roy.

Harris, I., Gary, E., Cynon, S., Henri, T., George, P. & John, W. (2000). Selective right parietal lobe activation during mental rotation: A parametric PET study. *Brain*. 123. 10.1093/brain/123.1.6

Hashimoto, Y. & Sakai, K. (2003). Brain activations during conscious self- monitoring of speech production with delayed auditory feedback: an fMRI study. Human Brain Mapping, 20(1):22-8. doi: 10.1002/hbm.10119. PMID: 12953303; PMCID: PMC6871912.

Haug, T. & Audeoud, M. (2013). “Directionality Effect” beim Gebärdensprachdolmetschen Welche Dolmetschrichtung präferieren Gebärdensprachdolmetscher in der Schweiz? – Teil 2. Das Zeichen. 94. 306-316.

Hauser, M., Chomsky, N., & Fitch, W. (2002). The faculty of language: What is it, who has it, and how did it evolve? *Science*, 298(5598), 1569–1579. https://doi.org/10.1126/science.298.5598.1569

Hauser, M., Yang, C., Berwick, R., Tattersall, I., Ryan, M., Watumull, J., Chomsky, N. & Lewontin, R (2014). The mystery of language evolution. *Frontiers in Psychology*, Vol 5; Art 401, 1-12.

Heap, M. & H. Morgans. (2006). Language policy and SASL interpreters in the public service. In Disability and social change: A South African agenda, ed. M. Watermeyer, L. Swartz, T. Lorenzo, M. Schneider, and M. Priestley., 134–147. Pretoria: HSRC Press.

Henderson, J., Choi, W., Lowder, M. & Ferreira, F. (2016). Language structure in the brain: A fixation-related fMRI study of syntactic surprise in reading. *NeuroImage* 132 (2016) 293–3.

Herrera, E. & García Frigola, C. (2008). Genetics and development of the optic chiasm. *Frontiers in bioscience* : a journal and virtual library. 13. 1646-53. 10.2741/2788.

Hervais-Adelman A, Moser-Mercer B, Golestani N. (2011). Executive control of language in the bilingual brain: integrating the evidence from neuroimaging to neuropsychology. *Frontiers in Psychology*. 2:234

Hervais-Adelman, A. & Babcock, L. (2019). The neurobiology of simultaneous interpreting: Where extreme language control and cognitive control intersect. *Bilingualism: Language and Cognition* 23(4):1-12

Hervais-Adelman, A., Moser-Mercer, B., Michel, C. & Golestani, N. (2015). fMRI of Simultaneous Interpretation Reveals the Neural Basis of Extreme Language Control, *Cerebral Cortex*, Volume 25, Issue 12, Pages 4727–4739, https://doi.org/10.1093/cercor/bhu158

Hesse, M., Thiel, C., Stephan, K. & Fink, G. (2006). The left parietal cortex and motor intention: An event related functional magnetic resonance imaging study. *Neuroscience*, 140(4):1209–1221.[PubMed: 16675134].

Horwitz, B., Amunts, K., Bhattacharyya, R., Patkin, D., Jeffries, K. & Zilles, K. (2003). Activation of Broca's area during the production of spoken and signed language: A combined cytoarchitectonic mapping and PET analysis. Neuropsychologia. Vol. 4. pg. 1868-1876.

Haualand, H. (2019). The field of sign language interpreting is totally dominated by women at the national level, but women are hugely under-representated the international. Also deaf education dominated by females, but at international level - abundance of men [Twitter]. 23 July. Accessed on 06 October 2019. Available on: https://twitter.com/hildemh/status/1153670753591746560

Hubel, D. (1995). Eye, brain and vision (2nd ed). New York: Scientific American Library.

Humphries, T. & MacDougall, F. (1999). “Chaining” and other links. Making connections between American sign language and English in two types of school settings. *Visual Anthropology Review*, 2, 84-94.

Ibrahim, M. (2015). The Art of data analysis. *Journal of Allied Health Sciences Pakistan*, Vol.1(1), 98-104.

International Association of Conference Interpreters. (AIIC). ABC of Interpreting Available from: https://aiic.africa/abc-of-interpreting/ Accessed: May 2019

Jacquemot, C. & Scott, S. (2006). What is the relationship between phonological short-term memory and speech processing? *Trends Cognitive Science*, 10 (11), 480–486.

Jafari, L. & Silverman D. (2015). What is NeuroQ™ ? Available from: https://s3.amazonaws.com/rdcms-snmmi/files/production/public/ACNM/Documents/Spotlight_Articles_2015/What%20is%20NeuroQ_May2015.pdf Accessed: December 2020.

Jamadar, S., Ward, P., Close, T., Fornito, A., Premaratne, M., O’Brien, K., Stäb, D., Chen, Z., Shah, N. & Egan, G. (2020). Simultaneous BOLD-fMRI and constant infusion FDG-PET data of the resting human brain. *Scientific Data.* 7. 10.1038/s41597-020-00699-5.

Janzen T. & Korpiniski D. (2005). “Ethics and professionalism in interpreting”, in T. Janzen (ed.) Topics in Signed Language Interpreting, Amsterdam/Philadelphia

Jarvis, P. (1999). The Practitioner-Researcher. Developing Theory from Practice. San Francisco, CA: Jossey-Bass

Jeannerod, M. (2006). Motor cognition: What actions tell to the self. Oxford: Oxford University Press. John Benjamins, 121-130.

Jeong H., Baek, C., Son, Y., Choi, J., Kim, H., Ko, Y., Chung, J. & Baek, H. (2006). Integrated 18F-FDG PET/CT for the initial evaluation of cervical node level of patients with papillary thyroid carcinoma: comparison with ultrasound and contrast-enhanced CT. *Clinical Endocrinology (Oxford).* 65(3):402-7. doi: 10.1111/j.1365-2265.2006.02612.x. PMID: 16918964.

Jolliffe, I. & Cadima, J. (2016). Principal component analysis: A review and recent developments. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences.* 374. 20150202. 10.1098/rsta.2015.0202.

Jørgensen, J., Karrebæk, M., Madsen, L., & Møller, J. (2011). Polylanguaging in superdiversity. *Diversities*, 13, 23–37.

Kaas, J. (1997). Topographic maps are fundamental to sensory processing. Brain Research Bulletin, 44 107–112.

Kagan, J. & Herschkowitz, N. (2005). A young mind in a growing brain. Lawrence Erlbaum Associates Publishers.

Kahane, E. (2000). Thoughts on the quality of interpretation. Retrieved March, 2019. http://www.aiic.net.ViewPage.cfm/page197.htm

Kalina S. (2002). “Quality in interpreting and its prerequisites. A framework for a comprehensive view”, in G. Garzone / M. Viezzi (eds), Interpreting in the 21st Century: Challenges and Opportunities, Amsterdam/Philadelphia.

Kameyama, M., Murakami, K., & Jinzaki, M. (2016). Comparison of [(15)O] H2O Positron Emission Tomography and Functional Magnetic Resonance Imaging in Activation Studies. *World journal of nuclear medicine*, 15(1), 3–6. https://doi.org/10.4103/1450-1147.172139)

Karolis, V., Corbetta, M. & Thiebaut de Schotten, M. (2019). The architecture of functional lateralisation and its relationship to callosal connectivity in the human brain. *Nature Communications*,10, 1417. https://doi.org/10.1038/s41467-019-09344-1

Kedar, Y. (2019). Innateness of Language. Oxford Research Encyclopedia of Linguistics. Accessed on 13 October 2019.

Kellett, B. (2002). "Spoken-language and signed-language interpretation. Are they really so different?" in G. Garzone / M. Viezzi (eds) Interpreting in the 21st Century: Challenges and Opportunities.

Kelly, R., Tapio, E., & Dufva, H. (2015). *Many languages, many modalities: Finnish sign language users as learners of English*. In T. Jakonen, J. Jalkanen, T. Paakkinen, & M. Suni (Eds.), Kielen oppimisen virtauksia [Flows of language learning] (pp. 113–125). Jyväskylä: Suomen soveltavan kielitieteen yhdistys.

Kemeny, S., Xu, J., Park, G., Hosey, L., Wettig, C., Braun, A. (2006). Temporal dissociation of early lexical access and articulation using a delayed naming task—An FMRI study. *Cerebral. Cortex,* 16 (4), 587–595.

Kent, S. (2012). The Vision of David Marr. *Perception*. 41.1061-72.10.1068/p7297.

Keyser, C. & Perret, D. (2004). Demystifying Social Cognition: A Hebbian Perspective. *Trends in Cognitive Sciences*, 8, 501-507.

Kheder, S. & Kaan, E. (2018). Lexical selection, cross-language interaction, and switch costs in habitually codeswitching bilinguals. *Bilingualism: Language and Cognition*, 1-21. DOI:10.1017/S1366728918000500.

Koechlin, E., Ody, C. & Kouneiher, F. (2003). The architecture of cognitive control in the human prefrontal cortex. *Science,* 302, Vol. 302. Issue 5648, pp. 1181-1185 DOI:10.1126/science.1088545

Kohli, A. (2012). Coping with globalization: Asian versus Latin American strategies of development, 1980-2010. *Brazilian Journal of Political Economy*. vol.32 no.4 Available at: https://doi.org/10.1590/S0101-31572012000400001 Accessed 12 January 2020

Kohn, K. & Kalina, S. (1996.) "The Strategic Dimension of Interpreting". *Meta* 41, 1, 118-138.

Kosslyn, S., Gazzaniga, M., Galaburda, A. & Rabin, C. (1999). Hemispheric specialization. In Fundamental Neuroscience, ed. MJ Zigmond, FE Bloom, SC Landis, JL Roberts, LR Squire. San Diego: Academic Press

Kotz, S., Meyer, M., Alter, K., Besson, M., Cramon, D. & Friederici, A. (2003). On the lateralization of emotional prosody: An event-related functional MR investigation. *Brain and language*. 86. 366-76. 10.1016/S0093-934X(02)00532-1.

Kovelman, I., Shalinsky, M., Berens, M. & Petitto, L. (2008). Shining new light on the brain's "Bilingual Signature:" a functional Near Infrared Spectroscopy investigation of semantic processing. *Neuro Image*, 39, 1457-1471.

Kroll, J. & Sunderman, G. (2003). Cognitive processes in second language learners and bilinguals: The development of lexical and conceptual representations. In: Doughty, C.; Long, M., editors. The handbook of second language acquisition. Blackwell; Oxford: p. 104-129.

Kubota, R. (2014). The multi/plural turn, postcolonial theory, and neoliberal multiculturalism: Complicities and implications for applied linguistics. *Applied Linguistics*, amu045.

Kurz, I. (1993). "Conference interpretation: expectations of different user groups", in *The Interpreters' Newsletter*, 5, 13-21.

Kusters, A. & De Meulder, M. & O'Brien, D. (2013). Innovations in Deaf Studies – The Role of Deaf Scholars. Oxford University Press.

Kusters, A. (2017). Gesture-based customer interactions: Mumbaikars' multimodal and metrolingual practices. *International Journal of Multilingualism*, 14.

Kusters, A., Spotti, M., Swanwick, R. & Tapio, E. (2017). Beyond languages, beyond modalities: transforming the study of semiotic repertoires. *International Journal of Multilingualism*, Vol 14, No 3, 219-232 https://doi.org/10.1080/14790718.2017.1321651

Ladd, P. (2003). Understanding Deaf Culture: In Search of Deafhood. 10.21832/9781853595479.

Lai, G. & O'Brien, B. (2020). Examining Language Switching and Cognitive Control Through the Adaptive Control Hypothesis. *Frontiers in Psychology* Vol 11, 1171 .

Lambon Ralph, M. & Patterson, K. (2008). Generalization and differentiation in semantic memory: Insights from semantic dementia. *Cognitive Neuroscience*, 1124, 61–76.

LaPres, J. (2009). Cranial Nerves Figure 14–18 Origins of the Cranial Nerves. Pearson Education, Inc., publishing as Pearson Benjamin Cummings.

Lees, N. (2021). The Brandt Line after forty years: The more North–South relations change, the more they stay the same? *Review of International Studies, 47*(1), 85-106. doi:10.1017/S026021052000039

Leisman, G., Moustafa, A. A., & Shafir, T. (2016). Thinking, Walking, Talking: Integratory Motor and Cognitive Brain Function. *Frontiers in public health*, 4, 94. https://doi.org/10.3389/fpubh.2016.00094

Lewis, M., Simons, G. & Fennig, C (Eds.) (2013). Ethnologue: Languages of the World, 17th edition. Dallas: SIL International. Available from: http://www.ethnologue.com Accessed: June 2019

Lewis, P. & Simons, G. (2013). The world's languages in crisis: A 20-year update. Responses to language endangerment. Elena, M., Perley, B., Rei-Doval, G. & Wheatley, K. (eds.). Responses to language endangerment. In honor of Mickey Noonan. *Studies in Language Companion Series* 142. Amsterdam: John Benjamins. Pp. 3–19.

Li, H. & Marsh, L. (2020). Building the BRICS: Media, Nation Branding, and Global Citizenship. *International Journal of Communication* 10(2016), 2973–2988 Available from: https://ijoc.org/index.php/ijoc/article/viewFile/5878/1689 Accessed: January 2020

Liddell, S. (2003). Grammar, gesture, and meaning in American sign language. Cambridge: Cambridge University Press.

Locker McKee, R. & Davis J. (Eds). (2010). "Signed Language Interpreting in Multilingual Contexts", *Studies in Interpretation Series*, Volume 6, Washington DC, Gallaudet University Press.

Locker McKee, R. (2008). "'Quality' in interpreting: a survey of practitioner perspectives." *The Sign Language Translator and Interpreter* (SLTI), 2/1, 1-14

Lundin, S. *Ubuntu-"I am what I am because of who we all are".* 02 June 2012. Available from: http://morvensblog.wordpress.com/2012/04/23/ubuntu-a-lesson-from-the-children/ Accessed 08 March 2019.

Ma, H., Hu, J., Xi, J., Shen, W., Ge, J., et al. (2014). Bilingual Cognitive Control in Language Switching: An fMRI Study of English-Chinese Late Bilinguals. PLoS

Maalej, Z. (2001). Robin Setton, Simultaneous Interpretation. A Cognitive-pragmatic Analysis. *Journal of Literary Semantics*. 30. 10.1515/jlse.2001.012.

MacDougall, D. (2012) "Gendered Discourse and ASL-to-English Interpreting: A Poststructuralist Approach to Gendered Discourse and the ASL-to-English Interpretive Process," *Journal of Interpretation*: Vol. 19 : Iss. 1 , Article 2. Available at: http://digitalcommons.unf.edu/joi/vol19/iss1/2

Macswan, J. (1999). A Minimalist Approach to Intrasentential Code Switching. In L. Horn (Ed.), *Outstanding dissertations in linguistics*, a Garland series.New York, NY: Garland Publishing.

MacSwan, J. (2000). The architecture of the bilingual language faculty: Evidence from codeswitching. *Bilingualism: Language and Cognition,* 3(1), 37–54.

MacSweeney, M., Campbell, R., Woll, B., Brammer, M. Giampietro V, David, A., Calvert, G., & McGuire, P. (2006). Lexical and sentential processing in British Sign Language. *Human Brain Mapping*, 27(1): 63–76.

MacSweeney, M., Capek, C. Campbell, R. & Woll, B. (2008). The signing brain: The neurobiology of sign language. *Trends Cognitive Science*, 12 (11): 432-440.

Mahendra, N., Plante, E., Magloire, J., Milman,L. & Trouard, T. (2003). fMRI variability and the localization of languages in the bilingual brain. *Neuro Report* ;14:1225–1228.

Makalela, L. (2018a). "Imagining a Thriving Multilingual World" , 4th International Conference on Language and Literacy Education 2018 Conference Report. *Educational Research for Social Change* (ERSC), Volume: 7 No.; pp. 97-99 ersc.nmmu.ac.za, ISSN: 2221-4070

Makalela, L. (2018b) "Our academics are intellectually colonised": Multilanguaging and Fees Must Fall, Southern African Linguistics and Applied Language Studies, 36:1, 1-11, DOI: 10.2989/16073614.2018.1452877

Marshall, S & Moore, D. (2018). Plurilingualism amid the panoply of lingualisms: addressing critiques and misconceptions in education, *International Journal of Multilingualism*, 15:1, 19-34, DOI: 10.1080/14790718.2016.1253699

Marshall, S. (2020). Understanding plurilingualism and developing pedagogy: teaching in linguistically diverse classes across the disciplines at a Canadian university. *Language, Culture and Curriculum*, 33:2, 142-156, DOI: 10.1080/07908318.2019.1676768

Martín, R. (2010). On paradigms and cognitive translatology. 10.1075/ata.xv.10mun.

Martin, R., Miller, M. & Vu, H. (2004). Lexical-semantic retention and speech production: Further evidence from normal and brain-damaged participants for a phrasal scope of planning. Cognitive *Neuropsychology*, 8, 506-523.

Mazoyer, B., Tzourio, N., Frak, V., Syrota, A., Murayama, N., Levrier, O., Salamon, G., Dehaene, S., Cohen, L. & Mehler, J. (1993). The Cortical Representation of Speech. Journal of Cognitive *NeuroScience*, 5. 467-79.10.1162/jocn.1993.5.4.467.

Mazzaferro, G. (2018). (Ed). Translanguaging as an Everyday Practice. Springer. DOI: 10/1007/978-3-319-94851-5_1.

Mbembe, A. (2016). Decolonizing the university. *New directions Arts & Humanities in Higher Education 2016*, Vol. 15(1) 29–45.

McGuire, P., Robertson, D., Thacker, A., David, A., Kitson, N. & Frackowiak, R. (1997). Neural correlates of thinking in sign language. *Neuro Report*, 8 (3), 695–698.

Mcnamara, T. (2011). “Multilingualism in Education: A Poststructuralist Critique.” *The Modern Language Journal* 95(3): 430–441/

Mechelli, A., Crinion, J., Noppeney, U., O'Doherty, J., Ashburner, J., Frackowiak, R. & Price, C. (2004). Neurolinguistics: Structural plasticity in the bilingual brain. *Nature*. 431. 757. 10.1038/431757a.

Mehra, D. & Moshirfar, M. *Neuroanatomy, Optic Tract*. (2020) Jul 31. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021 Jan–. PMID: 31751030.

Meir, I., Israel, A., Sandler, W., & Padden, C. & Aronoff, Mark. (2012). The influence of community on language structure: Evidence from two young sign languages. *Linguistic Variation*. 12.

Merriam, S. (2009). *Qualitative research: A Guide to design and implementation.* San Francisco, CA: Jossey-Bass.

Meulder, M. & Haualand, H. (2019). Sign language interpreting services: A quick fix for inclusion?. *Translation and Interpreting Studies*. https://doi.org/10.1075/tis.18008.dem

Mijalkov, M., Kakaei, E., Pereira, J., Westman, E. &Volpe, G. (2017) Alzheimer's Disease Neuroimaging Initiative. BRAPH: A graph theory software for the analysis of brain connectivity. *PLoS One*. 1;12(8):e0178798. doi: 10.1371/journal.pone.0178798. PMID: 28763447; PMCID: PMC5538719.

Mikkelson, H. & Jourdenais, R. (2018). Introduction. The Routledge handbook of interpreting. Routledge, New York.

Miller, J. (2004). Culturally sensitive research questions and methods in social psychology. *The SAGE Handbook of Methods in Social Psychology*. 93-116.

Mion M., Patterson K., Acosta-Cabronero J., Pengas G., Izquierdo-Garcia D. & Hong Y. (2010). What the left and right anterior fusiform gyri tell us about semantic memory. *Brain*. 133(11):3256–3268.

Mizuno, A. (2005). Process Model for Simultaneous Interpreting and Working Memory. *Meta*. 50. 10.7202/011015ar.

Mohajan, H. (2018). Qualitative Research Methodology in Social Sciences and Related Subjects. *Journal of Economic Development, Environment and People*, Vol-7, Issue 01,pp. 23-48.

Morse, J. (2011). Moulding Qualitative Health Research. *Qualitative Health Research*. 21(8):1019-1021. doi:10.1177/1049732311404706

Moser-Mercer, B. (2000). Simultaneous interpreting: cognitive potential and limitations. *Interpreting.* Vol 5:83–94.

Moser- Mercer, B. (2010). “The search for neuro-physiological correlates of expertise in interpreting.” In *Translation and Cognition*, G. Shreve & E. Angelone (eds), 263-288. Amsterdam: John Benjamins Publishing Company.

Moser, P. (1995) Survey on expectations of users of conference interpretation. Final report commissioned by AIIC, Vienna: SRZ Stadt + Regionalforschung GmbH.

Moser, P. (1996). “Expectations of users of conference interpretation”, I*nterpreting* 1/2, 145-178.

Moser-Mercer, B. (2000). ‘Simultaneous Interpreting: Cognitive Potential and Limitations’, Interpreting 5(2): 83–94.

Müller, N., Arnaus Gil, L., Eichler, N., Geveler, J., Hager, M., Jansen, V., Patuto, M., Repetto, V. & Schmeißer, A. (2015). Code-Switching: Spanisch, Italienisch, Französisch. Eine Einführung. Tübingen: Narr.

Murray, E., Bussey, T. & Wise, S. (2000). Role of prefrontal cortex in a network for arbitrary visuomotor mapping. *Experimental Brain Research*, 133, 114–129.

Murray. J. (2015) Linguistic Human Rights Discourse in the Dea Community. *Sign Language Studies*, Vol. 15, No. 4, Special Issue: Language Planning and Sign Language Rights (Summer 2015), pp. 379-410

Muysken, P. (1997). Code-Switching processes. Alternation, insertion, congruent lexicalization. In M. Pütz (Ed.), Language Choices: Conditions, constraints, and consequences (pp. 361–380). Amsterdam: Benjamins.

Napier, J. & Barker, R. (2004). Sign Language Interpreting: The Relationship between Metalinguistic Awareness and the Production of Interpreting Omissions. *Sign Language Studies*. 4. 369-393. 10.1353/sls.2004.0020.

Napier, J. & Rohan, M. (2007). An invitation to dance: Deaf consumers' perceptions of signed language interpreters and interpreting. in M Metzger & E Fleetwood (eds), Translation, sociolinguistic, and consumer issues in interpreting. *Studies in interpretation*, vol. 3, Gallaudet University Press, Washington, DC, pp. 159-203.

Napier, J. (2002). University Interpreting: Linguistic Issues for Consideration. *Journal of Deaf studies and Deaf education.* 7. 281-301. 10.1093/Deafed/7.4.281.

Napier, J. (2003). "A sociolinguistic analysis of the occurrence and types of omissions produced by Australian Sign Language/ English interpreters", in M. Metzger, S. Collins, V. Dively & R. Shaw (eds), From Topic Boundaries to Omission: Research on Interpretation, Washington DC, Gallaudet University Press,160-240

Napier, J. (2009). International perspectives on sign language interpreter education / Jemina Napier, editor. (*Interpreter education series: v. 4*). Gallaudet University Press. http://search.ebscohost.com/login.aspx?direct=true&db=edshlc&AN=edshlc.011977912-9&site=eds-live

Napier, J. (2018). Comparing signed and spoken language interpreting. In H. Mikkelson, & R. Jourdenais (Eds.), *The Routledge Handbook of Interpreting* (pp. 129-143). Routledge.

Napier, J., Rohan, M., & Slatyer, H. (2005). Perceptions of bilingual competence and preferred language direction in Auslan/English interpreters. *Journal of Applied Linguistics*, 2(2), 185-218.

Narain, C., Scott, S., Wise, R., Rosen, S., Leff, A. & Iversen, S. (2003). Defining a left-lateralized response specific to intelligible speech using fMRI, *Cerebral Cortex*. Vol. 13, pg. 1362-1368.

Nasios, G., Dardiotis, E. & Messinis, L. (2019). From Broca and Wernicke to the Neuromodulation Era: Insights of Brain Language Networks for Neurorehabilitation. *Behavioural neurology*. Volume 2019. 10.1155/2019/9894571.

Ndhlovu, F. (2008).The politics of language and nationality in Zimbabwe: Nation building or empire building?, *South African Journal of African Languages*, 28:1, 1-10, DOI: 10.1080/02572117.2008.10587297

Negrón-Oyarzo, I., Aboitiz, F. & Fuentealba, P. (2015). Impaired Functional Connectivity in the Prefrontal Cortex: A Mechanism for Chronic Stress-Induced Neuropsychiatric Disorders. *Neural Plasticity*. Volume 2016, Article ID 7539065, 16 pages http://dx.doi.org/10.1155/2016/7539065

Nenov, V., Halgren, E., Mandelkern, M. & Smith, M. (1994). "Human brain metabolic responses to familiarity during lexical decision," *Human Brain Mapping*, vol. 1, no. 4, pp. 249–268.

Neubauer, S., Gunz, P., Scott, N., Hublin, J. & Mitteroecker, P. (2020). Evolution of brain lateralization: A shared hominid pattern of endocranial asymmetry is much more variable in humans than in great apes. Science Advances, 6 (7): eaax9935 DOI: 10.1126/sciadv.aax9935

Neville, H., Coffey, S., Lawson, D., Fischer, A., Emmorey, K. & Bellugi, U. (1997). Neural systems mediating American Sign Language: Effects of sensory experience and age of acquisition, *Brain and Language*, Vol. 57. pg. 285-308.

Neville, H., Nicol, J., Barss A, Forster, K. & Garrett, M. (1991). Syntactically based sentence processing classes: evidence from event-related brain potentials. *Journal of Cognitive Neuroscience*, 3(2):151-65. doi: 10.1162/jocn.1991.3.2.151. PMID: 23972090.

Nicodemus, B. & Emmorey, K. (2015). Directionality in ASL-English interpreting: Accuracy and articulation quality in L1 and L2. *Interpreting* (Amst). 17(2):145-166. doi: 10.1075/intp.17.2.01nic. PMID: 28855844; PMCID: PMC5573233.

Nishimura, H., Hashikawa, K., Doi, K., Iwaki, T., Watanabe, Y., Kusuoka, H., Nishimura, T. & Kubo, T. (1999). Sign language 'heard' in the auditory cortex. *Nature*, 397(6715): 116.

Noble, H. & Heale, R. (2019). Triangulation in research, with examples. *Evidence Based Nursing*, 22(3):67-68. doi: 10.1136/ebnurs-2019-103145.

Nystrom, L., Braver, T., Sabb, F., Delgado, M., Noll, D. & Cohen J. (2000). Working memory for letters, shapes, and locations: fMRI evidence against stimulus-based regional organization in human prefrontal cortex. *Neuro Image*, 11, 424–446.

Olulade, O., Seydell-Greenwald, A., Chambers, C., Turkeltaub, P., Dromerick, A., Berl, M., Gaillard, W. & Newport, E. (2020). The neural basis of language development: Changes in lateralization over age. *Proceedings of the National Academy of Sciences* (PNAS) 117 (38) 23477-23483. https://doi.org/10.1073/pnas.1905590117

Pan South African Language Board. (2021). PANSALB calls for information on Covid-19 vaccine to be made available in all languages. Accessed: 20 February 202. Available at: https://www.gov.za/speeches/pansalb-calls-information-covid-19-vaccine-be-made-available-all-languages-3-feb-2021-0000#

Pandya, D. (1995). Anatomy of the auditory cortex, *Rev. Neurol*. 151, 486–494

Passow, S., Specht, K., Adamsen, T., Biermann, M. , Brekke, N., Craven, A., Ersland, L., Grüner, R., Kleven-Madsen, N. , Kvernenes, O., Schwarzlmüller, T, Olesen, R. & Hugdahl, K. (2015). Default-mode network functional connectivity is closely related to metabolic activity. Human Brain Mapping, 36(6):2027-38. doi: 10.1002/hbm.22753.

Penn, C., & Reagan, T. (1994). THE PROPERTIES OF SOUTH AFRICAN SIGN LANGUAGE: LEXICAL DIVERSITY & SYNTACTIC UNITY. *Sign Language Studies*, (85), 319-327. Retrieved July 15, 2021, from http://www.jstor.org/stable/26204735

Pennycook, A. (2010). Critical and alternative directions in applied linguistics. *Australian Review of Applied Linguistics*, 33(2), 16.1–16.16.

Pennycook, A., & Otsuji, E. (2015). Metrolingualism: Language in the city. London: Routledge.

Peperkamp, S. & Mehler, J. (1999). Signed and Spoken Language: A Unique Underlying System. *Language and Speech*, 42 (2–3), 333– 346

Perry, L. & Lupyan, G. (2013). What the online manipulation of linguistic activity can tell us about language and thought. *Frontiers in behavioral neuroscience*. 7. 122. 10.3389/fnbeh.2013.00122.

Pessoa L. (2014). Understanding brain networks and brain organization. *Physics of life reviews*, 11(3), 400–435. https://doi.org/10.1016/j.plrev.2014.03.005

PET-CT. (2020). *DBpedia*. Available at: https://dbpedia.org/page/PET-CT Accessed on 05 November 2020.

Petersen, S., Fox, P. Snyder, A. & Raichle, M. (1990). Activation of extrastriate and frontal cortical areas by visual words and word-like stimuli. *Science.* Vol. 249, Issue 4972, pp. 1041-1044. DOI: 10.1126/science.2396097

Petitto, L. & Dunbar, K. (2004). New findings from educational neuroscience on bilingual brains, scientific brains, and the educated mind. In: Fischer, K. & Katzir, T., editors. *Building Usable Knowledge in Mind, Brain, & Education.* Cambridge University Press.

Petitto, L. & Kovelman, I. (2003). The bilingual paradox: How signing-speaking bilingual children help us to resolve it and teach us about the brain's mechanisms underlying all language acquisition. *Learning Languages*, 8(3):5–19.

Petitto, L. & Marentette, P. (1991) Babbling in the manual mode: Evidence for the ontogeny of language. *Science*, 251:1483–1496.

Petitto, L. (2005). How the brain begets language. In J. McGilvray (Ed.), *The Cambridge Companion to Chomsky*. England: Cambridge University Press, 84-101.

Petitto, L. (2009). New Discoveries from the Bilingual Brain and Mind Across the Lifespan: Implications for Education. *International Journal of Mind, Brain and Education*, 3(4), 185-197.

Petitto, L., Katerelos, M., Levy, B., Gauna, K., Tetreault, K. & Ferraro, V. (2001). Bilingual signed and spoken language acquisition from birth: Implications for the mechanisms underlying early bilingual language acquisition. *Journal of Child Language*. 28(2):453–496.

Petitto, L., Langdon, C., Stone, A., Andriola, D., Kartheiser, G., & Cochran, C. (2016). Visual sign phonology: Insights into human reading and language from a natural soundless phonology. WIREs Cognitive Science.

Petitto, L., Zatorre, R., Gauna, K., Nikelski, E., Dostie, D. & Evans, A. (2000). Speech-like cerebral activity in profoundly Deaf people processing signed languages: Implications for the neural basis of human language, *Proceedings of the National Academy of Sciences of the United States of America*, Vol. 97 (pg. 13961-13966).

Pfau, R., Steinbach, M. & Woll, B. (2012). Sign Language - An International Handbook. Sign Language & Linguistics. 16. 10.1075/sll.16.2.07abn.

Pinel, J. (2000). Biopsychology (4th ed.). Boston: Allyn and Bacon.

Plante, E., Patterson, D., Sandoval, D., Vance, C. & Asbjørnsen, A. (2017). An fMRI study of implicit language learning in developmental language impairment, *NeuroImage*: Clinical. Volume 14, 277-285

Pöchhacker, F. (2004). Introducing interpreting studies. Introducing Interpreting Studies. 1-252. 10.4324/9780203504802.

Pöchhacker, F. & Shlesinger, M. (2002).The Interpreting Studies Reader. London and New York: Routledge.

Pöchhacker, F. (1995). 'Those who do … ': A profile of research(ers) in interpreting. *Target*, 7(1), 47–64.

Pöchhacker, F. (2005). From Operation to Action: Process-Orientation in Interpreting Studies. *Meta: Journal des traducteurs.* 50. 682. 10.7202/011011ar.

Population Division of the UN Department of Economic and Social Affairs (UNDESA). (2020). *International Migration 2020 Highlights*. Available at: https://www.un.org/en/desa/international-migration-2020-highlights Accessed: 17 January 2021

Posner, M. & Raichle, M. (1994). Images of mind. Scientific American Library/Scientific American Books.

Prah, K. (2012). The language of development and the development of language in contemporary Africa. *Applied Linguistics Review*. 3. 10.1515/applirev-2012-0014.

Prah, K. (2005). Languages of instruction for education, development and African emancipation. In B. Brock-Utne and R. K. Hopson (eds), *Languages of Instruction for African Emancipation: Focus 11th Language & Development Conference 77 on Postcolonial Contexts and Considerations*, 23-51. Cape Town: CASAS; Dar es Salaam: Mkuki na Nyota; East Lansing: State University of Michigan Press.

Price, C., Green, D. & von Studnitz R. (1999). A functional imaging study of translation and language switching. *Brain*, 122 (Pt 12): 2221--2235.

Pulvermüller, F. (1996). Hebb's concept of cell assemblies and the psychophysiology of word processing. *Psychophysiology*. 33, 317-333.

Pulvermüller, F. (1999). Words in the brain's language. *Behavioural and Brain Sciences*, 22, 253-336

Pulvermüller, F. (2018). Neural reuse of action perception circuits for language, concepts and communication. *Progress in Neurobiology*,Volume 160, 1-44,

Pulvermüller, F., Moseley, R., Egorova, N, Shebani, Z. & Boulenger, V. (2014). Motor Cognition - Motor Semantics: Action Perception Theory Of Cognition And Communication. *Neuropsychologia* 55:71-84. DOI:10.1016/j.neuropsychologia.2013.12.002

Queens University. Brain Map: Temporal Lobes. 22 January 2021.https://www.health.qld.gov.au/abios/asp/btemporal_lobes Accessed: 30 June 2021.

Quer, J. & Steinbach, M. (2019). Handling Sign Language Data: The Impact of Modality. *Frontiers in Psychology*. doi: 10.3389/fpsyg.2019.00483

Quinto-Pozos, D. & Adam, R. (2013). Sign language contact. In R. Bayley, R. Cameron, & C. Lucas (Eds.), *The Oxford handbook of sociolinguistics* (pp. 379–400). Oxford: Oxford University Press.

Raichle, M. (2015). The brain's default mode network. *Annual Review of Neuroscience*, 38, 433–447. doi: 10.1146/annurev-neuro-071013-014030.

Rampton, B. (1995). Language Crossing and the Problematisation of Ethnicity and Socialisation. *Pragmatics*; Vol 5, No 4 (1995). 5. 10.1075/prag.5.4.04ram.

Ravicz, M., Melcher, J. & Kiang, N. (2000). Acoustic noise during functional magnetic resonance imaging. *The Journal of the Acoustical Society of America*, 108(4), 1683–1696. doi:10.1121/1.1310190

Ravitch, S. & Matthew, R. (2017). Reason and Rigor: How Conceptual Frameworks Guide Research. Second edition. Los Angeles, CA: SAGE.

Reeves, T. & Hedberg, J. (2003), *Interactive Learning Systems Evaluation*, Educational Technology Publications, Englewood Cliffs, New Jersey.

Registry of interpreters for the Deaf, Inc. (2018). Annual Report 2018. Available at: https://rid.org/2018-annual-report/ (Accessed: 17 July 2020).

Rizzolatti, G. & Craighero, L. (2004). The mirror-neuron system, *Annual Review of Neuroscience*, Vol. 27 (pg. 169-192).

Rizzolatti, G., & Sinigaglia, C. (2010). The functional role of the parieto-frontal mirror circuit: Interpretations and misinterpretations. *Nature Reviews Neuroscience*, 11, 264–274.

Roy, C. & Metzger, M. (2014). Researching signed language interpreting research through a sociolinguistic lens. *Translation & Interpreting*, Vol 6 No 1 (2014) DOI: ti.106201.2014.a09.

Rohrer, J. (2018).Thinking Clearly About Correlations and Causation: Graphical Causal Models for Observational Data. Advances in Methods and Practices. *Psychological Science*, March 2018:27-42. doi:10.1177/2515245917745629

Russel, D. & Takeda, K. (2018). Consecutive Interpreting. In H. Mikkelson, & R. Jourdenais (Eds.), *The Routledge Handbook of Interpreting* (pp. 96-111). Routledge.

Ryen, A. (2004). Ethical issues. In Seale, C., Gobo, G., Gubrium, J. F., & Silverman, D. (Eds.), Qualitative research practice (pp. 218-235). SAGE Publications Ltd, https://www.doi.org/10.4135/9781848608191

Saldana, J. & Omasta, M. (2018). *Qualitative research: Analyzing life*. Los Angeles: Sage

San Jose-Robertson, L., Corina, D., Ackerman, D., Guillemin, A. & Braun, A. (2004) .Neural systems for sign language production: Mechanisms supporting lexical selection, phonological encoding, and articulation. *Human Brain Mapping*. Vol. 23. pg. 156-167.

Sandler, W. & Lillo-Martin, D. (2006). Sign Language & Linguistic Universals. Cambridge: Cambridge University Press.

Schatzki, T. (2010). Pippin's Hegel on action. *Inquir*y, 53(5), 490–505.

Schermer T. (2012). "Language planning" in Sign language. An international handbook. eds. Pfau R., Steinbach M., Woll B., editors. (Berlin: Mouton de Gruyter;), 889–908.

Schiffman, H. (1996). *Linguistic Culture and Language Policy*. London; New York:

Schreckenberger, M., Gouzoulis-Mayfrank, E & Sabri, O. et al. (1998). "Cerebral interregional correlations of associative language processing: a positron emission tomography activation study using fuorine-18 fuorodeoxyglucose," *European Journal of Nuclear Medicine and Molecular Imaging*, vol. 25, no. 11, pp. 1511–1519.

Scott, S., Blank, C., Rosen, S. & Wise, R. (2000). Identification of a pathway for intelligible speech in the left temporal lobe. *Brain*. Vol. 123, pg. 2400-2406.

Seeber, K. (2018) Simultaneous Interpreting. In H. Mikkelson, & R. Jourdenais (Eds.), *The Routledge Handbook of Interpreting* (pp. 79-95). Routledge.

Sekine, T., Burgos, N., Warnock, G., Huellner, M., Buck, A. et al. (2016). Multi-Atlas–Based Attenuation Correction for Brain 18F-FDG PET Imaging Using a Time-of-Flight PET/MR Scanner: Comparison with Clinical Single-Atlas– and CT-Based Attenuation Correction. *Journal of Nuclear Medicine,* 57 (8) 1258-1264. DOI: https://doi.org/10.2967/jnumed.115.169045

Seleskovitch, D. (1962). "L'interprétation de conférence," Babel, 8-1, p. 13-18. In Pöchhacker, F. (2005). From Operation to Action: Process-Orientation in Interpreting Processes and Pathways in Translation and Interpretation Volume 50, Number 2.

Seleskovitch, D. (1976). "Interpretation, A Psychological Approach to Translating," Translation: Applications and Research (R. W. Brislin, ed.), New York, Gardner Press, p. 92-116.

Seleskovitch, D. (1978). *Interpreting for International Conferences*. Washington, D.C.: Pen and Booth.

Seleskovith, D. & Lederer, M. (1986). *Interpréter pour traduire*. Paris: Publications de la Sorbonne Didier Erudition

Seravalle, V. (2011). *Native, non-native and near-native accent: The mediating role of identity in performance vs. perception* (Ph.D. dissertation). Royal Holloway, University of London, London, UK.

Setton, R. (1999). Simultaneous Interpretation: A Cognitive-Pragmatic Analysis. Amsterdam/ Philadelphia: John Benjamins.

Setton, R. (2016). Models of the Interpreting Process. In Encyclopedia of Interpreting Studies. 263-268 Ed. F. Pöchhacker. London: Routledge. Encyclopaedia of Interpreting Studies

Shlesinger, M. (1997): Quality in simultaneous interpreting. In: Yves Gambier, Daniel Gile, and Christopher Taylor, eds. Conference *Interpreting: Current Trends in Research. Proceedings of the International Conference on "Interpreting: What Do We Know and How*?" (Turku, August 25-27, 1994). Amsterdam: John Benjamins, 123-131.

Siemens-healthineers. (2019). *Biograph TruePoint PET/CT*. Available at: https://www.siemens-healthineers.com/es/molecular-imaging/pet-ct/biograph-truepoint-petct Accessed: 05 May 2019.

Söderfeldt, B., Ingvar, M., Rönnberg, J., Eriksson, L., Serrander, M. & Stone-Elander, S. (1997). Signed and spoken language perception studied by positron emission tomography. *Neurology*, 49 (1) 82-87.

Sommerville, J. & Decety, J. (2006). Weaving the fabric of social interaction: Articulating developmental psychology and cognitive neuroscience in the domain of motor cognition. *Psychonomic Bulletin & Review*, *13*(2), 179–200.

South African Language Practitioners Council Act 8 of 2014. Department of Arts and Culture, South Africa. Available from: http://www.dac.gov.za/sites/default/files/Legislations%20Files/South%20African%20Language%20Practitioners%27%20Council%20Act%208%20of%202014.pdf Accessed: 12 May 2019

Sporns O. (2013). Structure and function of complex brain networks. *Dialogues in clinical neuroscience*, 15(3), 247–262. https://doi.org/10.31887/DCNS.2013.15.3/osporns

Stephan, K., Fink, G. & Marshall, J. (2007).Mechanisms of hemispheric specialization: insights from analyses of connectivity. *Neuropsychologia*. 2007 Jan 28;45(2):209-28. doi: 10.1016/j.neuropsychologia.2006.07.002.

Stinnett, T., Reddy, V. & Zabel, M. (2021). *Neuroanatomy, Broca Area*. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021 Jan–. PMID: 30252352.

Strange, B. & Dolan, R. (2006). Anterior medial temporal lobe in human cognition: memory for fear and the unexpected. *Cognitive neuropsychiatry*, 11(3), 198–218. https://doi.org/10.1080/13546800500305096

Sutton-Spence, R. & Woll, B. (1999). The Linguistics of British Sign Language: Cambridge University Press.

Talpade, M. & Talpad, S. (2014). African-American learning styles, 'Sankofa' teaching and learning: evaluating relevance for today's African-American student. *Journal of Instructional Pedagogies* Volume 15.

Tapio, E. (2013). *A nexus analysis of English in the everyday life of FinSL signers: A multimodal view on interaction* (doctoral dissertation). University of Oulu, Finland.

Tapio, E. (2014). The marginalisation of finely tuned semiotic practices and misunderstandings in relation to (signed) languages and Deafness. *Multimodal Communication*, 3, 131–142

Teixeira, M. (2021). 20 most spoken languages in the world in 2021 [BLOG] 16 February 2021. Available at: https://blog.lingoda.com/en/most-spoken-languages-in-the-world-in-2020/ Accessed on 20 February 2021.

Terre Blanche, M., & Durrheim, K. (1999). Social constructionist methods. In M. Terre Blanche & K. Durrheim (Eds.), Research in practice: *Applied methods for the social sciences* (pp. 147-177). Cape Town, SA: University of Cape Town Press.

Thakur, S. & Lahiry, S. (2019). Research ethics in the modern era. *Indian Journal of Dermatology Venereology and Leprology*. 85. 351-354. 10.4103/ijdvl.IJDVL_499_18.

Thompson-Schill, S., Bedny, M. & Goldberg, R. (2005). The frontal lobes and the regulation of mental activity. *Current Opinion in Neurobiology* 15(2):219-24. DOI:10.1016/j.conb.2005.03.006

Turner, B., Marinsek, N., Ryhal, E. and Miller, M. (2015). Hemispheric lateralization in reasoning. Ann New York Academy of Sciences; 1359:47-64. doi: 10.1111/nyas.12940.

Turner, D. (2020). Sampling Methods in Research Design. Headache: *The Journal of Head and Face Pain*. 60. 8-12. 10.1111/head.13707.

Tymoczko, M. (2012). The Neuroscience of Translation. *Target* 24:1, 83–102. John Benjamins Publishing Company.

United Nations Department of Economic and Social Affairs (UNDESA). 2020. Key messages are based on International Migration 2020 Highlights. Accessed: 20 November 2020. Available at: https://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/files/international_migration_2020_highlights_ten_key_messages.pdf

University of the Witwatersrand. (2020). *Impact on Society*. Available at https://www.wits.ac.za/about-wits/wits-impact/ Accessed: 02 November 2020

University of York. (2021). *What is research impact?* Available at: https://www.york.ac.uk/staff/research/research-impact/impact-definition/ Accessed: 02 November 2020.

Vallejo, C. & Dooly, M. (2020). Plurilingualism and translanguaging: emergent approaches and shared concerns. Introduction to the special issue, *International Journal of Bilingual Education and Bilingualism*, 23:1, 1-16, DOI: 10.1080/13670050.2019.1600469

Vaquero, J. & Kinahan, P. (2015). Positron Emission Tomography: Current Challenges and Opportunities for Technological Advances in Clinical and Preclinical Imaging Systems. *Annual review of biomedical engineering*, 17, 385–414. doi:10.1146/annurev-bioeng-071114-040723

Varvatsoulias, G. (2013). "The Physiological Processes Underpinning PET and fMRI Techniques With an Emphasis on the Temporal and Spatial Resolution of These Methods". *Psychological Thought*, Vol. 6(2), 173–195. doi:10.5964/psyct.v6i2.75

Verger, A. & Guedj, E. (2018). The renaissance of functional ^{18}F-FDG PET brain activation imaging. *European Journal of Nuclear Molecular Imaging*, 45(13):2338-2341. doi: 10.1007/s00259-018-4165-2. Epub 2018 Sep 29. PMID: 30269156.

Vermeerbergen, M., Leeson, L. & Crasborn, O. (Eds.). (2007). Simultaneity in signed languages: Form and function. Amsterdam: John Benjamins.

Visser, M. & Jefferies, E. & Ralph, M. (2009). Semantic Processing in the Anterior Temporal Lobes: A Meta-analysis of the Functional Neuroimaging Literature. *Journal of cognitive neuroscience*. 22. 1083-94. 10.1162/jocn.2009.21309.

Vuorikoski, A. (1995). "Simultaneous interpretation as experienced by the audience", Krawutschke, 165-174.

Wa Thiong'o, N. (1981). Decolonising the mind: The politics of language in African.

Wa Thiong'o, N. (2004). African identities: Pan-Africanism in the era of globalisation and capitalist fundamentalism. *Macalester International* 14, 21-42.

Wagner, P., Malisz, Z. & Kopp, S. (2014). Gesture and speech in interaction: An overview. *Speech Communication*. 57. 209-232. 10.1016/j.specom.2013.09.008.

Watabe, T. & Hatazawa, J. (2019). Evaluation of Functional Connectivity in the Brain Using Positron Emission Tomography: A Mini-Review. *Frontiers in Neuroscience*. 13. 775. 10.3389/fnins.2019.00775.

Watts, G. (2016). “Inside the mind of a simultaneous translator.” The Open University. Accessed: 12 March 2019. https://www.open.edu/openlearn/languages/more-languages/linguistics/inside-the-mind-simultaneous-translator

Wei, L. (2011). “Moment Analysis and Translanguaging Space: Discursive Construction of Identities by Multilingual Chinese Youth in Britain.” *Journal of Pragmatics* 43: 1222–1235.

Wei, L. (2018a). “Translanguaging as a Practical Theory of Language.” *Applied Linguistics* 39 (1): 9–30

Wei, L. (2018b). Translanguaging and Code-Switching: what’s the difference? [BLOG] 9 May 2018. Available at: https://blog.oup.com/2018/05/translanguaging-code-switching-difference/ Accessed on 15 April 2019.

Whitely, P., Xue, M. & Wheeler, W. (2019). Revising the bantu tree. *Cladistics* 35, 1–20

Wilcox, S. & Shaffer, B. (2005). Towards a cognitive model of interpreting. In Janzen, T. (Ed.). *Topics in Signed Language Interpreting*. Pp 135-164. Amsterdam/Philadelphia: John Benjamins Publishing Company.

Wojciulik, E. & Kanwisher, N. (1999). The generality of parietal involvement in visual attention. *Neuron*, 23, 747–764.

Wolpert, D., Goodbody, S. & Husain, M. (1998). Maintaining Internal Representations: The Role of the Human Superior Parietal Lobe. *Nature Neuroscience*. 1. 529-33.10.1038/2245.

World Federation of the Deaf. Charter on Sign Language Rights for All. Available from: https://wfDeaf.org/charter/ [Accessed10 February 2020]

Worsley, K., Evans, A., Marrett, S. & Neelin, P. (1992). A Three-Dimensional Statistical Analysis for CBF Activation Studies in the Human Brain. *Journal of Cerebral Blood Flow and Metabolism*. 12.900-18.10.1038/jcbfm. 1992.127.

Yang, Y., Gates, K, Molenaar, P. & Li, P. (2015). Neural changes underlying successful second language word learning: An fMRI study. *Journal of Neurolinguistics*, Volume 33,

Yeung, H. & Werker, J. (2013). Lip movements affect infants' audiovisual speech perception. *Psychological Science*, 24, 603–612.

Young, A., Oram, R. & Napier, J. (2019). Hearing people perceiving Deaf people through sign language interpreters at work: on the loss of self through interpreted communication. *Journal of Applied Communication Research.* 47(1), 90-110. https://doi.org/10.1080/00909882.2019.1574018

Yu, R., Park, H., Cho, H., Ko, A., Pae, C,. Oh, M., Kang, H., Kim, H., Park, E., Shim, K., Kim, D. & Lee, J. (2018). Interregional metabolic connectivity of 2-deoxy-2[18F]fluoro-D-glucose positron emission tomography in vagus nerve stimulation for pediatric patients with epilepsy: A retrospective cross-sectional study. *Epilepsia.* 59. 10.1111/epi.14590.

Zeshan, U. & Panda, S. (2015). Two languages at hand: Code-switching in bilingual Deaf signers. *Sign Language & Linguistics*. 18. 90-131. 10.1075/sll.18.1.03zes.

Zeshan, U. (2015). “Making meaning”: Communication between sign language users without a shared language. *Cognitive Linguistics*, 26, 1–50.

Zhang, J. (2019). Secrets of the Brain: An Introduction to the Brain Anatomical Structure and Biological Function.

Zhou, Y. & Wei, M. (2007). Code-switching as a Result of Language Acquisition: A Case Study of a 1.5 Generation Child from China. *2007 Annual Conference of Teaching English to Speakers of Other Languages (TESOL). Seattle, Washington. p1-25.*