University of the Witwatersrand

Phonological memory and sentence processing in South African L2 English-speaking children

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DECLARATION

I hereby declare that this is entirely my own work and all primary and secondary sources have been appropriately acknowledged. The dissertation has not been submitted to any other institution as part of an academic qualification.

This dissertation is prepared in fulfilment of the requirements of the degree of Master of Arts in Linguistics at the University of the Witwatersrand

2023/08/25

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Thinking back to when I began this journey, being where I am now was a mere fantasy. The past few years have been some of the most difficult of my life. So, to see how far I’ve come and to witness this research come to fruition has been a blessing bestowed by God, and for that I am eternally grateful.

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ABSTRACT

Out of the many factors that have impacted the state of education in South Africa (resulting in low literacy rates and high rates of academic failure), it is critical to investigate the linguistic implications on education. Comprehension has been pinpointed as a site of further research and intervention; therefore, this current study aimed to investigate the possible contributions that phonological short-term memory (pSTM) has on spoken sentence comprehension of South African second language (L2) English-speaking children from southern African Bantu language backgrounds. Discourse has claimed pSTM – a temporary auditory information memory store – to be an independent language process system from that of comprehension. However, it presents an interesting focal point for a few reasons including the following: i) L2 English-speaking children from southern African Bantu languages are confronted with the phonologically distinct English language in educational spaces; ii) children need to store sentences to process and respond to them; and iii) children's complex linguistic skills have not yet been developed – thus, there is dependence on lower-level linguistic skills. In this study, 25 children from Polokwane, Capricorn District, participated in tasks to identify the effects of pSTM in relation to sentence processing. The researcher then analysed the developmental aspects of these processes. The corpus fell into two separate groups: i) the Grade 1, 6–7-year-olds and ii) the Grade 4, 9–10-year-olds. Three tasks were presented to the participants: i) the nonword repetition task to assess their pSTM capacity, ii) a sentence-repetition task, and iii) a sentence-picture naming task. The results indicated that pSTM capacity was present from age 6 and improved with age. However, there was no clear contribution to sentence processing; despite high pSTM capacity results, sentence comprehension and repetition results remained low. In this study, we also found the following: i) syntax was a marker for comprehension issues; ii) sentence repetition showed better results than comprehension, indicating a possibly stronger link between pSTM and sentence repetition; iii) possible language interactions during pSTM disyllabic recall were noted.

Keywords: *phonological short-term memory (pSTM), sentence processing, sentence comprehension, oral sentences, bilingualism, language development, nonword repetition (NWR), sentence repetition, sentence-picture naming*

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LIST OF ABBREVIATIONS AND ACRONYMS

CAPS	Curriculum and Assessment Policy Statement
CC	consonant clusters
CTOPP	Comprehension Test of Phonological Processes
CLT	cross-linguistic transfer
CV	consonant–vowel
HREC	Health Research Ethics Committee
L1	first language acquired
L2	second language learnt
LTM	Long-term memory
NWR	nonword repetition
PIRLS	Progress in International Reading and Literacy Studies
pSTM	phonological short-term memory
RAS	reversible active sentence
SAE	South African English
SLI	Specific Language Impairment
SONA	State of the Nation Address
STM	short-term memory
SVO	subject, verb, object
TD	typically developing
TROG	Test for Reception and Grammar
VOT	voice onset times
WM	working memory
XYS	X-but-not-Y sentence construction

CHAPTER 1: INTRODUCTION

1.1 Background to the Study

Education in South Africa has been characterised by inequality and poor scholastic performance. Apart from socio-economic issues that contribute to subpar academic outcomes, there is a need to assess the linguistic factors affecting this educational issue. Language and comprehension are agreed to be critical factors impacting education. These areas of cognition are central to this study. Therefore, the purpose of this research seeks to contribute literature on the development of South African English second language (L2) speakers. The target speakers are typically developing (TD) children, and this study assesses their phonological short-term memory (pSTM) capacities as well as their language processing of oral sentences.

1.1.1 Education in South Africa

Language learning is essential for communication and acquiring an education. This is especially true in South Africa where students need to learn English or Afrikaans to succeed within a scholastic environment. Spaull (2013) reports that in South Africa, the performance rates of learners in literacy and numeracy are poor. These results and performance rates are determined by various tests completed on a national level such as the Annual National Assessments, and on an international level such as the Southern and Eastern African Consortium for Monitoring Educational Quality and the Progress in International Reading and Literacy Studies (PIRLS). Anderson (2017) and Chambers (2017) identified the increase in the number of students that cannot read or cannot read for meaning. These 2017 findings were reported to have dropped further in 2021, with PIRLS results showing eight out of ten grade 4 students not being able to read for meaning (PIRLS, 2023). Moreover, this type of failure rate has shown a trending cascade from primary to secondary and then the tertiary level, with 40% of learners dropping out of university in the first year and a rate of 15% not completing their degrees (Macgregor, 2007). Ultimately, this indicates the need to target the foundation of learning.

To combat poor literacy results and academic failure, it is important to place focus on young children. This need has been emphasised by the South African government which has targeted early child development and education. In 2020, for example, during the South African State of the Nation Address (SONA), more than a billion rands were pledged to support and improve early childhood education, which is from birth to the age of 4 in South Africa ("Minister Motshekga's response to SONA 2020", n.d.). This is a continued mission for the government which has seen an increase in access to early childhood development. Although Eslick, le Roux, Geertsema and Pottas (2020) state that many factors such as low socio-economic status, lack of resources, and lack of skilled teachers – to name a few – result in poor literacy rates, McNamara and Kendeou (2011) assert that comprehension issues are at the centre of academic failure globally. It is therefore imperative to focus linguistic research on oral sentence comprehension to inform the intervention strategies and resolutions among young children.

1.1.2 Spoken sentence processing

Spoken sentence processing is essential to our everyday speech. When we communicate, sounds become words which become sentences and then full-blown discourse. Discourse is a complex level of speech that develops over time and with age. Comprehension of discourse also depends on the context provided by the sentences making up that very discourse being focused on. In contrast, singular sentences do not have the context of surrounding sentences. This brings about the question of what processes and capacities are integral to the comprehension of singular sentences, especially for an age group that has not fully developed their linguistic skills. Therefore, by researching this language process in children, we can analyse the linguistic skills that should be better developed to evidence developmental trends or identify any issues that may arise.

1.1.3 Language development

The focus on language is critical because humans use language to communicate, i.e., share ideas and process information either through verbal or written speech, signing, or gestures – and that language is acquired and then developed with age. According to Bochner and Jones (2008), research has proven that children learn language systematically. They assert that the system constitutes four main aspects which include the following: i) pragmatics – how we use language; ii) semantics – the meaning of language; iii) syntax and morphology – the grammatical rules and system of language; and iv) phonology – the form, sound patterns, and mechanisms used to convey intended meanings. Furthermore, difficulties arise when there are challenges encountered linguistically and through the systematic learning of language. While all of these components are integral to language learning, this research focuses on the form of language – that is, phonology – in relation to memory and sentence processing.

1.1.4 Phonological short-term memory (pSTM)

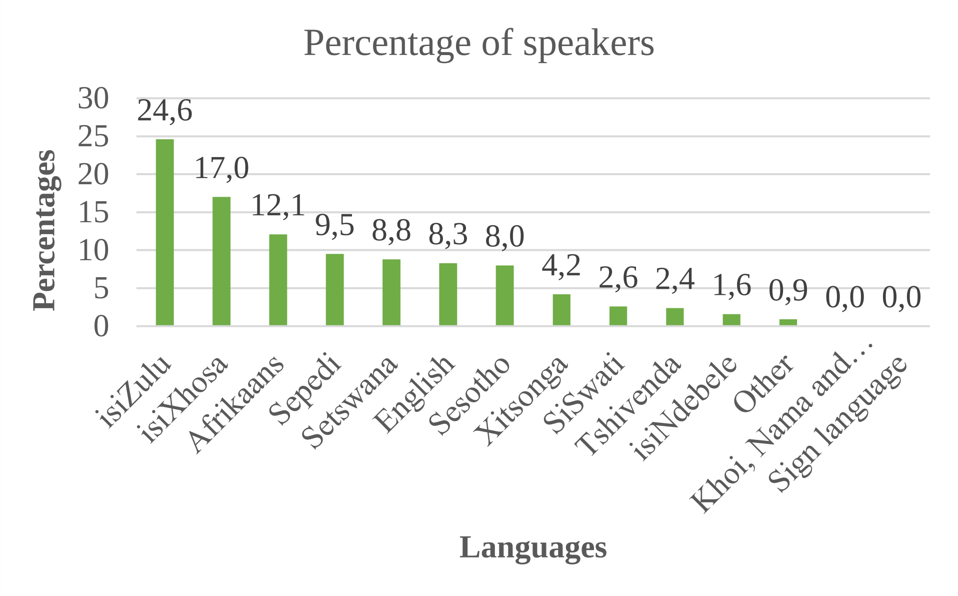
There are many essential cognitive skills every learner requires. One of these is memory which is integral to language processing and language learning. To process and respond to language, we have to have the ability to store it. Short-term memory in particular – conceptualised by researchers to encompass visual and verbal language (Baddeley & Hitch 1974; Baddeley, 2000; Morey & Cowan, 2005; Cowan, 2010) – is vital for instructional learning and communication. Many theories and models of the human memory system have been proposed; however, Baddeley and Hitch (1974) present a working memory (WM) model highlighting the presence of a pSTM mechanism. According to Zaretsky *et al.* (2023), pSTM has been defined as a capacity used to store temporary (a few seconds) verbal information within the working memory, allowing the perceiver of that information to recognise and recall the phonological elements based on the order at which they occur. Zaretsky *et al.* (2023) state that pSTM is made up of the phonological loop from the WM model first developed by Baddeley and Hitch (1974) and further revised by Baddeley (2000). Other scholars such as Jacquemot and Scott (2006) support this. Jacquemot and Scott propose that pSTM comprises two components from the articulatory loop model presented by Baddeley, Lewis and Vallar (1984) including: i) a phonological buffer used to hold memory traces, and ii) a subvocal rehearsal process to process said traces, both of which make up the phonological loop.

The relationship between memory and language has been researched, but pSTM and uttered sentences require further insight as to the extent and impact that the pSTM mechanism has on individual oral sentences. While discourse contains context clues, individual sentences do not and this calls into question what cognitive mechanisms play major roles during the processing of sentences, especially for bilinguals who presumably have to navigate their known multiple language systems.

1.1.5 South Africa’s multilingual landscape

South Africa’s complex multilingual landscape further impacts comprehension and education. According to the 2011 Census (Statistics South Africa, 2011), 2016 Community Survey Results (Statistics South Africa, 2016), and Patrick and Bhengu (2023), South Africa is a multilingual nation with twelve official spoken languages including isiXhosa, isiZulu, isiNdebele, Siswati, Sepedi, Sesotho, Setswana, Tshivenda, Xitsonga, Afrikaans, English, and recently recognised South African Sign Language (in new bill signed by President Cyril Rhamaposa). Further, there are numerous foreign languages spoken. **Figure 1** provides an outline of the languages spoken most often in a household and linguistic landscape of the country.

Figure 1: Overview of South African Linguistic Landscape



Source: 2016 Community Survey Results (Statistics South Africa, 2016, p. 23)

Figure 1 is a representation of the linguistic make-up of South Africa with nine of the languages belonging to the southern African Bantu language linguistic family and the others being English, Afrikaans, Sign Language, and other foreign languages. IsiZulu is the most spoken language with 24,6% speakers and the least-spoken being South African Sign language and Khoi, Nama and San at 0,0%. These statistics indicate that the majority languages spoken in the household are from southern African Bantu language backgrounds, therefore, mapping out the number of people who are impacted by language barriers within the classroom.

1.2 Current Study

Keeping in mind i) the processing of uttered, isolated sentences, ii) the multilingual landscape of South Africa, and iii) the requirement for phonological memory skills, this raises the question of how all these aspects affect how children understand sentences. To further investigate this, the present study consists of three separate measures including a nonword repetition (NWR) task, a sentence-repetition task, and a sentence-picture naming task to address the problem at hand. First, the NWR task is commonly used to assess pSTM. Although various other tasks including real word, digit span, and sentences have been used, the NWR task provides results that are particularly language-dependent and that focus on the phonological aspects of language. This allows for the analysis of the children's competence in the English language, i.e., their second language learnt (L2). Second, the sentence-repetition task is one widely used to assess recall ability of spoken sentences and to an extent examine the comprehension of the utterance. Finally, the sentence-picture naming task is used to measure participants' abilities to match a sentence to an image that accurately depicts it, thus indicating comprehension of the sentence.

Ultimately, these measures have been employed to assess the possible contributions of pSTM when a typically developing (TD) L2 English-speaking child from a southern African Bantu language background processes an oral sentence. To investigate this, the assessments took place in Polokwane with large populations of Sepedi, Tsonga, and Venda first language acquired (L1) speaking peoples.

1.2.1 Problem statement

Academic success is contingent on one's linguistic abilities. The capacity to perceive, process, and respond to information is critical for every child. When this is impossible, this leads to educational challenges and poor academic results. This is evident in multilingual South Africa, where the majority of learners struggle with comprehension and reading for meaning, also referred to as reading comprehension, which is defined as "the ability to extract meaning from written text" (Patterson *et al.*, 2018, p. 291). Majority of South African learners struggle with this language skill because they are taught in their non-native language.

In addition to the linguistic barriers, young children do not have the complex, fully developed capacities that adults use to comprehend language. In children the processing of discourse and long-term memory is not yet fully developed. Notably, research has shown that poor memory capacity in adults results in a decline in language comprehension; this begs the question: What does this mean for children? A focus on processing isolated sentences without providing surrounding sentences (that would normally provide contextual clues) becomes an interesting focal point.

This could thus mean that the role pSTM plays could be integral. Given that the languages known are phonologically distinct, short-term memory storage is needed consistently in the classroom to make sense of instruction and concepts, and phonology is a linguistic capacity that is in development from an early age. There thus needs to be more research examining the potential contribution that pSTM may provide in the processing of sentences. Therefore, there is a need for psycholinguistic research investigating young bilingual children and their processing of oral sentences in their second language, particularly within the South African multilingual context.

1.2.2 Aims

This study had two major aims: i) to identify the type and extent of the role that phonological processes such as phonological memory play during spoken sentence processing, and ii) to investigate the effect of age on the possible connection between phonological short-term memory (pSTM) processing and oral sentence processing. This study assessed English second language (L2) speakers aged 6–7 and 9–10, all of whom were L1 South African Bantu language speakers. At the study outset, all participants had their pSTM tested using a nonword repetition (NWR) task. To determine the effects of the possible connection between pSTM and sentence processing, sentence repetition and sentence-picture naming tasks were administered. The research thus took a quantitative approach.

1.2.3 Research questions

The aims of the study were achieved by asking the following investigative questions:

1. What is the effect of pSTM on typically developing South African L2 English-speaking children's sentence comprehension?
2. Does age have an effect on phonological memory processes, spoken sentence comprehension, and sentence repetition?

1.2.4 Rationale

The research questions above addresses the literature and theoretical gaps within the field. Previous auditory and comprehension-based research studies have focused on adults and atypical children. This brings into question how TD as well as bilingual children process language using a mechanism such as phonological memory especially in relation to comprehension. Additionally, there is a need to focus more of this research on African populations, especially in South Africa where multilingualism is the norm. A focus on bilingual comprehension presents an understanding of language that is considered "hidden" in monolinguals (Kroll *et al*., 2015). This further adds to discourse on cognitive processes and mechanisms of bilinguals.

This research further adds to multiple fields. First, it combines formal and applied linguistics by looking at the phonological memory level effects on cognitive processes like sentence processing and comprehension. The current study can also add to the field of literature in education. Comprehension issues are linked to low literacy rates and poor academic results; thus, this current research set out to inform educational practices. Therefore, the focus on what could affect comprehension was intended to add to the literature on education and to shed light on what needs to change in education.

There is also a lack of research displaying the possible relationship and interaction between speech comprehension and pSTM particularly within multilingual settings. Jacquemot and Scott (2006) state that models of speech comprehension have not traditionally been placed with pSTM processes; they have always been seen as separate and independent of each other. Studies that have arisen have assessed the potential contributions of phonological short-term memory (pSTM) in sentence processing (Willis & Gathercole, 2001) and investigated the effects of pSTM on sentence processing versus speech perception (Higgins *et al.*, 2017). This study adds to that conversation – but most especially within a South African multilingual context.

1.3 Chapter Outline

Chapter One: Introduction

The introductory chapter presents the study's main focus, research questions, and aims. It outlines the intent to investigate developmental trends relating to pSTM and its possible contributions to sentence processing within a South African context. It further rationalises the significance of this topic and what it adds to the current debates and research within the field.

Chapter 2: Literature Review

The literature review outlines the discourses within the field pertaining to phonological memory, sentence processing, bilingualism, and children's language processing. The chapter highlights arguments presented by various scholars relating to development trends in language learning, the theoretical framing of this study (i.e., studies in close relation to this current study), as well as methodological strategies utilised within this investigation.

Chapter Three: Methodology

This chapter elaborates on the methods used to both collect and analyse data. It expands on the choice of the quantitative research approach while outlining participant criteria and selection processes. Furthermore, this chapter provides more insight into the research procedures with a focus on stimuli created to assess pSTM and sentence processing using (NWR), sentence repetition, and sentence-picture naming tasks.

Chapter Four: Analysis

This section presents an overview of the results from the data collected. It follows a quantitative approach to analysing the data. In response to the main research questions, the chapter both elucidates the statistics of the data collected and illustrates the results through various tables and figures.

Chapter Five: Discussion and Conclusion

This section is dedicated to addressing the two main research questions. While in direct conversation with past literature, the chapter discusses the study's research results concerning pSTM capacity, sentence processing, and further discoveries. Moreover, it presents the limitations of the study, and provides further recommendations and ways forward in future research, and, finally, concludes the study.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This study investigates the effects of phonological short-term memory (pSTM) on the processing of uttered sentences by typically developing (TD) South African bilingual children with English as a second language (L2). The present section outlines the literature review that underpins this study, aligning with my research questions:

1. What is the effect of pSTM on TD South African L2 English-speaking children's sentence processing?
2. Does age have an effect on phonological short-term memory, spoken sentence comprehension, and sentence repetition?

To answer these questions, the language background of the target sample consists of children who come from Sepedi-, Tshivenda-, and Xitsonga-speaking households. These children speak their first acquired languages (L1) while learning English within the classroom.

In this current chapter, the literature for this investigation is presented. This chapter provides overviews of the aforementioned sample languages and explores literature rooted in language memory, language development, bilingualism, and language processing, and outlines the theoretical framework for this study.

2.2 Formal Linguistic Description

This research considers bilingual participants who speak a South African Bantu language as their first language acquired (L1) and are being assessed in South African English (SAE), their second language learnt (L2). The target sample of this study resides in the Capricorn District of Polokwane, Limpopo, whereby the population is made up of speakers of the South African indigenous languages: Northern Sesotho (Sepedi), Tshivenda, and Xitsonga. Given the bilingualism and distinct language families of the L1s and L2, it is important to provide an overview of their linguistic typologies. These aforementioned languages differ typologically with their structures varying syntactically, morphologically, phonetically, and – most important to this study – phonologically.

2.2.1 Linguistic overview

South African English (SAE)

English falls under the Indo-European language family and is classified as a West-Germanic language (Bech & Walkden, 2014). The origin of English dates back to fifth-century England (Great Britain) where it arrived from northern Europe (Crystal, 2012). It is a global language spoken in many Commonwealth countries and formerly British colonies. It is also used for international communication (Crystal, 2003). The South African dialect of English was borne out of linguistic imperialism from British colonisation (Kamwangamalu, 2018; Kamwangamalu, 2016). Now SAE forms part of the twelve official languages (including South African Sign Language; Patrick & Bhengu, 2023) as seen by the most recent community survey (Statistics South Africa, 2016) and 2011 census statistics (Statistics South Africa, 2011). According to Bekker (2012), SAE is primarily spoken by and designated as a first acquired language (L1) for white South Africans. However, it is not exclusive to this group given that English, along with Afrikaans, is used in most schools as a medium of instruction.

Tshivenda

Tshivenda is a Bantu language forming part of the Niger-Congo language family (Doke, 2017; Evans & Nthulana, 2018). The language is native to speakers in both South Africa and Zimbabwe. In South Africa, it is spoken by nearly 1,3 million people (Statistics South Africa, 2011). The majority of its speakers are found in northern South Africa, within Limpopo province. Webb and Sure (2000) claim that Tshivenda is now considered a marginalised language group. Evans and Nthulana (2018) state that given its genetic relationship with other Bantu languages, Tshivenda shares similar linguistic features and systems with them. For example, Tshivenda and Sesotho are said to share the same vocabulary. Additionally, Tshivenda and other Bantu languages share features including noun classes, an agreement system, and an open syllable structure.

Xitsonga

Xitsonga is a name generally referred to the Tsonga family group. It is spoken largely in southern Africa with 2,3 million speakers in South Africa (Statistics South Africa, 2016). Xitsonga is an under-researched language with information gaps in Xitsonga phonology needing to be filled. What has been noted, according to Zerbian (2007) and Doke (2017), is that the language is spread across south-eastern southern Africa, centred in southern

Mozambique. Zerbian (2007) does also state that the language is not closely related to other Bantu languages and is instead classified under the Tekeza cluster in the Nguni group. Despite this classification, Xitsonga shares linguistic features with other Bantu languages including subject, verb, object (SVO) word order, noun class system, agglutinative structure, tonality, and open syllable structure.

Sepedi

Sepedi ("Pedi") is a Sotho language that falls under the Northern Sotho Cluster. According to the 2016 Community Survey results, it is spoken mostly within the central region of Limpopo by more than half of its population – over 3 million speakers (Statistics South Africa, 2016). Sepedi is also spoken in Gauteng and Mpumalanga. According to Mojela (2008), Sepedi – which is also referred to as Sesotho sa Leboa (i.e., Northern Sotho under the Constitution of the Republic of South Africa, 1996 [the Constitution]) – has around 27 dialects including Sepedi, Sepulana, Kelobedu, and more. From the other Northern Sotho dialects, missionaries transcribed bibles in the Bapedi (Sepedi speaker's) regions. This led to Sepedi becoming the standardised variant of Sesotho sa Leboa (Mojela, 2008). According to Jacob (2019), it is important to note the controversy surrounding the use of the term "Sepedi" as it is a dialect among many others and should not be considered as favoured above the rest. Therefore, for this study, the use of the term is merely to reflect the language as described by the Constitution.

2.2.2 Phonological structures

This study examines the pSTM mechanism which stores auditory information and maps their phonological representations (Yllinen, Nora & Service, 2020). The capacity of this mechanism is measured through the recall of words that fit a language's phonological and morphemic structure. Therefore, it is important to present an overview of phonology, the phonological structures, and the basic morphemic structure of the principal languages focused on in the study. Skandera and Burleigh (2022) define phonology as the study of sound systems and the rules that inform sound patterns of languages (or how sounds are put together). Universally accepted in phonological theory is the presence of the syllable.

The syllable

According to Zec (2007), the syllable is fundamental to phonology theory. It is universally acknowledged and defined as a unit that is used to organise speech sounds sequentially to build a word (Skandera and Burleigh, 2022). A syllable is thus a critical domain used to designate phonological rules (Hooper, 1972), meaning that it is the descriptive tool that is used to account for sound patterns in language. Phonotactics are the rules that govern the combination and use of speech sounds, and each language has its own rules and syllable structure (Zec, 2007; Skandera & Burleigh, 2022). To illustrate and understand processes at the syllable level, the consonant–vowel (CV) syllable structure and prosodic word minimality are explored.

Minimal word size constraints

Phonology and morphology have a distinct relationship. Inkelas (2011) affirms that phonology affects the morphology of words. Morphology refers to how words are formed and their internal structures (Aronoff & Fudeman, 2022). Inkelas (2011) maintains that the phonological requirements of a language can influence and change the shape of a morpheme. A morpheme is considered the smallest linguistic unit that has meaning; it can be used as a word or be considered a root word forming part of another word; and it can be used to determine grammatical categories, e.g., noun, adjective, pronoun, etc. (Anderson, 2015; Aronoff & Fudeman, 2022). This morphophonological effect is exemplified by prosodic minimality – i.e., the minimal word size constraints of prosodic words, also known as phonological words or content words (Peperkamp, 1997; Ryan, 2019). Prosodic words are defined as domains for phonotactics along with word stress and word-level rules including matching syntactic categories such as verbs and nouns (Peperkamp, 1997; Downing and Kadenge, 2015). These well-formed prosodic words can have restrictions on their size in many languages (Park, 1997; Inkelas, 2011); function words, however, are not always subject to the same restrictions (Bloomfield, 1933).

Minimal size requirements are determined by mora and syllables. Prosody is thus measured using these units: i) mora (μ), ii) syllable (σ), and iii) metrical foot (F) and prosodic words. The Prosodic Hierarchy sees the mora (a timing unit that is either the same or less than a syllable) at the bottom. It is followed by the syllable. Above the syllable is the foot (repetition of rhythmic units). The prosodic word is found at the top of the hierarchy. Syllables are considered to be light if they follow a CV structure which makes them monomoraic[1]. Syllables are considered heavy if they are CVV or CVC structures which makes them bimoraic (McCarthy and Prince, 2017).

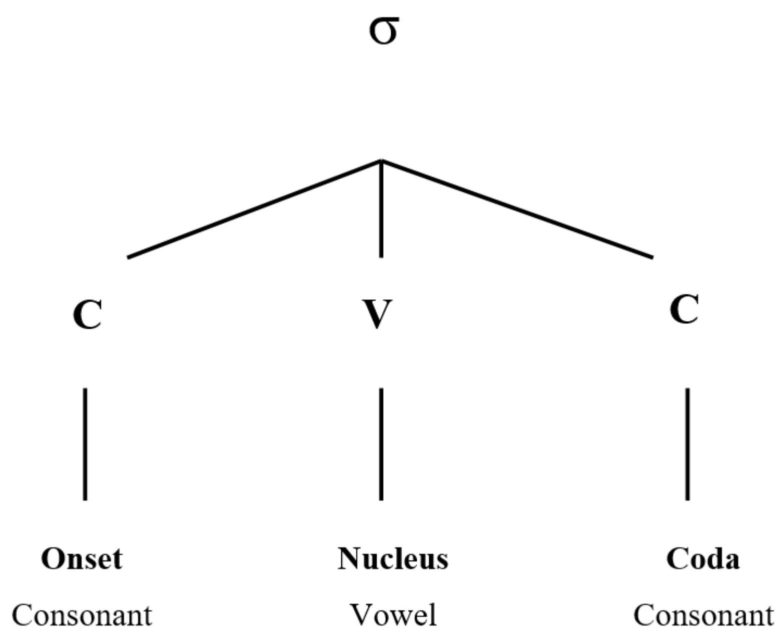
[1] According to phonological theory, Syllables are considered building blocks of lexical items (words)whereby different combinations of C and V are used to denote consonant and vowel combinations.

The following presents a linguistic overview of South African English (SAE), Tshivenda, Xitsonga, and Sepedi. The section also outlines the phonological structures of these languages. Finally, prosodic words and prosodic minimality are briefly discussed to account for the disyllabic minimality effect found in the southern African Bantu languages.

South African English

Each language has rules which contain phonotactic constraints/restrictions on how phonemes (abstract sounds in a language) can be put together within a syllable. Looking specifically at a syllable, it can include three components: i) the onset, ii) the nucleus, and iii) the coda (Skandera & Burleigh, 2022) as seen in **Figure 2** below.

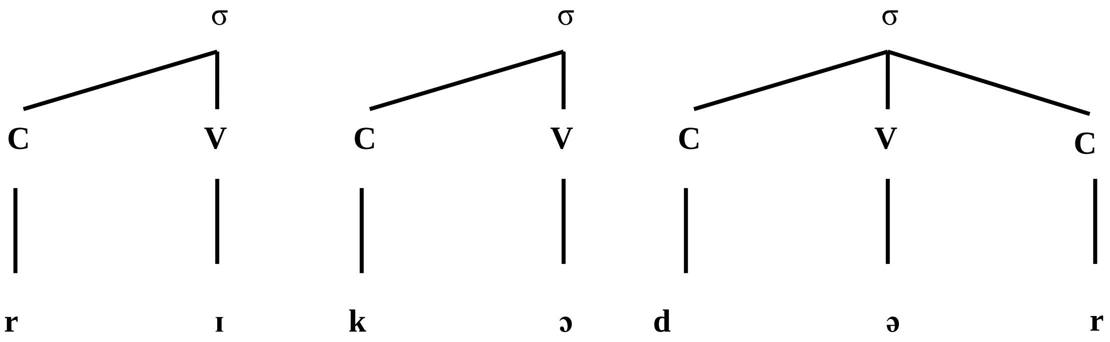
Figure 2: The syllable structure



Source: Adapted from Tian (2004, p. 3) and Köhlo *et al.* (2017, p. 128)

The figure above represents the universal syllable structure. According to Skandera and Burleigh (2022), the onset is the consonant or consonant cluster (a group of consonants) placed ahead of the vowel. For example, the word **[stɑːt]** "start" in English follows the **CCVC** (Consonant–Consonant–Vowel–Consonant) syllable structure. The word has a cluster for an onset made up of the two consonant sounds **[st].** The onset is thus followed by the nucleus. A nucleus is the vocalic centre of a syllable (Toft, 2002). It is universally accepted that the nucleus is essential to the syllable structure and generally accepted that a vowel always stands as nuclei. However, according to Toft, "some languages allow segments which are not traditionally classed as vocalic to form the nucleus of a syllable, for example the /Q/ in /E¡WQ/ 'button' or the /O/ in /P¡GO/ 'muddle'" (2002, p. 111). In the example **[stɑːt]**, the lengthened **[ɑː]** is the nucleus. The vowel as the nucleus for each syllable can also be seen in the example in **Figure 3** below.

Figure 3: Syllable structure of the word "recorder" [rɪ.kɔ.dər]



Source: Adapted from (Kadenge, 2012, p. 70)

Figure 3 shows three separate syllables in the word "recorder", with each syllable including a nucleus. The vowel stands as the nucleus of each syllable with **/ɪ/** being the nucleus of the first syllable, **/ɔ/** the nucleus of the second, and finally **/ə/** the nucleus of the third. As mentioned, a syllabic consonant can also stand as a nucleus, forming a syllable on its own. This is evident in the English word "bottle" **[ˈbɒt.l̩]** (Roach *et al.*, 1992). Finally, the coda is a consonant or consonant cluster placed at the end of the syllable, after the nucleus. An example of this is the monosyllabic English word "start" where the coda is the consonant cluster **/rt/**.

Phonologically, an English syllable follows the CVC type (Skandera & Burleigh, 2022; Kadenge, 2015). English is considered a Type 4 language, meaning that it can follow these structures shown in **Table 1**.

Table 1: Different English syllable types

	Syllable Type	**Example**	**Gloss**
i.	V	/ə/	"a"
ii.	CV	/tu/	"to"
iii.	CVC	/bʌt/	"but"
iv.	VC	/ɪn/	"in"

Source: Adapted from Vratsanos (2018, p. 49)

The above table illustrates the different syllable types found in English. The language permits syllable codas of consonant–vowel–consonant (CVC), diphthongs which are two vowels (VV), and consonant clusters (CCs). English has a maximal structure $C_0^3VC_0^4$ [CCCVCCCC] meaning that it can have up to three consonants within an onset cluster and up to four consonants within a coda cluster as exemplified by the word "strengths" **[streŋkθs]**. English is also said to have a bimoraic minimal size restriction (Golston, 1991); this means that syllables in English are considered heavy. **Table 2** presents examples of English words with bimoraicity.

Table 2: Examples of bimoraicity

		Gloss	**Phonemic transcription**
i.	CVV - Diphthong	eye	/aɪ/
ii.	Lengthened vowel	do	/du:/
iii.	CVC - Syllable coda	cat	/kat/

Source: Park (1997, p. 3)

The table above illustrates examples highlighting the bimoraic minimality in English. Bimoraicity is found in the CVC and CVV structures which include diphthongs, lengthened vowels, and codas; these make the syllable heavy (McCarthy & Prince, 2017). Monosyllables are thus produced with bimoraic minimal sizes. Therefore, monosyllabic words are generally found in English with bimoraic minimality.

Tshivenda

Tshivenda, like other Bantu languages, also has an open syllable structure (Evans & Nthulana, 2018). This is called a Type 2 CV structure (Doke, 2017); more specifically, the language follows a Type 2 C_0^1V phonotactic structure which means that every syllable in the language should always include a vowel (the nucleus) with only a maximum of one consonant permitted as an onset. A syllable can stand without an onset. Among others, the following is a list of notable syllable constraints within the languages: i) there are no codas, ii) there no CCs in the onset, iii) only monophthongs are permitted in the nucleus. **Table 3** shows some examples of the permitted syllable types within Tshivenda.

Table 3: Syllable types in Tshivenda

	Syllable Type	Example	Gloss
i.	V	a-mba	"sing"
ii.	CV	khu-hu	"chicken"
iii.	C – syllabic nasal	n-ngu	"sheep"

Source: Adapted from Madiba (1994, p. 124–125)

The table above indicates three specific syllable types consisting of a consonant and a vowel. First, the syllable structure can stand as a vowel alone, as seen in the word "a-mba" with the initial syllable "a". Second, a syllable in Tshivenda can stand as CV (consonant-vowel) as seen with "khu-hu", where both syllables of the word follow the CV syllable structure. Finally, rather than a consonant cluster forming the onset, in words like "n-ngu", a singular nasal consonant becomes syllabic, allowing it to stand as its own syllable.

Notably, minimum word requirements differ between SAE and southern African Bantu languages. Doke (2017) states that most Bantu languages avoid monosyllabic (one-syllable) words and monosyllables are also avoided in Tshivenda. According to Ziervogel and Dau (1961), Tshivenda imposes disyllabic prosodic word minimality requirements. This means that well-formed words with two syllables are permitted. This is evident through rephonologisation strategies that are used to maintain or go beyond these minimum requirements. This can be seen in the following example (adapted from Vratsanos, 2018, p. 114):

i. /la/ "eat" → [i.l̪a]

Bantu languages utilise strategies such as adding a suffix or prefix to the root word to avoid violating this constraint. The stem of the verb /la/ in Tshivenda is realised as an imperative through the insertion of the prefix {i}. This allows the language to maintain a disyllabic minimality.

Xitsonga

Xitsonga as a Southern Bantu language that follows a strict CV structure (Vratsanos & Kadenge, 2017). Similar to other Type 2 CV languages, Xitsonga only permits one consonant and a monophthong vowel. Consonants are permitted to be complex, but the onset cannot be a cluster (see example iii in **Table 4**). Codas, diphthongs, and consonant clusters in the onset are considered marked constraints in Xitsonga, meaning that they violate the phonological rules of the language. **Table 4** illustrates the syllable structures found in Xitsonga.

Table 4: Syllable types in Xitsonga

	Syllable Type	**Example**	**Gloss**
i.	V	[í.ᵑkí]	'ink'
ii.	CV	[ʃi.to.lo]	'store'
iii.	C – complex consonant	[ɲa. ᵑgʷa]	'entrance'

Source: Adapted from Doke (2017, p. 104) and Vratsanos and Kadenge (2017, p. 179)

In Table 4, there are three possible syllable types as per the Vratsanos and Kadenge (2017) paper. First, we find that a syllable can stand as a vowel alone, as seen in the disyllabic word [í.^{ŋ}kí] ‘ink’, whereby out of the two syllables, the first only contains a vowel. Second, there is the CV structure which contains a consonant and a vowel. In the word, [ʃi.to.lo] ‘store’ – a rephonologised loanword from the English language – there are three syllables evident. In the separate syllables, there is only a consonant and a vowel with no coda (which would violate the rules of the language). Finally, while syllables maintain a strict CV structure and the onset cannot contain a cluster, the consonant (which forms part of the onset) can be a complex one. This is demonstrated through the example of the word [ɲa. ^{ŋ}g^{w}a] ‘entrance’. The word contains two syllables. In the second syllable, the onset [^{ŋ}g^{w}] forms a complex consonant because rather than the preceding and succeeding sounds of [g] acting as their own consonants, they are in fact features of the sound [g]. This means that the features both nasalise and labialise the word respectively (Vratsanos & Kadenge, 2017); therefore, this maintains the CV syllable structure of the language.

Similar to Tshivenda, Xitsonga is a Bantu language that avoids monosyllables. Vratsanos (2018) claims that prosodic words in Xitsonga are required to be minimally disyllabic. Vratsanos (2018, p. 3) presents the following imperative formation as an example:

i. /ba/ “beat” → [ba.**na**] “beat IMP”

To maintain this disyllabic minimality, morphemes are epenthesised to ensure the word remains disyllabic. In the above example, the stem /ba/ is realised as [ba.na]. The second syllable is added to fit the disyllabic prosodic word constraint.

Sepedi

Similar to other languages within the southern African Bantu language family, Sepedi follows a CV syllable structure with a maximum of one consonant in the onset position, a vowel, or syllabic consonant as the nucleus and no coda. **Table 5** illustrates the Sepedi syllable types.

Table 5: Syllable types in Sesotho

	Syllable Type	**Example**	**Gloss**
i.	V	[i.jɑ]	‘go!’
ii.	CV	[be.la]	‘boil’
iii.	C – syllabic nasal	[bɑn̩na]	‘men’

Source: Adapted from Rose and Demuth (2006) and Demuth (2007)

In the table above, the following three syllable types are evident in Sesotho: V, CV, and the syllabic nasal. The first syllable construction is represented in the word [u.ma.la] ‘to marry’ whereby the first syllable [u] is a vowel. The second is the CV construction [ta.la] which shows that the syllable does not permit codas. Finally, the additional consonant which, to maintain the set structure, is a syllabic nasal consonant. This is in line with Doke (2017) who notes that although there are words orthographically represented as a cluster, for example, “nku” or “ntja” and those come across as one syllable, phonologically, the first consonant is a syllabic nasal which is prefixed onto the monosyllabic stem to create a disyllable.

This is an intriguing feature of the language, as this differs exponentially from English where monosyllables are very much accepted. This phonological feature alludes to how Sotho languages avoid monosyllables (Doke, 2017), with the minimum number of syllables in a word being a disyllable. This, according to the prosodic minimality, is referred to as the minimal word effect (Park, 1997) which underscores how in a language, a produced word has to contain a certain number of syllables to be viable. Despite there not being sufficient research on Northern Sotho, it holds similar features to Sesotho. In Sesotho, Demuth and Fee (1995) assert that minimal words should have two syllables to make a well-formed word. Here are some examples presented by Demuth and Fee (1995, p. 7):

i. /ja/ ‘eat’ →/ho-já/ 'to eat'
ii. /ja/ ‘eat’ →/ejá/ 'eat! IMP’

Example i) indicates a monosyllabic verb stem which is realised as a disyllabic to satisfy the minimality requirements. This is done through the insertion of the infinitival marker /ho/. In addition, vowel epenthesis is also used in example ii) whereby the vowel /e/ is epenthesised in the realisation of the imperative to meet the minimal disyllabic requirements.

Different syllable structures: SAE vs South African Bantu languages

English’s syllable structure is vastly different to that of southern African Bantu languages. Evidence of these differing syllable structures stems from loanwords/word borrowing process (Campbell, 1998). Loaning words is a commonality between languages, where a word from one language is taken and used within another language (Haspelmath, 2008). Given the differences between languages and their structures, adaptive processes take place to allow the received words to fit the borrowing language (Kadenge, 2009). These loanwords are thus rephonologised to fit the phonotactics (grammatical rules) of the borrowing language (Kang, 2010).

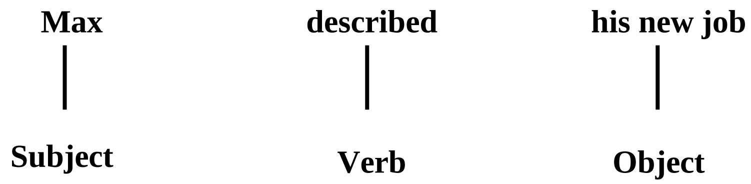
Southern African Bantu languages maintain a strict CV structure when using English loanwords with CVC structures. These different structures are evident through the many strategies that go into the correction of borrowed words to fit the language rules of the borrowing language. One example among southern Bantu languages is vowel epenthesis is thus employed to fix and maintain the CV structures of the three languages as seen in Kadenge (2015) who looks at the rephonologisation of Shona loanwords from English, Madiba (1994) who analyses Venda adoptives, and Rose and Demuth (2006) who analyse vowel epenthesis in Sesotho/Southern Sotho, a close relative of Northern Sotho.

With the syllable structures differing, the following question comes to light: how do these differences impact bilingual South African second language (L2) English speakers? Moreover, not only are the syllables different in structure, the number of syllables in a word may vary as well. We see this particularly in Sepedi whereby a word has to have a minimum of two syllables. While it is unclear in literature what the minimal word effect in Tshivenda and Xitsonga is, Sepedi tries to avoid monosyllables. Therefore, on a phonological level, the following question arises: how do English L2 speakers navigate that? This study provides further insight into the phonological processes at hand.

2.2.3 South African English sentence structures

This study focuses on the processing of oral English sentences. South African English adheres to the same structure as standard British English. English nominal sentences and clauses are constructed using the SVO structure (Sado Al-Jarf, 2006). The SVO structure indicates grammatical roles consisting of the following: S**ubject + Verb + Object.** In this main structure, the subject begins the sentence, then a verb follows, and the object comes after. This can be seen in **Figure 4** below.

Figure 4: Example, the sentence "Max described his new job"



Source: Adapted from Kennedy (2014, p. 111)

The above diagram illustrates an example of a typical English sentence fitting the SVO word order. "Max" is a proper noun that stands as the subject of the sentence executing an action. In

English, a sentence is considered incomplete if it does not have a verb. A verb is an action word, and, in this example, the action is presented through the word "described" that follows and modifies the subject. The verb is then succeeded by the object "his new job" which is made of a noun phrase. From this rigid structure, several sub-patterns can be constructed for clauses and sentences (see **Table 6**).

Table 6: SVO sub-patterns of English sentence structures

i.	**(SV)**	**Subject**	**Verb**		
		Sue's cat	*died*		
ii.	**(SVC)**	**Subject**	**Verb**	**Complement**	
		She	*seems*	*pleasant*	
iii.	**(SVA)**	**Subject**	**Verb**	**Adverbial**	
		Sam	*is*	*on the committee*	
iv.	**(SVOO)**	**Subject**	**Verb**	**Object**	**Object**
		He	*bought*	*Fred*	*a ticket*
v.	**(SVOC)**	**Subject**	**Verb**	**Object**	**Complement**
		The ride	*made*	*me*	*dizzy*
vi.	**(SVOA)**	**Subject**	**Verb**	**Object**	**Adverbial**
		I	*put*	*the book*	*on the shelf*

Source: Adapted from Kennedy (2014, p. 111–113)

Many sentences can be formed in the English language, including the X-but-not-Y construction and the reversible active sentence (see Chapter 3: Methodology). These structures will be used to assess the processing of sentences.

2.3 Language and Memory

This section provides an overview of the scholarship that has examined the cognitive view of language in connection with memory. Memory is an essential component to processing and comprehending language, as it stores information that is learnt so that it can be used both in the moment when one perceives language or in the future. Ardila (2003) posits that memory is needed for everyday communication, particularly working memory (WM) which stores information received for a short period. The WM stores information so that it can be comprehended, and a response can be produced. Ardila (2003) thus deduces that the WM component is imperative for second language learning and, in turn, its comprehension because it helps in storing and reusing information learnt temporarily. This deduction and the need for memory in communication aligns with the current study's investigation which is assessing (phonological) short-term memory in line with sentence comprehension.

The term "working memory" is used to refer to the domain-general Baddeley (2000) model. WM has been highlighted as a mechanism that plays a critical role in the performance of everyday cognitive functions including mathematics, reasoning, learning, and language comprehension (Gathercole & Baddeley, 2014). The WM model proposed by Baddeley (2000) introduces what is referred to as phonological loop that houses two components including the phonological memory store or short-term memory (pSTM). This store is the main cognitive mechanism of this study. The store is assessed in relation to bilingual children's sentence processing.

Therefore, the following overview presents insights into the WM model and pSTM, the development of memory in children, tools to help measure pSTM, findings on the influences of bilingualism and memory, as well as the possible contributions of pSTM when processing sentences.

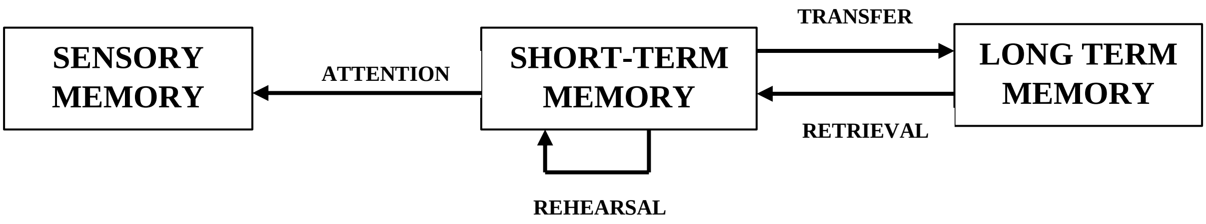
2.3.1 Working memory models

Literature underpinning WM and storage of temporary information has evolved. This study zones in on the Baddeley (2000) WM model to frame and account for pSTM. In this section, we present an overview of the evolution of the WM model. The following models of WM are discussed: i) Atkinson and Shiffrin (1968), ii) Baddeley and Hitch (1974), iii) the Baddeley (2000) WM model (the primary focus for this study), and iv) the capacity theory of memory (Just & Carpenter, 1992).

The memory modal model

Memory is an abstract concept that has been explained to have various levels. The modal model, also known as the multi-store model of memory, was outlined by Atkinson and Shiffrin (1968). In this model, Atkinsin and Shiffrin revised an earlier model proposed by William James (1890) which represented memory in two levels: primary and secondary memory. In their revisions, they added the sensory register. **Figure 5** illustrates the short-term store presented by Atkinson and Shiffrin (1968).

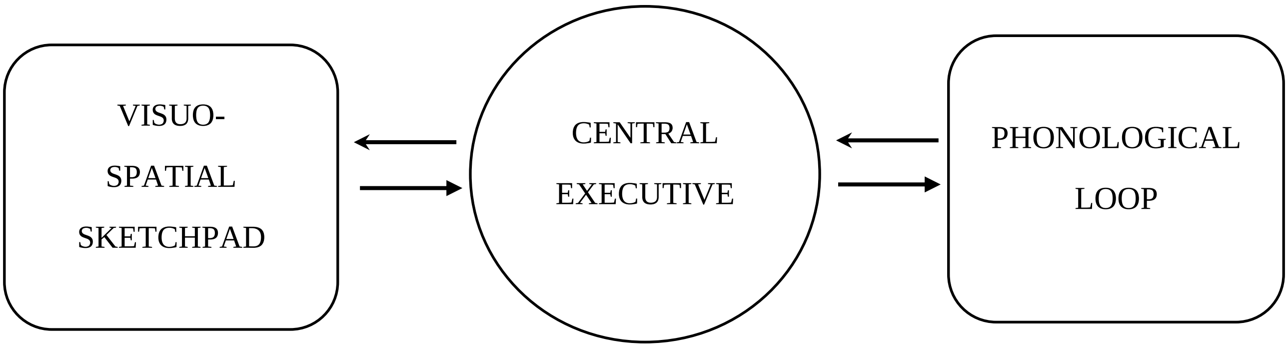
Figure 5: The Modal model



Source: Atkinson and Shiffrin (1968, p. 3b)

The model exemplified a multi-store memory model with three components, namely i) sensory register, which consists of the input of sensory information into one's memory, ii) short-term memory store (known also as working memory), where both sensory and long-term information is stored, and finally iii) long-term memory store, which includes what is referred to as rehearsed information which was stored within the short-term storage (Atkinson & Shiffrin, 1968). Scholars heavily contested the memory modal. This included the criticism of its lack of subdivision into separate components (Baddeley & Hitch, 1974). The revisions to this model by Baddeley and Hitch (1974) were extensive and evolved further into revisions resulting in the Baddeley (2000) model, as seen in **Figure 6**.

Figure 6: Baddeley Model



Source: Adapted from Baddeley (1983, p. 315)

Working memory model

In direct opposition to the modal model of memory, this model was first introduced as a revision to the short-term store by Atkinson and Shiffrin (1968). Baddeley and Hitch (1974) conceptualised their WM model and it is through this model that pSTM is presented. WM is presented in relation to the idea that WM is broken up into three distinct parts, as presented by Baddeley and Hitch (1974). Figure 6 is a representation of the 1974 Baddeley Model of WM.

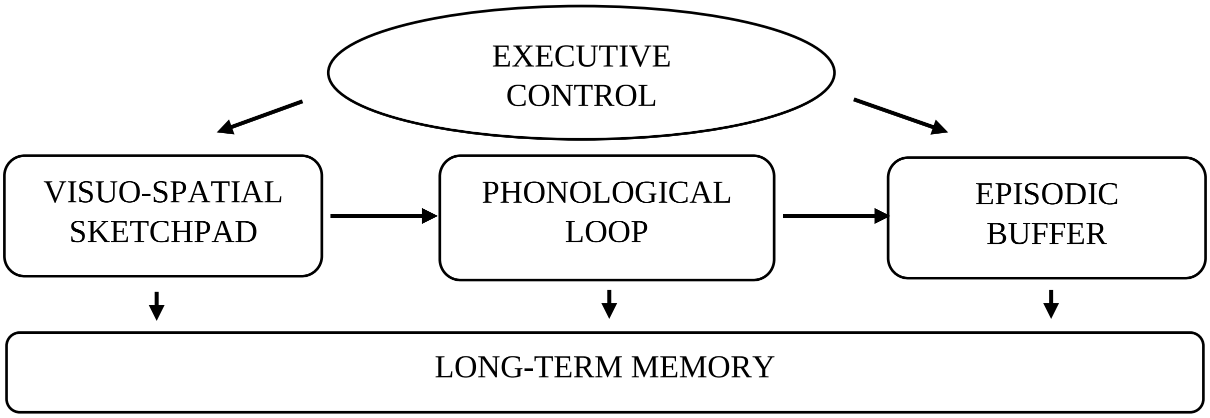
The working memory (WM) model displayed in Figure 6 consists of three separate components, including: i) the **central executive** which controls and interacts with the other two slave components, ii) the **phonological loop** which holds verbal and auditory information – namely, speech sounds, and iii) the **visuo-spatial sketchpad** which allows for the mapping of information that is both visual and spatial. As a direct response to Atkinson and Shiffrin (1968) who presented the original modal model, Baddeley and Hitch (1974) proposed their model which consists of the central executive at its helm, as it controls the two other slave systems – the visuo-spatial sketchpad and the phonological loop.

These two slave components are integral to the concept of short-term memory, or rather the storage of temporary information; and, therefore, a more expansive understanding of them are needed. The **visuo-spatial sketchpad** collects and saves visual and spatial information, ultimately storing the information for manipulation. This system is also responsible for creating and manipulating mental images. In contrast, the **phonological loop** accounts for perceived/auditory/verbal information, thus storing phonological information or speech sounds. This early WM model was however revised in 2000 to account for the link between short-term memory and long-term memory.

Revised working memory model

The initial WM model (see Figure 6 above) was revised, as seen in **Figure 7** below, to include i) the episodic buffer – controlled by the central executive (Baddeley, 2000) – and ii) all the components being entered/stored in the long-term memory (LTM). Interestingly, according to Baddeley (2013), short-term memory (STM) only became a major area of investigation in the 1950s and was conflated with LTM. This notion was first introduced by Broadbent (1957) who identified the notion of the two memory systems. The existence of these two mechanisms is a generally agreed-on idea as echoed by Yoo and Kaushanskaya (2012) who claim that although there is a separation of WM and LTM, which is defined as the indefinite storage of information, the interaction between the two memory types takes place through the episodic buffer in the short-term storage system. The episodic buffer was included to account for the integration of the WM systems with LTM based on time sequencing, meaning that it allows for information to be processed sequentially.

Figure 7: Revised Baddeley Model



Source: Baddeley (2000, p. 418)

The episodic buffer – like the other two slave components, i.e., the visuo-spatial sketchpad and phonological loop – was added to demonstrate the link between the other stores and the long-term memory (LTM). As a buffer, the component is a passive system (Baddeley *et al*., 2011) that stores perceptive and visual information. Ultimately, Baddeley needed to account for the ability that amnesiacs had to recall short-term memory and store and maintain other linguistic knowledge, yet not be able to recall LTM. This led to the incorporation of an episodic buffer which an individual uses to conceptualise new ideas based on the information stored. This revision of the Baddeley (1974) working memory (WM) model shows the evolution of research on memory and the models that have developed from the initial WM model. It is in this revised model that the WM model central to this study resides. Moreover, this model houses the phonological loop which will be assessed for the sake of the central research questions surrounding the role phonological short-term memory plays in language comprehension.

Comprehension capacity theory

This brings us to the possible connection between WM and comprehension. The role of WM with regard to cognitive skills such as comprehension and reasoning should be understood in line with individual differences. While memory has been connected to language comprehension, it has been claimed that working memory limitations exist. Kintsch and Dijk (1978) presented a cognitive model in relation to a speech production system. They argued that capacity constraints in comprehension were a result of working memory and its own limited capacity. Daneman and Carpenter (1983) and Oakhill *et al.* (1988) also posited that constraints in WM have implications on comprehension. This notion has been echoed by Just and Carpenter (1992) who proposed the comprehension capacity theory. This theory states that

WM ultimately impacts comprehension through its constraints, i.e., limited capacity caused by taxing information or information overload. Just and Carpenter (1992) claim that both storage and processing are mediated by activation; however, this depends on the individual and their individual WM capacities. Meaning that they believe that while WM can influence comprehension, this might affect some people but not others. In their study, Just and Carpenter (1992) discovered that a larger capacity allows for pragmatic and syntactic information to interact.

While there is some consensus, comprehension capacity theory and WM model are, however, distinguishable. Just and Carpenter (1992) argue that spoken sentence comprehension needs temporary storage for processing and even responding to it. The WM model can be applied to understanding the processes that could impede whether one can understand a sentence or not. However, Just and Carpenter (1992) do distinguish their theory from the Baddeley and Hitch (1974) model by stating that their conceptualisation of WM for language encompasses processes and mechanisms connected to the performance of language comprehension. Just and Carpenter (1992) also allude to the central executive and not the articulatory (phonological) loop. They assert that their theory is more in line with the central executive component of the WM model proposed by Baddeley (1986) that deals with language comprehension. What the Just and Carpenter (1992) model does not include is the articulatory loop, which includes the phonological short-term memory store (pSTM). This argumentation has subsequently been critiqued by Waters and Caplan (1996) who argue that the theory proposed by Just and Carpenter (1992) does not hold weight owing to insufficient results. Therefore, contention in the relationship between pSTM and comprehension does exist.

This contention is further attributed to more research indicating a possible relationship between comprehension and pSTM. Higgins *et al.* (2017) acknowledge and assert that the phonological loop and the central executive are the two components of the model that are present during language comprehension. The presence of the phonological loop in language comprehension is emphasised by Higgins *et al.* (2017). They explain that the phonological loop temporarily stores spoken language, while the central executive focuses on the processes regarding attention. Given the role of WM on spoken sentences based on the claims made by Higgins *et al.* (2017), we can determine that if storage is taxed because of weighty and lengthy material that needs to be stored, the processing of received information will be impacted which corresponds with the capacity theory of comprehension (Just & Carpenter, 1992). The same goes for the opposite case, i.e., if the processing is taxed, then the storage will be impacted as well. Ultimately, more research is needed to determine is such a link between memory and comprehension exists.

Based on the evolution of the literature on short-term and working memory, it is evident that most scholars believe there to be a short-term memory storage/mechanism. Given the scope of this study, investigating the effects of phonological short-term memory (pSTM) on sentence processing, the focus here will be that of short-term phonological storage and not the WM model in its entirety. This study is reliant on the existence of a phonological short-term store, hereafter referred to as pSTM, which is based on the phonological loop component found in the Baddeley (2000) revised WM model.

2.3.2 Working Memory (WM) and Phonological short-term memory (pSTM)

Working Memory (WM)

This study is dependent on the Baddeley (2000) WM model (see **Figure 7**) and how it stores temporary information which is often split into visual and verbal stores. According to Henry (2011), WM allows one to temporarily store and manipulate information. At the same time, it is a limited capacity that can be easily constrained. Henry (2011) goes on to stipulate that WM is essential for other cognitive functionalities such as learning, reasoning, and – most essential to this study – comprehension. In this section, the Baddeley (2000) WM model is elaborated on as it is a commonly supported theory within the field, with many studies utilising this framework to develop their research. And although more competing WM models have surfaced (e.g., Cowan, 2010; Unsworth & Engle, 2007a; Unsworth & Engle, 2007b), the Baddeley (2000) WM model forms the basis of this study.

In research, there is often confusion between WM and short-term memory (STM). According to Aben *et al.* (2012), WM and STM are often conflated, with the terms being used interchangeably when they are in fact distinct. Prior to the conception of WM, STM referred to the temporary storage of information. This, however, formed part of the debate surrounding its passivity and from these contentions, the concept of WM was formed. WM is regarded as a theoretical concept whereby the temporary storage of information can be manipulated (Aben *et al*., 2012). These concepts have often overlapped, and consistent distinctions have not been overly present in studies (Aben *et al*., 2012). For the purpose of this study, the terms are used interchangeably with the preferential use particularly of the term (phonological) short-term memory (pSTM) rather than (phonological) working memory (see discussion of pSTM in **Section 2.4.2**), whereby pSTM is storage for auditory information. Moreover, this places it in direct conversation with other studies focused on the possible relationship between phonological short-term memory (pSTM) and sentence processing.

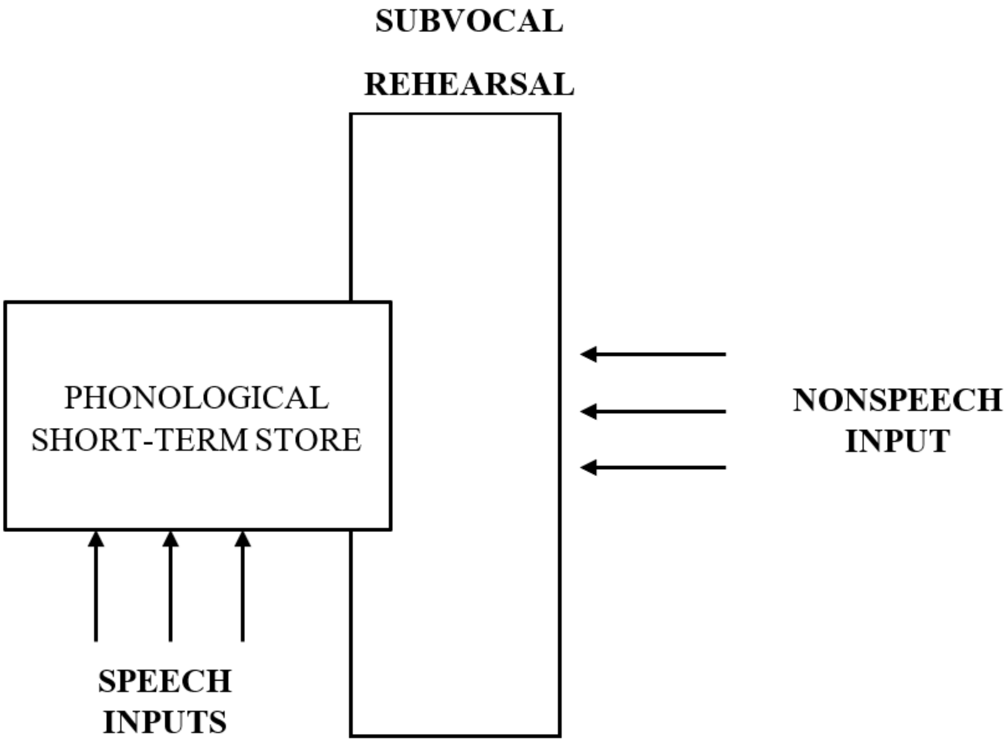
It is important to understand the models and theories that have defined our overall understanding of memory, given that memory is essential to language learning and processing. According to Baddeley (2013), prior to its use in cognitive studies and language processing research, the term *working memory* was used in two instances: i) animal learning, task performances, and memory (Olton, 1978) and ii) computer-based modelling of cognition (Newell & Simon, 1972). Working memory (WM) has since been coined to denote a temporary store utilised in the performance of cognitive skills such as comprehension, reasoning, and learning (Baddeley, 2013).

Phonological short-term memory (pSTM)

To investigate how pSTM could potentially play a role in sentence processing and comprehension, it is important to account for the existence of pSTM and outline the existing memory model that informs the field’s overall understanding of memory and its contributions. Although WM is a multidimensional system that can be investigated in many ways, pSTM is an interesting component in relation to comprehension. Montgomery and Evans (2009) define pSTM as a buffer for the temporary storage of input during a cognitive processing task like comprehension.

Many proposed memory models have informed our understanding of memory in our processing of language. The phonological loop, which forms part of the Baddeley (2000) model, is the component that this study is dependent on. The WM model is used in the modelling of phonological memory. Although other memory models have both preceded and succeeded the Baddeley model and are still in development, the Baddeley WM model, which includes the phonological loop as a slave system functioning as short-term storage, forms the theoretical basis of this study. As mentioned before, the phonological loop, also referred to as the articulatory loop, is the slave part of the model that stores sound/phonological information (Baddeley, 2013). This component is divided further into two subdivisions: i) phonological short-term store, and ii) the articulatory rehearsal. **Figure 8** below illustrates these sections of the model and their relationship.

Figure 8: *A model of the phonological loop and its components*



Source: Adapted from Baddeley (1986)

Figure 8 above represents the subdivisions of the phonological loop. According to Anjomshoae *et al.* (2021), working memory (WM) models separate the visual and verbal stores. Auditory information is temporarily stored by phonological short-term memory (pSTM) store, while the articulatory rehearsal component reactivates phonological information through inner speech (Fiez, 2016). According to Baddeley, Gathercole and Papagno (1998), the articulatory loop (articulatory rehearsal component) is the inner voice, while the pSTM is the inner ear of the phonological loop. The phonological store is where the speech sounds are kept in order of occurrence (i.e., order of how they appear within an utterance), just as the articulatory loop replays the words over and over again so that the information is preserved and not lost. An example of this is being given (and recalling) the gate code 79189. An individual would perceive this verbal code given that they need to use it five minutes from receiving it. To keep it active for use within their phonological short-term memory store, they would need to rehearse the number over and over again for its ultimate use.

Evidence of the phonological short-term store is quite established. Baddeley (2013) highlights two phenomena which evidence the existence of the store. The evidence includes: i) the phonological similarity effect, and ii) the irrelevant speech effect. For the phonological similarity effect, Baddeley (2012) explains that with regards to this effect, it is easier to remember words that are phonologically distinct in contrast to phonologically similar words. One reason evidencing the hypothesis that stored auditory information is inputted and coded in the phonological working memory was presented by Baddeley (1966) and Conrad and Hull (1964). The irrelevant speech effect refers to the notion that there can be a hindrance in remembering numbers that are presented visually if there is irrelevant information uttered at the same time (Baddeley, 2013).

These findings are evident in the Baddeley (1966) and Conrad and Hull (1964) studies which showed the existence of the phonological short-term store through i) the phonological similarity effect, and ii) semantics which played no role in the process. The phonological aspect of the words increased the difficulty in temporarily remembering words. This points to the concept of a phonological store that manipulates, stores, and rehearses phonologically distinct words. Additionally, a second reason supporting this are Person/s with Aphasia with developmental verbal dyspraxia and an impaired articulatory rehearsal component, leading to their inability to utilise their speech motor codes when attempting to articulate information (Water *et al.*, 1992).

While a lot of other evidence of the component's existence has been found, it is clear that there is strong support showing that the phonological loop, including its two components, seems to be a present concept. Vallar and Baddeley (1984) provide the most compelling evidence supporting their claims of a phonological loop comprising a phonological store. The pSTM model aligns strongly with the findings from Vallar and Baddeley (1984) who noted that their patient showed fluent speech in conjunction with short-term memory deficits. While the patient showed STM deficits, the patient exhibited a phonological similarity effect which, as mentioned above, concludes that an individual can easily recall phonologically different words and has difficulty recalling phonologically similar words. This points to the presence of the phonological loop in the patient's processing. However, the patient was able to recall auditory representation and not visual representation when immediately recalling consonant sequences. This meant the phonological loop and not the visuo-spatial sketchpad was central to the patient's memory issues. In addition, there was no evidence of the subvocal rehearsal seeing that there was no articulatory suppression and impact on the word length. This meant that some other component was at play in the phonological loop which was indicative of a short-term phonological store. Based on this information, the Baddeley (1986) model supports the existence of a pSTM mechanism which is the main focus of this study.

2.3.3 Measures of pSTM

There are many tools researchers use to assess phonological short-term memory (pSTM) capacity, including various tasks that have been used in studies such as digit span, word span, and nonword repetition (NWR) tasks. The most commonly used measure is the NWR task. This task includes the presentation of nonwords in varying lengths of syllables. The task is a great indicator of pSTM because it requires memory and phonologically related processes (Montgomery & Evans, 2009). A poor performance following this task indicates a limited pSTM capacity (Montgomery & Evans, 2009). With this, it has been demonstrated that typically developing (TD) children show accuracies in nonwords with one to three syllables, but their accuracies decline with more than three words. Therefore, phonological short-term memory (pSTM) in relation to sentence comprehension is tested in this paper and NWR is used to assess the capacity of pSTM prior to testing sentence comprehension.

2.3.4 Memory and comprehension

Discourse surrounding the role of pSTM in comprehension and speech perception has evolved with research overtime providing opposing claims. The possible relationship between working memory (WM) and language comprehension has been controversial. There is a divide in research regarding the involvement of WM in sentence processing, with some research results being in direct opposition to the claim, while others are in support of it. There has not been any research that has clearly linked pSTM with speech processing, although pSTM has been clearly linked to speech production and speech perception (Higgins *et al.*, 2017; Fiez, 2016; Jacquemot & Scott, 2006). Apart from the link to speech production and perception, the overall views of the contributions of pSTM in language comprehension have surfaced. Neuropsychological studies have indicated this correlation, while other studies have shown pSTM to contribute to other sentence processes like sentence repetition but not comprehension. Here we illuminate some of the studies, conclusions reached, and ultimately, how they all relate to the current study.

In some literature models of pSTM and speech processing – including perception, comprehension, and production – they have been seen as separate and independent from each other. According to Jacquemot and Scott (2006) the model of speech comprehension, the focal process of this study, is seen as being completely independent of pSTM (that is, with no overlap). In addition, pSTM is also presented as a system that assists with language acquisition over speech processing (Jacquemot & Scott, 2006).

These oppositional views of the role played by phonological short-term memory (pSTM) has been elucidated in other various theoretical outcomes over the years. Gathercole and Baddeley (2014) discuss and identify three major claims from researchers. First is the shared claim that the comprehension of sentences is an online process that happens in real time, meaning that every process happens in the moment, without the inclusion of the pSTM's representation of linguistic input. Second is the idea that pSTM becomes involved during the comprehension process but only at a later stage. Third, the most infrequent claim is that phonological memory is not required for comprehension at all, as supported by the typical development of language comprehension in individuals with phonological memory deficits (Howard & Butterworth, 1989). These claims move away from the idea of pSTM having a close association with sentence processes.

Additionally, there has been research that has shown that sentence repetition (a sentence process) is dependent on a more dynamic memory system and not solely pSTM. McCarthy and Warrington (1987b) who found that patients with impaired WM had intact sentence comprehension abilities. McCarthy and Warrington (1987a; 1987b) have argued that the role pSTM plays in sentence recall is minimal owing to the dissociation between the recall of lists and the recall of sentences. They claim that pSTM supports the recalling of lists, whereas a larger memory capacity is supported by sentence repetition because of access to lexical/semantic information. These findings are exhibited through impaired pSTM individuals who have shown good verbatim recall of meaningful sentences and poor recall of unrelated items in a list, in contrast to patients with an intact memory span having good recall of lists and poor recall of sentences. The findings by McCarthy and Warrington (1987a; 1987b) support the Baddeley (2000) revision of the working memory model with the addition of the episodic buffer, which is the integration of other memory-related subsystems and semantic memory (permanently stored knowledge). Despite these conclusions, McCarthy and Warrington (1987b) contend that pSTM does play a role in patients with deficits in sentence repetition when placed in extraneous conditions that affect their auditory perception.

In contrast to the studies that have claimed pSTM's lack of a role in sentence processing (repetition and comprehension), other studies have been presented to oppose this. Notably, Caramazza *et al.* (1981) who claim that the phonological loop based on the Baddeley and Hitch (1974) WM model is triggered and made active during sentence processing. They provide evidence of short-term memory deficits correlating with poor comprehension of reversible passive sentences. In line with Caramazza *et al.* (1981) is Papagno *et al.* (2007) who provide support for this through patients with impairments in their verbal short-term memory (STM), a term used to refer to the ability to store and manipulate verbal–linguistic information, with sentence comprehension deficits. They pinpoint syntactic complexities (i.e., complex sentence constructions) as markers for issues with sentence comprehension and not the number of propositions. This means that the link between verbal STM patients with impairments in sentence comprehension suggests the claim that the phonological loop is involved in sentence comprehension. Additionally, researchers like Just and Carpenter (1992) claim that sentence comprehension utilises a similar working system to that of non-linguistic tasks. Just and Carpenter (1992) state that the relationship between short-term memory and spoken sentences exists because memory stores information so that can be processed. This memory storage allows an individual to process, create a representation of the language perceived in their brains, and respond to it accordingly.

Additionally, the relationship between pSTM and sentence processing has been demonstrated through evidence of pSTM in repetition which is argued to be key in comprehension. It is argued that memory is about being able to retain and recall the concept of the sentence and conceptualisation is dependent on comprehension. This argument presented by Lombardi and Potter (1992) is furthered through the claim that the ability to recall sentences is thus based on the conceptual reconstruction of the sentence using bottom-up processing. Therefore, as stated by Lombardi and Potter (1992), phonological storage might not only play a role in the recall and repetition of sequences of items; they argue that comprehension is required to repeat sentences. In their argument, Lombardi and Potter (1992) suggest that sentence repetition is at its most accurate when the original construction of the sentence is reproduced only when these three strict attributes are present: i) the concept from the original sentences; ii) the activated lexical items; and iii) the syntactically primed sentence constructions. With that, the reconstruction of sentences in recall based on the strict attributes shows that one needs to first comprehend the concept presented for them to reconstruct and reproduce sentences given. Therefore, sentence-repetition tasks are crucial to comprehension and to this study.

The correlation between sentence repetition and pSTM is also reflected in neuropsychological studies. Harris *et al.* (2014) sought to investigate the link between sentence comprehension and short-term memory. They assessed patients who had incurred impairments in their verbal short-term memory; they utilised a sentence-picture matching task to assess the general sentence comprehension skills of the patients. One of the patients had semantic short-term memory deficits while the other had pSTM deficits. In this study, the patients were treated for their deficits in their respective impaired capacities. In regard to the patient with pSTM issues (which is the central mechanism within this current study), the patient showed improvement in sentence repetition. Hanten and Martin (2000) echoed similar findings in their investigation of two 10-year-olds with acquired closed-head injuries. In their study, they sought to find the contributions of phonological and semantic short-term memory in the 10-year-olds' sentence processing. Both participants were found to have a reduced memory span incurred from the injury. From the study, they found that the repetition of sentences was affected by the taxing of pSTM; however, the participants of the study were able to note the semantic complexities and irregularities in sentences. Ultimately, these findings were interrogated by Willis and Gathercole (2001).

In their efforts to interrogate the notion that pSTM influences repetition rather than comprehension, Willis and Gathercole (2001) investigated the contributions of phonological short-term memory (pSTM) on the aforementioned sentence processes of 4- to 5-year-olds. The accuracy of repetition and comprehension was tested in conjunction with the variables of sentence type and length. To test the two processes, the six sentence types from the Test for Reception and Grammar (TROG) by Bishop (1982) were used. To test the effects of pSTM on repetition and comprehension, the participants' phonological memory was taxed through the complexities of sentence length and sentence type. Sentences presented were either short or long. The six sentence types covered: *on/in*, *above/below*, *reversible active sentences (RASs)*, *X-but-not-Y sentence construction (XYS*), e*mbedded*, and *relative clause* sentences.

From the findings, Willis and Gathercole (2001) gathered that the participants with good phonological memory skills presented more accurate repetitions; however, the comprehension of the sentences did not differ between those with good versus those with poor pSTM skills. Similar to the findings from Hanten and Martin (2000), pSTM only affected sentence repetition but not comprehension. What was noted was that some sentence structures (such as that of the above/below sentences which created a spatial complexity within the sentence) had the participants presenting accurate repetitions but not understanding the spatial differences. The inaccuracies displayed through spatial differences were attributed to the lack of syntactic skills developed. Additionally, the lengthening of words only complicated the repetition of sentences and their comprehension. Furthermore, it was deduced that repetition as a sentence process was backed by pSTM, whereas comprehension was backed by access to temporary semantic representations. Although this study indicated a possible contribution of pSTM in repetition, it is still critical to a sentence process. Not only that, but if one were to align this with the notion that repetition is key to comprehension, according to Lombardi and Porter (1992), this further incentivises the need for this paper's current study.

Despite evidence of a relationship between pSTM and repetition, there has been evidence of the correlation between pSTM and sentence comprehension through neuropsychological studies focused on patients with impairments and studies concluding a correlation with other sentence processes. According to Willis and Gathercole (2001), majority of the findings surrounding the relationship between language and memory have suggested that studies on pSTM show good sentence repetition, but comprehension is dependent on semantic storage. Despite these findings, through their investigation of the contributions of pSTM to sentence processing, Willis and Gathercole (2001) claim that most of the arguments regarding pSTM and comprehension are borne out of research of adults with acquired impairments, i.e., those who developed typically but subsequently incurred injuries to their brains. The argument for the relationship between pSTM and comprehension provided by the research involving adults with acquired impairments is that these adults have already developed typically. Thus, they have advanced semantic and syntactic skills needed to process and comprehend sentences (Willis & Gathercole, 2001). Therefore, their dependency on a capacity such as pSTM would not be heavily leaned on – seeing that their other memory subsystems and long-term memory (LTM) are developed enough to carry the weight of meaningful sentences – in comparison to an individual that is not fully developed yet. Despite this, it is also shown that adults with memory deficits have challenges with their comprehension. This begs the question of whether pSTM is heavily dependent on.

Despite the arguments presenting a lack of a role played by pSTM in sentence comprehension (but featuring more strongly in sentence repetition), simulating phonological short-term memory (pSTM) deficits has presented evidence of the contrary. Hayiou-Thomas, Bishop, and Plunkett (2004) found that pSTM plays a significant role by simulating pSTM deficits during an experiment with Typically Developing (TD) children. The deficit was simulated through the doubling of sentence length which increased the difficulty of storage because of the weighty material. This taxed the pSTM, which showed a significant impact in TD children, evidencing the importance of pSTM in the processing of sentences. The effect of the deficits of TD children mirrored that of specific language impairment (SLI) -impaired children. The results from this experiment corroborate the capacity theory presented by Just and Carpenter (1992), who claim that comprehension declines when one forgets earlier parts of a sentence because of its lengthened form and present distractors.

In line with the simulated experiment by Hayiou-Thomas *et al.* (2004), Higgins *et al.* (2017) present a phonologically based study on children's sentence comprehension with a focus on pSTM and speech perception. (Speech perception involves the mapping of acoustic elements onto basic segmental forms.) In the Higgins *et al.* (2017) study, their investigation is based on the simulation of pSTM deficits in Typically Developing (TD) children. Both experiments (Hayiou-Thomas et al, 2014; Higgins et al, 2017) used sentence length to tax memory. Ultimately, their results show that pSTM and speech perception play a role in the comprehension of sentences, with pSTM having a larger impact than speech perception. This calls into question how such circumstances (whereby memory is taxed) would affect not just TD children, but bilingual TD children and their processing of spoken sentence comprehension.

Moreover, it is critical to note that older research supported the inclusion of WM in language comprehension. According to Gathercole and Baddeley (2014), the earlier research indicating the possible association between the two processes included two models: the four-step model of spoken comprehension by Clark and Clarke (1977) and the text comprehension model presented by Van Dijk and Kintsch (1983). In the four-step model, it is said that i) linguistic input is reconstructed phonologically within the WM; ii) the constructed representation is then used to pinpoint the functions and content of the input; iii) the propositions (main ideas of the sentence/message) allow for a sentence structure to be created; and iv) representation of the message is eradicated, and the meaning remains. In contrast, Van Dijk and Kintsch (1983) argued for the major involvement of a short-term memory buffer in the retaining of propositions. Moreover, the role of pSTM in oral sentence comprehension is still not apparent. Many researchers have contended that language comprehension is a process that is independent of pSTM. Gathercole and Baddeley (2014) maintain that while temporary storage by the WM and representation of linguistic input during the process of language comprehension has prompted subsequent research, this idea is not sufficient. Meaning that more investigation needs to take place.

In spite of the opposing claims, the reports and findings of a possible correlation between sentence processing and pSTM inform the need for this study. Phonological memory is crucial for language functions including comprehension and language learning. This notion is important to this study given that we are investigating English second language speakers who are still learning the language and are becoming more exposed to it phonologically, lexically, and syntactically. To effectively use these linguistic skills, language knowledge needs to be retained over time. With that, the ability to store information is complex as the memory capacity is limited and varies between individuals.

Furthermore, it can be argued that a lack of findings surrounding the correlation between pSTM and sentence processing in children is a result of adult-focused studies. In fact, studies have focused more on adult comprehension and the effects of pSTM have been intensively studied through the simulation of deficits in the phonological loop. Gathercole and Baddeley (2014) present an overview of the three manners in which these simulations have been achieved: i) by suppressing the articulatory loop, ii) by manipulating phonological similarity, and iii) by focusing on unattended speech. Through these techniques, Gathercole and Baddeley (2014) conclude that involvement of the phonological loop (pSTM) does occur in the processing of sentences; however, those sentences have to be syntactically complex and long. Given this outline, there does remain the possibility of pSTM playing a role in the comprehension of sentences, yet studies have focused mainly on typical adults, which provides a more complicated take, as adults have more fully developed language capacities than TD children who are the main subjects of this current study.

Therefore, we can deduce that while skilled language comprehenders, i.e., typically developed adults, may not indicate a strong use of pSTM in their processing of sentences, the same cannot be said for children. According to Gathercole and Baddeley (2014, p. 219), "language processing is obviously more difficult and less automatised in early childhood, when the child is struggling to master the many different forms that spoken language can take". This means that children are still acquiring their language skills with comprehension being a complicated process that is only truly efficiently used once their complex language skills have been mastered. Keeping in mind that phonological short-term memory (pSTM) is present at the age of four or even earlier (see **Section 2.4.2**), the importance of its role in sentence comprehension in comparison to that of an adult may in fact be greater. Gathercole and Baddeley (2014) also conclude that there is a lack of research on pSTM and its contribution to children's language comprehension. Moreover, there is a lack of consistency in the methodologies as well.

Moreover, research that has essentially focused on children has been on those that are atypically developing. Higgins *et al.* (2017) claim that most research on sentence comprehension has focused on children that are atypically developing with Developmental Language Disorder and Specific Language Impairment (SLI) showing deficiencies in both pSTM and speech perception. This results in a need to understand the effect that pSTM has on how typically developing children comprehend information, particularly oral sentences.

Essentially the need to further investigate the role of pSTM in relation to bilinguals can be supported by the idea that is has been shown that familiarity of language ensures better memory storage performance. Yoo and Kaushanskaya (2012) present this idea in their study on adult English monolinguals and bilingual Korean–English adult speakers and the effect of the phonological memory capacities on lexical–semantic knowledge. In the study, it was demonstrated that one's knowledge of the language determines the preservation of verbal information and structural knowledge of the language being received (Yoo & Kaushanskaya, 2012). The Yoo & Kaushanskaya study determined that the proficiency of first language acquired (L1) English speakers resulted in their outperformance of the English second language learned (L2) speakers because of the familiarity of linguistic representations embedded in their knowledge. Therefore, the more knowledgeable a speaker has of the structure of a language, the better their performance; however, given the context of our current study, the participants come from African language backgrounds and their exposure to English is seemingly mostly through their education.

With that, it can be argued that for a speaker learning a second language, phonological short-term memory would be essential for processing and comprehending it. This idea is relayed by Ardila (2003), who also mirrors the claims by Yoo and Kaushanskaya (2012) about familiarity of the language making it easier to process, by concluding that the phonological system, i.e., the phonological loop, is crucial in the acquisition of a second language because it allows the storage of unfamiliar verbal information. Ardila (2003) thus asserts that any defects in the phonological system can influence a speaker's understanding of their English L2. Given what Ardila (2003) claims, the relationship between phonological memory, more specifically phonological short-term memory (PSTM), and comprehension is an interesting and critical point of investigation. Given the phonological loop's properties, capacity, and overall process, it is claimed that it plays a significant role in the second language learned (L2) learning and vocabulary acquisition (Baddeley *et al.* 1998). However, according to Yoo and Kaushanskaya (2012), phonological memory is the ability to store and preserve verbalised information for a short time and is required to comprehend auditory information.

What is evident from the discourse surrounding pSTM's role and contributions is that it is paramount that research should be conducted on typically developing, bilingual children. Not only will this fill the gap needed to address that specific sample group, but it will also contribute to the ever evolving and diverse findings in literature. Therefore, with these conflicting accounts of the role that phonological short-term memory (pSTM) ultimately plays within the comprehension of language, it is important to investigate further and discover the connections that may or may not exist.

2.4 Language Development

This section discusses early language and phonological development. Research has shown that although not all language systems are the same, it is generally believed that the process children undergo when acquiring language is similar, whether they are acquiring one language or more (Grosjean & Byers-Heinlein, 2018). The development of language and theories of acquisition indicate the prominence of phonological and perceptive linguistic skills in early childhood, which are present and prominent over pragmatic processes in the use and comprehension of language (Harley, 2014). To investigate the potential role that pSTM plays when processing sentences, it is important to understand the trends surrounding the development of language for typically developing (TD) children, and how children acquire these early processes that allow them to use the bottom-up process (see **Section 2.6.1**) and as they age effectively use top-down processing when it comes to processing sentences.

Moreover, this section contains literature and information to help address the second research question about the effect of age, i.e., the developmental trends and aspects in relation to pSTM and sentence processing. While memory is a critical mechanism during the processing of language, its development is elaborated on in its own subsection (see **Section 2.4.2**) under the language and memory section discussing the theoretical framework the study is based on (see also **Section 2.7**). Such insight into pre-linguistic acquisition, early development of perception, phonological processes, and bilingualism is imperative and is discussed further in this chapter.

2.4.1 Phonological development

Evidence of language acquisition has presented universal trends indicating the initial development of phonetic and phonological capacities. Phonology in children is developed in tandem with non-verbal communication. While children pre-linguistically learn non-verbal cues and gestures, they begin to reconcile that ability with the learning of speech sounds. However, for a child to know how to use speech, they need to be able to perceive it; therefore, phonological development begins with perception. *Speech perception* is "the process by which a perceiver internally generates linguistic structures believed to correspond with those generated by a talker" (Boothroyd, 1991, p. 78). It is claimed that infants are born with innate mechanisms to categorise speech. Categorical speech perception, which is the failure to discriminate speech sounds any better than you can identify them, is found in infants. Eimas *et al.* (1971) found that infants aged 1 and 4 months, when presented with pairs of speech sounds such as /p/ and /b/ with differing voice onset times (VOTs), did not notice the VOT difference. However, when presented with phonemes from differing categories, i.e., /p/ and /b/ respectively, the children's sucking rate increased, indicating the recognition in phonemic difference. Similar results have been demonstrated by Lasky *et al*. (1975) and Aslin *et al*. (1981).

The development of speech production indicates early phonologically development. This development gives further basis for the overall development of linguistic levels that children are exposed to the most. Language starts from a perceptive level and develops to that of the pragmatic overtime. This is apparent in the stages of language development from the stage of vegetative sounds to holophrases in the early stages (Tomasello, 2003).

By the time children begin their transition into speech, there is evidence of phonological processes. This evidence is demonstrated in the errors that they make when they try to produce speech. Four of the most common phonological processes are reduction, reduplication, assimilation, and coalescence. Reduction includes the deletion of a sound; reduplication is the repetition of a syllable; assimilation refers to the change of one sound to match another within its environment; and coalescence includes the combination of phonemes from different syllables within a word (Martínez-Gil, 2012).

What these findings of phonological development evidence is the existence of lower-level linguistic skills from infancy. This further underscores the idea that certain skills could potentially be of more use at a certain stage of development in contrast with skills that have not yet been developed.

2.4.2 Memory development

This study sets out to investigate the effect of age and development on phonological short-term memory. To address this research aim, it is imperative to provide an overview signalling the developmental trends noted within the literature. According to Bauer *et al.* (2011), memory typically develops throughout one's lifetime. However, primarily in adulthood, memory development can notably face challenges in the form of diseases such as Alzheimer's and dementia which include the loss of memory capacities (Jahn, 2022). Despite these impairments, there are generally accepted claims within the field that are used to account for the development of memory.

Scholars have maintained that pSTM increases with age, and in support of this theory, the Baddeley (1974) working memory (WM) model has been used to account for the development of pSTM in typically developing (TD) children. As mentioned in Section 2.3.2, the WM model consists of the phonological loop. The phonological loop component within the WM model stores speech for a temporary period, supporting pSTM. It does this through the inclusion of two distinct components: i) the subvocal rehearsal where articulatory rehearsal (repeating linguistic input to help reactivate and remember it) takes place, and ii) the phonological memory store (storing information for recall). It is through these components that memory span in correlation with what is referred to as articulation rate is said to increase with age. Within this subsection, the term "memory span" will henceforth be adopted and used interchangeably with the term "pSTM" within this section of the literature review, given that much of the literature surrounding the development of pSTM generally interchange the term "memory span" with pSTM (Henry, 2011). Therefore, based on the WM model by Baddeley and Hitch (1974) and its revised model by Baddeley (2000), memory span has been proven to develop with age through the increase of articulation rate assessed between different age groups.

The most acknowledged account supporting the development of pSTM is the "standard" working memory account of short-term memory development. Gathercole and Hitch (2019) claim that in this account, the pSTM (components of the phonological loop) is apparent from the age of 4 or even at an earlier stage. They postulate that children mirror adults' use of the articulatory loop but not as effectively. Although they have the phonological loop components in place, they are unlikely to utilise the rehearsal component to store and reactivate verbal information in contrast to those who are older. Further, they are unlikely to recode spontaneously visual material such as lexical items into phonological form. Interestingly, they are more likely to use nonphonological memory strategies. While this notion stands in direct opposition to the research at hand, there is still the possibility that phonological memory strategies play a role in other language processes, and in this case sentence processing.

The deductions by Gathercole and Hitch (2019) are supported through evidence highlighting that in the first three years of life, pSTM develops through the form of LTM which progresses into adulthood (see **Section 2.3.1** for brief discussion on LTM). There are two types of LTM: declarative memory and implicit memory (Glassman *et al.*, 1998). In the first three years of life, the presence of declarative memory development is evident. Declarative memory, also referred to as explicit memory, is understood to be information that is stored consciously with effort put into recollection. This type of memory is categorised into two types: semantic memory where facts are stored, and episodic memory consisting of personal experiences (Tulving & Markowitsch, 1998). From this, further advancements occur within other memory including that of short-term memory.

With that, memory span is closely related to other cognitive abilities that advance at separate ages. Henry (2011) presents the correlation between memory span and academic abilities such as reading and vocabulary. Additionally, intellectual abilities (IQ) are also deemed to be dependent on memory span development as well (Henry, 2011) This dependent relationship indicates the development of pSTM. Moreover, scholars such as Hitch *et al.* (1989) posit that memory span for verbal items improves with age as confirmed through three separate results: i) children being able to accurately repeat three words sequentially at five years of age; ii) children at the age of nine being able to correctly repeat four words in a row; iii) 11-year-olds being able to repeat five words in order. Ultimately, these identified developmental trends indicate that pSTM does develop with age and correlates with other cognitive developments.

Much of the research has indicated further evidence to support memory span development. Henry (2011) presents an overview of two hypotheses that have been used to support the development of memory span: i) evidence of increased memory capacity (ability to store more information) and ii) the improvement of processing speed with age. Apart from these hypotheses, the correlation between the increases in reading rates and memory span have also been used to account for evidence of memory span development. Scholars have argued that reading speed and articulation between children and adults differ. While TD adults read and rehearse words faster to remember them, children read and rehearse words slowly. This distinction in the speed of memory processing is indicative of how the memory span grows.

This notion touting that memory span development is heavily dependent on articulation rate has been strongly supported in various research but opposed in others. Nicholson (1981) and consequently Hulme *et al.* (1984) argued that memory span corresponded with articulation rate across a diverse range of age groups. Evidence of this spawned from Nicholson (1981) assessing 8-, 9- and 10-year-olds and their ability to recall various words based on word type, i.e., words based on different syllable lengths. Although Hulme *et al.* (1984) replicated the study and mirrored the findings by Nicholson (1981), there was a distinct difference in the use of familiar words for the younger age group, while Nicholson (1981) used unfamiliar words. Overall, words with fewer syllables had high articulation rates, while more syllables resulted in low articulation rates. These ideas were, however, refuted with the argument that articulation rate did not have as high an influence on memory span as previously concluded. It has been argued that while articulation rate plays a role, it is minimal (Kail 1992; Kail & Park 1994). Despite these oppositions, these studies indicate pSTM development.

The role of LTM knowledge has been presented as a factor of pSTM development. Henry (2011) refers to how Watkins (1977) notably claimed that when presented with common words, adults exhibited a higher memory span whereas when presented with uncommon words, the memory span showed a considerable decrease. This means that their long-term knowledge of lexical items assisted in their recall of words. In support of this, Henry and Millar (1993) subsequently argued that familiarity played a role in one's ability to recall information. The familiarity would thus be based on semantic and phonological knowledge of words. Keeping this in mind, the LTM being a factor in the development and effective use of pSTM aligns with the revisions of the WM model by Baddeley (2000) which was amended to include not just the episodic buffer but the LTM knowledge component as well.

Ultimately, the existence of a memory capacity has been identified at a young age with clear indications that it develops over time, and it has proven to be most effective depending on age. However, research has also shown that high performance in the recall of language depends on the familiarity one has with said language. This further emphasises a need to identify the extent to which children rely on a short-term phonological memory capacity to understand sentences, especially when attempting to recall unfamiliar words and sentences in an additional language that is phonologically different to their native tongue while utilising a mechanism not fully developed without the assistance of complex, adult-level linguistic skills.

2.5 Bilingualism

Globally, bilingualism is the norm; this is also true for the current study's sample population. In South Africa, the linguistic landscape is complex because of its multilingualism. Many students coming from indigenous South African language backgrounds are exposed to English as an additional language and as a language of learning, thus adding to the languages already known. This calls into question the effects that multilingualism would have on their progression within the classroom. Therefore, an understanding of bilingualism is pertinent to this study.

Bilingualism is generally referred to as a speaker's knowledge and use of two languages (Mahootian, 2019; Harley, 2014). Its definition is also understood as people being fluent and proficient with some imperfections in the languages; therefore, an individual can achieve distinct levels of proficiency in known languages and still be considered bilingual. Terminologies have also expanded. Many linguists identify and refer to various other terms such as multilingualism and plurilingualism to identify the use and fluency of more than two languages (Mahootian, 2019; Bhatia & Ritchie, 2012).

Bilingualism has now become the standard worldwide and with that comes complexities. The complexity of bilingualism has resulted in its inclusion within several research fields such as linguistics, psychology, neuroscience, anthropology, and education. In the psycholinguistic field, contemporary research has gone on to focus on how known languages interact cognitively and behaviourally. In line with current research, this study centralises bilingual language processing and working memory to identify cognitive functions and behaviours that can contribute to the current discourse surrounding bilingualism.

What it means to be bilingual and who can be classified as being bilingual has been controversial. Bilingualism has often been construed as the ability to have equal knowledge and use of two or more languages. This conception has evolved overtime from the likes of Bloomfield (1933) who upheld the idea that native-like abilities in all languages would consider an individual bilingual, to Haugen (1969) who disputed those claims and ascertained that although they agree with the idea that bilinguals can be equally proficient in their known languages, a bilingual's use need only contain the production of meaningful discourse for one to be considered a bilingual. Grosjean and Byers-Heinlein (2018) argue that although proficiency and use can be seen as characteristics of a bilingual, they are merely building blocks that can be affected by various factors including a bilingual's changing life-experiences and diverse societal circumstances. The authors contend that the knowledge of the languages known can be affected by a geographical move, exposure to other languages by partners, etc.; they can even go on to lose their knowledge of a known language owing to lack of exposure. Grosjean and Byers-Heinlein (2018) go on to add that some language skills may not be present in all languages known as a result. This does, therefore, not dispute one's status as a bilingual.

Although there is no fixed idea on what does or does not constitute a bilingual, bilinguals can be classified in accordance with when and how an individual acquired their language, i.e., i) **simultaneous bilingualism** and ii) **sequential bilingualism**. Simultaneous bilingualism refers to the acquisition of the languages at the same time. This acquisition takes place from an early age (from birth, during infancy, or childhood) and both languages are declared first languages for those individuals (Bhatia & Ritchie, 2012). In contrast, sequential bilingualism refers to the early acquisition of one language at first, and later, another language (Grosjean & Byers-Heinlein, 2018); it can take place at any age. Generally, the additional languages acquired are the weaker; in some rare cases, the second language acquired can grow to become the dominant language due to factors such as lack of exposure to the first language acquired (L1) and attrition (loss of language). Sequential bilingualism also refers to the acquisition of a second language which most students from South African indigenous language backgrounds experience in South Africa when entering schools with English or Afrikaans as a medium of instruction.

Bilingualism is thus an interesting and complex phenomenon. First, a bilingual's language development differs from that of a monolingual. Bilinguals employ mental resources differently from monolinguals. Hoffman (2014) posits that bilinguals have the added obstacle of developing the same linguistic skills and capacities of two languages while navigating more than one language with presumably dissimilar language systems. Second, it can be argued that exposure to English as the instruction medium creates a barrier to comprehension through language processing by bilingual students. This argument is reflected by Kroll and Bialystok (2013) who claim that the mental resources used by bilinguals are more significant to bilingual language processing (i.e., comprehension and sentence production). They insist that the mental resources that bilinguals recruit are critical "in the less dominant of their two languages when they select the words to speak in one language only, and they switch from one language to the other in discourse" (Kroll & Bialystok, 2013, p. 498). This, according to Kroll and Bialystok (2013), changes how the mind functions and the structure of the brain.

In a schooling environment, through aspects of communication – such as auditory and verbal functions – the perceptive, conceptual, and analytical abilities of bilinguals are tested (Boudewyn, 2015). Comparative bilingual and monolingual studies have shown that linguistic complexities are experienced by bilinguals who have cognitively acquired and stored various syntactic and conceptual elements from differing language systems (Kroll *et al*., 2015). Despite these complexities, advantages of bilingualism have been a result of i) the frequency of bilingual immersion in languages (Tao *et al*., 2011), ii) the number of functional bilingual years (Luk *et al*., 2011), and iii) high bilingual proficiency (Singh & Mishra, 2012).

Bilinguals are also said to cognitively manage their languages differently from monolinguals. Research has suggested that when undergoing cognitive processes, bilinguals manage their languages, which are activated when either one of the languages is used, at the same time (Gollan & Kroll, 2001; Yang & Yang 2017). Arguments against separate memory stores for languages have thus been presented (Brysbaert, 1998). This indicates possible interaction between languages despite their differences. This brings to the forefront the question of how bilinguals who have acquired their first language, are learning English as an additional language, and can presumably be identified as early sequential bilinguals, manage their processing of language and memory.

2.5.1 Cross-linguistic transfer

Research overtime has identified the implications of one's native tongue on the acquisition and learning of another language. According to Wood (2017), these implications have been studied in connection with errors created by language learners. This discovery has led to many models and theories including cross-linguistic transfer. According to Nsengiyumva *et al.* (2021), cross-linguistic transfer (CLT), also referred to as language transfer, presents the main challenge to second language acquisition. The theory of CLT underscores the idea that there can be interference of one language in another. Yang (2019) states that transfer involves linguistic features from one language being applied to the other, meaning that it can take place on a discursive, sentential, and lexical level. CLT is also attached to the notion that the first language acquired (L1) could either have a positive or negative effect on the second language being acquired (L2) (Nsengiyumva *et al*., 2021; VanPatten and Williams, 2014). Positive CLT refers to the L1 facilitating rather than impeding the L2, while negative CLT constitutes an L1 hindering the process of the L2. CLT proposes that if languages had similar elements, there would be positive transfer and learners would not have difficulty acquiring the L2; however, if the languages were different, the opposite would be true (VanPatten and Williams, 2014; Yang 2019).

Positive language transfer has been displayed through similarities shared between languages. Williams (1980) claimed that second language learners begin to perceive their second language acquired (L2) based on their knowledge of the first language acquired. This has been argued further with the examination of sounds and their pronouncements; particularly, that it is easiest to pronounce a sound in an L2 based on its similarities to sounds in the first language acquired (L1). Flege (1987; 1991) examined this phenomenon and found that when pronouncing sounds that are familiar to the L1, L2 learners perform better as opposed to learning sounds that are foreign to them.

Despite this, much research has surfaced outlining negative language transfer. Earlier studies attributed CLT as the main factor behind second language acquisition errors (VanPatten and Williams, 2014). Cortés (2005) argues that negative transfer is demonstrated during foreign language learning, which they describe takes place in a country where only one language is spoken. Selinker, Swain, and Dumas (1975) attributed errors made by L1 English-speaking 7-year-olds learning French to the syntactic structure of the English language. Similarly, in their study, Cortés (2005) found that British students learning Spanish created similar errors in grammatical structures that were transferred from English when writing informal letters in Spanish. Yang (2019) further presents findings reflecting negative transfer from Chinese-English translations created by university freshmen (first-year students) indicating structural errors caused by language transfer.

Despite these findings on positive and negative language transfer, some scholars have distanced themselves from the idea of CLT. Mclaughlin (1984) states that the processes and strategies used when acquiring a second language are similar for any individual. This means that knowledge of a specific first language acquired (L1) cannot be transferred to the knowledge of an L2 if individuals with differing L1s can experience the acquisition process of a singular second language acquired (L2) similarly. For example, two individuals from Tshivenda and Sepedi backgrounds would have the same experience and trajectory when acquiring English as a second language. This phenomenon is proposed by Dulay and Burt (1974) who found that children between the ages of 5 and 8 who were Spanish and Chinese speaking (as L1s) acquired English morphemes similarly. A similar study by Bailey *et al.* (1974) was conducted in the same manner as the children studied by Dulay and Burt (1974). In their study, Bailey *et al.* (1974) assessed a group of L2-English speakers with various L1s acquiring morphemes. Although the learning of an L2 is shown to have a similar process despite the L1 known, the huge difference in learning a L1 and L2 can be indicated by the age at which individuals learn an L2. Grosjean (1982) asserts that older individuals have greater world knowledge than children; therefore, this influences their semantic conceptualisation when learning their L2. Still, the process of learning an L2 is generally argued to be the same.

According to Nsengiyumva *et al.* (2021), the notion of a negative influence of an L1 on an L2 resulted in negative perceptions of bilingualism. Over the years and through much research, this sentiment has changed with scholars such as Grosjean (2010) stating that a common misconception of bilingualism is that one language affects the acquisition of the other negatively; he goes on to argue that the L1 can, in fact, positively influence the second language (L2) being learnt. Grosjean (2010) argues that the spoken language at home versus the language learnt at school, although different, does not impede but rather provides a basis for a child to learn the second language. This basis is dependent on similarities between languages; the basis that the one language provides the other is based on the aspects shared. The effect of the L1 (southern African Bantu language) on the L2 (South African English) in the context of a South African classroom poses an interesting point of study, however, arguably due to their distinct structures. Moreover, the point of contention is with comprehension and not second language learning, which are distinct processes. Despite the contention surrounding the language transfer hypothesis, it is paramount to this study, which focuses on the effects of phonology on the sentence processing of multilingual L2 English speakers. It calls into question whether this can evolve into the L1 influencing sentence processing, especially given evidence of structural errors.

To further understand the effects of bilingualism on language processing, i.e., the cognitive function that allows the mental representation of language and its comprehension (see **Section 2.6.3** for further discussion), it is important to note the proposed models of it. As mentioned above, the debates regarding the interdependence or lack of between languages have resulted in models corroborating both notions. The two models borne out of these debates have been the separate-store and the common-store models. In the separate-store model, lexicons are said to be separate with only the connection between languages being at the semantic level. In contrast, the common-store model lexicon and semantic memory are all stored in one compartment and direct interaction and facilitation between languages. Harley (2014) contends that there has been growing consensus on the common-stores model. Given this, the notion of interference and/or interaction is notable to study. Therefore, studying the plurilingual effects of a memory capacity such as phonological memory, could further inform the navigation of the language systems in the processing of sentences.

2.5.2 Bilingualism and memory

Memory is needed to process language. How an individual processes more than one language using their memory store poses an interesting point of study. According to Harley (2014), bilinguals do not experience any major disadvantages when they learn two languages at the same time. However, deficits show up in cognitive processes, especially those of working memory tasks in the second language learnt (L2). This affects bilingual performance. This section reviews how bilinguals organise their languages in their memory. It presents proposed bilingual models and theories that have been developed to provide a possible idea of how bilinguals store and access linguistic input.

Concerns surrounding bilingualism have stemmed from a fear of languages and systems interfering with one another during language development, causing confusing and intellectual deficiency. In the case of this study which considers the multilingual landscape of South Africa, the question arises of how a possible interference or language transfer of languages can affect the phonological memory used to process sentences by children. This study is made of a corpus group which includes second language (L2) South African English speakers from southern African Bantu language backgrounds. With this in mind, the question of how bilinguals organise and navigate their languages in memory arises. Overall, bilingualism poses an interesting point of study which will be further developed in this subsection.

From the previous literature discussed in this section, it is clear that working memory (WM) has been deemed an essential component in linguistic processes (such as reading and vocabulary acquisition) and multilingualism can be beneficial to linguistic processing and phonological memory capacity. For bilinguals, WM capacity – which is used to navigate, store, and process multiple linguistic information – is enhanced (Monnier *et al.*, 2022). Given this, authors such as Cunnings (2017) and Cockcroft *et al.* (2019) have asserted that multilinguals have high-capacity WM in comparison to monolinguals, given that practice of language results in the heightened ability of the capacity. Zaretsky et al. (2023) have gone on further to argue that bilingualism can lead to pSTM developing faster because bilingualism demands more from the capacity than for monolinguals. In further investigating WM advantages in South African multilinguals, Espi-Sanchis and Cockcroft (2021) found that having balanced proficiency in languages informs high verbal processing performance. Interestingly, English – which was the language used to assess the participants – did not indicate any correlations with WM components. Ultimately, for there to be cognitive advantages to multilingualism, there needs to be a balanced proficiency between the languages known.

There has been a common trend featuring bilingual outperformance of monolinguals, particularly regarding memory. Grundy and Timmer (2016) note how bilinguals possess greater working memory (WM) capacity than monolinguals. This notion is reflected in the study by Blom *et al*. (2014) who studied bilingual Turkish-Dutch children from a lower socio-economic status. Blom *et al.* (2014) conclude that bilingualism is a benefit that goes beyond WM tasks. They claim that sequential bilingual children have enhanced WM. The benefits are exhibited in language-independent WM tasks encompassing processing and storage. In addition, when a bilingual possesses higher proficiency in their languages, there is greater verbal WM performance.

Further evidence of benefits to bilinguals has been demonstrated by long-term domain-specific efforts. Jones and Macken (2015) claim that phonological memory capacity is improved through long-term learning and experience. Woodward *et al.* (2008) also assert that availability and accessibility of phonological representations that have been stored long-term determine the performance of how recall is supported. This is an intriguing prospect; however, the question of how this conclusion impacts bi- or multilingual children arises. If experience and learning are predictors of higher phonological memory capacity, does the use of the capacity thus become effortful? And if so, does it have an impact or correlation, if one even exists, on the processing of sentences?

In terms of bilingual research on children and memory, the impacts of WM have not been found. In a longitudinal study of 6-year-olds and 8-year-olds, Engel (2011) found that while simultaneous bilingual children had to navigate the processing of multiple language systems, language skills were impacted with no actual effect on WM development. This glaringly contrasts with previously mentioned studies that indicate bilingual WM benefits in comparison to monolingual WM performance. Moreover, Engel (2011) found that bilingual languages do, in fact, interact during speech production, as the bilinguals were outperformed by monolinguals in lexical and syntactic retrieval. Cockcroft (2016) found that bilingual South African school beginners showed no particular effect on the development of verbal working memory skills despite knowing two structurally different languages. This finding was an interesting one despite the bilinguals exhibiting poor receptive and expressive vocabulary in contrast to that of the monolinguals assessed. In spite of these findings, Espi-Sanchis and Cockcroft (2022) do concede that more studies using WM models are needed to further investigate multilingual influences on verbal processing, linking back to the current study.

While these multilingual advantages have been demonstrated, other comparative studies have indicated a lack of bilingual advantage. Yoo and Kaushanskaya (2012) noted the outperformance of bilinguals by monolinguals in lexical and semantic tasks, and more significantly, in phonological memory tasks. In this study, it was found that although these monolingual advantages were present, the more the demand for executive processing, the more the bilinguals' performances improved. In comparison, Anjomshoae *et al*. (2021) found that there was not much of a difference between monolingual and bilingual WM capacity. What was notable was that while the monolinguals exhibited the use of one WM store, bilinguals demonstrated the use of two WM stores. Important to reiterate is that while this discovery is important to demonstrate the distinct performances of monolinguals and bilinguals, this study will not be a comparative one. What this information indicates is that there is a distinct cognitive memory performance of bilinguals, and this study will provide further insight into the performance of bilinguals when processing language.

The literature that has been brought forth regarding bilingual WM has shown a distinct experience and a need to further fill the gap with South African studies. Using the Baddeley (2000) WM model to assess the phonological short-term memory (pSTM), a capacity that forms part of the said WM model, this study will assess bilingual children's performance. Although this will not be compared to monolingual performance, this will inform developmental trends and capacity performance.

2.5.3 Bilingual memory models

Literature on the cross-linguistic transfer (CLT) theory proposes the possible interference that languages known by bilinguals could have on processing. This is also presented through models of bilingual memory which indicate interaction and connectedness between the languages spoken. Heredia and Brown (2012) offer the proposition that bilingual lexical access is language nonselective. This means that a bilingual is not able to switch off the language that is not contextually appropriate when processing language. Starreveld *et al.* (2014) claim that bilinguals could potentially access their lexicons in a non-language-specific manner involving perpetual interaction and competition between the languages, especially during the process of language comprehension. This interaction of language in memory has been modelled by the earlier bilingual models including the Weinrich model (seen in Ardila, 1998) which presented a separation of the **lexical** and **semantic** levels. These levels indicated interactions between languages based on similarities of lexical words or their meanings, which would thus help in their translation and understanding of word use.

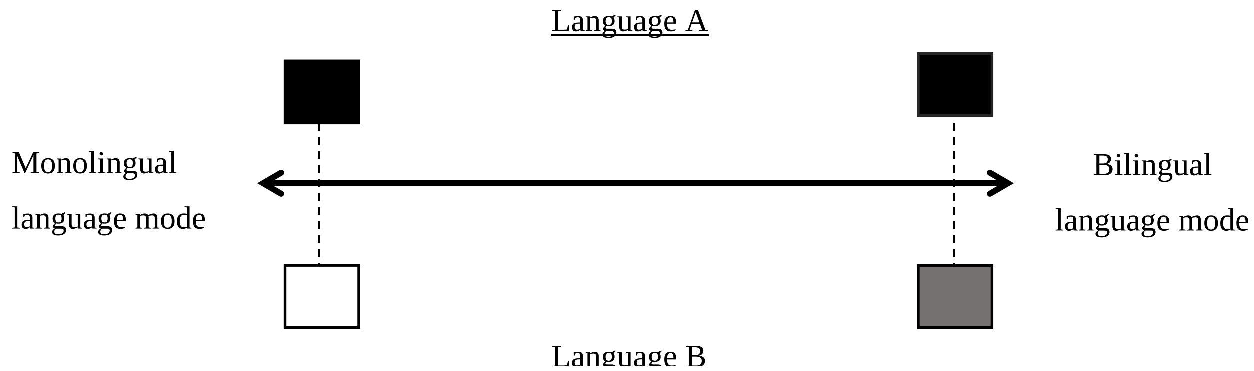
Following this are the prominent hypotheses of the s*hared (interdependent) vs. the separate memory (independent) hypotheses* (Heredia & Brown, 2012; Walters, 2014). The shared (interdependent hypothesis) versus the separate memory (independent) hypothesis stipulates that a bilingual either stores the languages known in one memory storage that is shared between the languages or into separate systems. Similar to the separate memory hypothesis, is the Bilingual Dual Coding Model. This model proposes that memory storage systems of language known are separate; however, the systems are still interconnected (Paivio and Desrochers, 1980). Given the interconnectedness proposed, these models map the idea that language systems can overlap. Heredia and Brown (2012) posit that while there has been evidence of these separate hypotheses, there is the possibility of bilinguals possessing neither of these memory systems.

Further revisions have led to the hierarchal account by Kroll and Stewart (1994) which elucidates what Heredia and Brown (2012) refer to as a two-way link between a bilingual's lexicon and conceptual store. The bi-directional link between the lexicons and concept stores of a bilingual's first language acquired (L1) and second language learnt (L2). The revised hierarchal model indicates the importance of the L1 in obtaining a concept. Interestingly, this model depicts the challenge bilinguals are said to face challenges when attempting to find the meaning of an L2 word directly from the concepts store. The bilingual would need to first create a link with the L1 which would then directly and strongly access the concepts store (Heredia & Brown, 2012). Essentially, this model enforces the idea that bilinguals translate their L2 lexical items through their L1s.

2.5.4 Bilingual performance

Further evidence of possible bilingual language interference is presented through the language mode continuum and parallel activation. The boom in contemporary research in neuroimaging, behaviour, and patient studies has displayed the activation of known languages when they are being used (Kroll *et al.*, 2012). Grosjean (2001) proposed that when bilinguals use one language, the other language remains active in a limited capacity. This was proposed through the language mode hypothesis. This hypothesis outlines a state of activation of the languages known by bilinguals. Grosjean (2013) claims that bilinguals communicate differently when in conversation with monolinguals compared to bilinguals. The author aligns this proposition with the Weinrich argument that bilinguals limited any interference, i.e., linguistic elements from one language, to accommodate monolinguals (Grosjean, 2013). The manner in which bilinguals navigate conversation between bilinguals and monolinguals is illustrated through the language mode hypothesis continuum presented below (see **Figure 9**).

Figure 9: Representation of the language mode continuum



Source: Adapted from Grosjean (2013, p. 489)

Figure 9 visually represents the language mode continuum proposed by Grosjean (2013). On one end (the left) we find the monolingual language mode position, while on the other end of the continuum, we find the bilingual language mode. Two languages (language A and language B) are represented on both ends by the square boxes. The extent to which a language is activated during language processing is illustrated by the degree of darkness the box is shaded. For monolinguals, the language mode hypothesis suggests that Language A, i.e., first language acquired (L1) is activated. In contrast, bilinguals have their Language A activated either at the exact or close to the same degree as a monolingual. While Language A is activated, Language B, i.e., the second language acquired (L2), is simultaneously activated but not to the degree that Language A is activated.

Another process termed the parallel activation hypothesis suggests that when a bilingual processes language, they activate both their languages at the same time even when only one language is used (Lee, 2011; Kroll *et al*., 2014). Although sequential activation means the lack of interactivity between the languages of the bilingual, the evidence of parallel activation underscores the importance of investigating the language processing of bilinguals.

The language mode hypothesis elucidates parallel language activation as a phenomenon evident in bilinguals. Dijkstra *et al.* (1999) exhibited parallel activation in a study of Dutch-English bilinguals. In their study, the bilinguals were with different English words that overlapped orthographically, semantically, and phonologically with Dutch words. The findings showed that lexical information was activated in both languages. This was evident in how bilinguals quickly recognised cognates (words that are similar in meaning and form in two different languages). Interlingual homographs, words that are similar in form but mean different things in different languages, were recognised more slowly. In this study, it was evident that cross-linguistic facilitation took place.

Further evidence of parallel activation has been presented in neuroimaging studies. Thierry and Wu (2007) utilised event-related brain potentials to gauge the interaction between the first language acquired (L1) and the (L2) when bilinguals read words in their L2. They found that bilinguals would spontaneously activate their lexical information from their L1 when presented with the L2 words. From their findings, they deduce that this is an everyday occurrence as there is no awareness of activation/explicit use processing of the L1.

What these findings represent is a possible interaction and interference between languages known when during language processing. This is integral to the current study which focuses on South African bilinguals and their processing of oral sentences.

2.6 Language Processing

Language comprehension is a critical higher-order processing skill. We hear and perceive many words and sentences in discourse every day. For one to respond to discourse, they need to first understand what is being spoken to or read by them. In discourse, comprehension as a process follows word recognition and parsing (Harley, 2014). Semantic and referential processing form part of the comprehension process. This indicates the complexities of comprehension because of the integration of language levels that takes place. Problems with comprehension arise when there are difficulties processing those high levels of language, especially when they have not been fully developed as we see with children.

This leads to the most critical aspect of comprehension in our day and age – education. Essentially, a focus on children's sentence processing aligns with education. The processing of language through auditory information such as uttered sentences is required in most classroom environments where students are spoken to and taught by a teacher. The processing of oral sentences is essential to understand day-to-day communication, following instructions, comprehending lessons within the classroom, and recalling information. Therefore, this section will explore aspects of sentence processing, and more specifically children's processing of sentences.

2.6.1 Sentence processing

Sentences form part of everyday discourse. Higgins *et al.* (2017) state that sentences are whole units made of lexical items, which are broken up into morphemes and further into phonological segments and phonemes. These lexical units are put together syntactically and, as a result, they are produced to send a message. According to Van Gompel (2013), sentences function as syntactic and semantic units, i.e., they are formed using special units that involve grammatical rules and convey certain meanings.

Ferreira and Cokal (2016) state that sentence processing refers to the way sentences are interpreted, and many sources of information are used during this processing. Comprehending sentences in discourse thus involves focusing on grammar, lexicon, semantics, and pragmatics (Hansson *et al*., 2017). However, the processing of sentences is much more complex requiring many linguistic and cognitive mechanisms to navigate its comprehension. Therefore, comprehension is a result of correct grammatical and lexical representations that are dependent on phonological and phonetic representations perceived.

Top-down vs bottom-up processing

Models have been proposed to account for the way language is processed. Language processing can either be described as **top-down** or **bottom-up**, which are hierarchical processes. Top-down processing refers to the use of knowledge and context to interpret written or spoken language (Treiman, 2001). This knowledge is embedded in semantic memory, i.e., long-term memory (LTM) (see **Section 2.3.1**), which is built on and stored permanently as a result of experiences in the world. From this knowledge, the processes move down and narrow to the smaller units of language. It thus moves from the pragmatic, semantic, syntactic, and morphemic, to the phonological and phonetic.

In contrast to this is the bottom-up process. The bottom-up process involves the transition from linguistic elements to the meaning of language. In other words, refers to when the receiver of an utterance begins at the phonetic perception stage and works up to the world view semantic knowledge to comprehend language (Treiman, 2001). These means of processing are used variously among individuals, especially children in development, as will be assessed in this study.

Brown (2017) argues that comprehension is a process that leans more towards the top-down processing of language. In turn, Brown (2007) reasons that the effectiveness of the top-down process is for reading and comprehension is dependent on what the perceiver of the information brings, i.e., what capacities, skills, intellect, and experience they can use to understand what they read or hear. This process negates the passiveness of the bottom-up process. However, the top-down processing of language relies on the development of higher-level linguistic skills like semantic, syntax, and pragmatics, all of which children have not fully developed yet. It can thus be argued that children are dependent on language processing skills that are phonological and phonetic to make sense of auditory information because according to Grosjean and Byers-Heinlein (2018), the more complex comprehension linguistic skills are still in development.

2.6.2 Children and sentence processing

Typical adults are more inclined to use top-down processing because of their developed linguistic skills, but that begs the question of how children truly process their language. Children, particularly those in early childhood, do not have fully developed language skills (Willis & Gathercole, 2001). Given this, the idea that they have not gained as much semantic knowledge as adults have to make sense of the world and effectively comprehend discourse becomes known. This alone could potentially indicate that they initially rely on the smaller units of language to comprehend it. Zamuner and Kharmalov (2016) state that speech perception is the initial linguistic structure that infants are exposed to. Therefore, bottom-up processing of language could be used, showing possible strong reliance on phonetic perception and phonological processing by children.

Opposing this possibility is that researchers have found that four-year-old children have been proven to exhibit adult language processing abilities. Thothathiri and Snedeker (2008) found that children as young as three years old were able to easily process through structural priming. This means that the children were able to process a sentence if the sentence was accompanied by a preceding sentence with a similar structure. This, therefore, indicates the use of abstract syntactic representations.

Further research has surfaced indicating adult-like linguistic abilities in children as young as four years old. Structural priming is one bit of scholarly evidence supporting this (Thothathiri & Snedeker, 2008). Another bit of evidence has emerged demonstrating children’s ability to resolve ambiguity in sentence processing. The Snedeker and Yuan (2008) study recorded children’s ability to use lexical and prosodic cues for resolving ambiguity. This is interesting to note because their ability to process a sentence derives from having another sentence – essentially discourse. This begs the following questions: What happens when children are left to process one sentence alone without any other sentences to provide context clues? What mechanisms play a significant role or simply contribute to the process? Does phonological short-term memory play a major role in the processing of individual oral sentences? This is what the study intends to investigate.

Nevertheless, with individual sentences, children cannot rely on context to make sense of a sentence or even structural priming which relies on a preceding sentence with a similar structure. This brings us back to possible bottom-up processing in children which could be supported by the manner in which adults communicate with children. According to Grosjean and Byers-Heinlein (2018), most children grow up being talked to using a simplified means of communication called child-directed speech. This type of speech holds properties on varying linguistic levels: i) Phonologically and phonetically, where intonation is exaggerated with articulation being pronounced and concrete; ii) syntactically, where sentences are simple and short; iii) semantically, whereby diminutives are more likely to be used with referents being direct; and iv) pragmatically, questions and directive speech are more prevalent. Infants and children are unable to rely on context and world knowledge, so they use perception and phonology to make sense of language.

Despite these similarities, this is not reflective of children's holistic sentence processing skills as there are differences. Research has shown that children have not developed to the same level as adults cognitively as well as linguistically. Through the Mazuka *et al*. (2009) study, it is evident that the prefrontal cortex has not developed fully for children; this develops slowly and overtime. Cognitively, this part of the brain is critical for executive function which underlies cognitive planning and control. The development of these functions is essential given that the functions are needed to be able to revise one's interpretation of garden path sentences (Snedeker, 2013). Therefore, cognitive differences have been shown to differentiate the abilities between adult sentence processing and child sentence processing.

Apart from the cognitive differences and linking back to the possible bottom-up processing, top-down constraints are evident in children. Snedeker (2013) notes that event-related potential findings have indicated constrains on the use of a top-down process on lower linguistic processes by children, whereas adults actively use a top-down process. Arnold *et al*. (2007) also provide further evidence indicating issues with the executive control function. Arnold *et al.* (2007) present the finding that children find first-mention bias challenging. The first mention of bias for pronoun resolution relates to an individual being able to identify who a pronoun is referring to within a sentence, based on the preceding sentences. Thus, children are unable to track a reference based on the pronoun, unlike adults. These cognitive deficits indicate differences in sentence processing for children in contrast to adults.

While there have been indicators for children sharing the same language processing skills as adults, there are some differences that call for investigating further the possible mechanisms that contribute to the processing of sentences. Ultimately, there Snedeker (2013) mentions that more work is needed on the language comprehension of children. At age four, children have accumulated an expansive lexicon and seem to understand what is being said to them; however, we must learn to understand the mechanism to inform language development. Even more so, is the need to examine how bilingual children, who are developing a language and learning another, process sentences in their second language learnt (L2).

In addition, the notion of factors such as noise in addition to bilingualism and age can impact phonological short-term memory and have an eventual effect on sentence processing highlighting a bottom-up process of language for children. First, difficult and noisy listening conditions can factor in the inability to perceive and comprehend sounds and language, as this impacts students' ability to identify, recall, and comprehend speech (Bradlow & Alexander, 2007). Secondly, differing sound systems embedded in bilingual minds could also present difficulties in children's auditory language processing and comprehension (Kroll & Bialystok, 2013). With multitudes of everyday auditory expectations placed on school-going children, this research is dependent on the fact that difficulties with the processing of sentences, and more specifically a lack of comprehension by children, has a significant implication on education and academic success (McNamara & Kendeou, 2011; Kendeou *et al.*, 2014).

2.6.3 Bilingual sentence processing

Bilingual sentence processing presents a fascinating area of research due to the complexities of navigating more than one language system to do so. Roberts states the following on monolingual sentence processing:

> It is uncontroversial that native speakers incrementally process the language input, making use of bottom-up, lexical-semantic and syntactic information, as well as top-down, discourse-pragmatic information as new material is integrated into the parse during real-time sentence processing. (Roberts, 2013, p. 221)

Given this already complex way of processing for native speakers, does this translate to that of a bilingual experience? According to Grosjean and Byers-Heinlein (2018), the process of listening to and understanding language is made difficult when the listener must process more than one language a day. Given the possibility that bilingual children are likely to use a bottom-up process of language to understand it and that language transfer might play a part, investigating phonological processes of memory and perception could give great insight into the possible influences on comprehension and ultimately academic success.

Bilingualism has been proven to benefit individuals on multiple development and intellectual levels. However, Akhavan *et al.* (2020) do iterate that the extent to which these benefits extend to sentence processing has not been well-defined. In their study, Akhavan *et al.* (2020) investigate the cognitive control and the interference resolution during parsing, in the process of object-relative sentences in Spanish-English bilinguals versus English monolinguals. They conclude that bilinguals can be effective in processing spoken sentences and resolving interference more so than monolinguals. This deduction is in line with arguments by Abutalebi *et al.* (2011) and Bialystok *et al.* (2009) who found that bilinguals had heightened cognitive control functions.

Despite these benefits in bilinguals that have been noted during sentence processing, some difficulties arise. On the one hand, researchers such as Clahsen and Felser (2006) have determined that L2 speakers find difficulty in processing language in a native-like way because they do not possess the grammar needed to do so. These conclusions are also shared by Jiang (2007) who posits that bilinguals struggle to easily access and use grammatical knowledge at the same pace as native speakers. On the other hand, other researchers such as Hopp (2010) assert that bilingual and monolingual processing maintains the same processing attributes and that issues or poor performances are a result of cognitive capacity limitations such as working memory (WM). Havik *et al*. (2009) support this notion through their study focused on German L2 learners of Dutch and self-paced reading. In their study, they discovered that bilinguals shared the same performance/capacity as native speakers with poor working memory. These results pose interesting implications for the study at hand because phonological short-term memory (pSTM) in this study is dependent on the WM model by Baddeley (2000), the theoretical basis of the memory mechanism (see **Section 2.3.1**).

2.7 Theoretical Framework

This current study works to adapt the studies by Willis and Gathercole (2001) and Higgins *et al.* (2017). Both of these studies worked to investigate the role of phonology in the processing and comprehension of spoken sentence comprehension, respectively. In both studies, there was a focus on young children. To account for age, language development, and atypical development, they examined the possible role that phonological processes would have on children given that critical linguistic skills were still in development and studies focusing on spoken sentence comprehension focused only on adults and participants with language development.

For the first part of the theoretical framework, we use the Willis and Gathercole (2001) study to frame this study. In addition, we use a sentence-picture naming task to assess the comprehension and repetition of the sentences. In their study, Willis and Gathercole (2001) assess the processing of sentences by young children from ages 4 to 5. They investigated the possible contribution of pSTM on sentence processing, such as repetition, and more importantly comprehension. Willis and Gathercole use the six sentence types from the Test for the Reception of Grammar (TROG; Bishop, 1982) to assess repetition and comprehension accuracy. Two experiments were conducted. The first included sentence repetition and comprehension being tested based on two variables: Sentence length and sentence type. The participants were asked to repeat sentences they had heard and then match the sentence to a picture (sentence-picture naming task). Experiment 2 constituted the comparison of two groups of children with either low or high phonological memory abilities. They found that pSTM contributed to sentence repetition and not comprehension. What they did find based on the different sentence types used was the effect of syntax on comprehension versus that of pSTM.

In contrast, Higgins *et al.* (2017) sought to simulate pSTM and speech perception deficits in young, typically developing (grade one to four) children. These deficits were meant to mimic Specific language impairments (SLI) due to individuals with SLI showcasing deficits in both speech perception and pSTM. Multiple measures and experimental measures were used to assess the participants of this study. To test the participants' pSTM, the nonword repetition (NWR) subtest from the Comprehension Test of Phonological Processes (CTOPP) was used. For a broad measure of spoken sentence comprehension, the Concepts and Following Directions and formulated sentences subtest of the Clinical Evaluation of Language Fundamentals (CELF-4) were used. Additional measures were word identification, word attack, and elision. For speech perception, a categorical speech perception task was administered. They then proceeded to present short and long sentences to tax their participants' memory capacities and deduce the extent to which pSTM affects the comprehension of sentences. A sentence-picture naming task was used to assess sentence comprehension. They concluded that pSTM and not speech perception had a bigger effect on sentence comprehension.

For this study, the tests used in both the abovementioned studies are used. Owing to time constraints, the NWR task is used to assess the participant's memory with only two sentence types from TROG used to assess the sentence-related component of the study. The sentence types are presented to the participants who are expected to repeat and choose a picture that matches the sentence. These measures are conducted for two separate age groups to account for developmental trends.

2.8 Chapter Summary

This chapter focused on presenting an overview of the debates and research in line with the current study. First, the chapter briefly discussed the linguistic backgrounds of the languages that are integral to the study, i.e., South African English and southern African Bantu languages (Tshivenda, Xitsonga, and Sepedi). Second, memory (specifically phonological short-term memory) and its relationship with language were explored along with the inclusion and establishment of the theoretical framework of this study, memory development and bilingual memory. Third, this chapter proposed a basis for understanding how language and memory are developed. Following memory, bilingual literature was discussed in conjunction with linguistic transfer, memory, and performance. Finally, the theoretical framework of this study was presented with an outlining of the aspects that have been adapted for the methodology. Overall, this chapter ensures a better understanding of the linguistic and cognitive aspects of language processing explored in this investigation.

CHAPTER 3: Methodology

3.1 Introduction

This chapter discusses the methods used to collect and analyse data in response to the study's research aims and questions. The aim of this study was to assess what role phonological short-term memory (pSTM) has on the processing of sentences, i.e., the process used by readers or listeners to understand language development of South African English second language (L2) English-speaking, typically developing (TD) children. In turn, it worked to assess the developmental aspects of the relationship by investigating the effect of age on pSTM capacity and sentence processing. Therefore, the study was conducted to answer the following investigative questions:

1. What is the effect of pSTM on South African L2 English-speaking children's oral sentence processing?
2. Does age have an effect on phonological memory processes, spoken sentence comprehension, and sentence repetition?

3.2 Research Design

To answer the research questions, this study was designed to take a quantitative approach with participant assessments. A total of 24 southern African Bantu-language speaking participants within the Polokwane Capricorn District were assessed with them being divided into two age groups: the 6–7 age group and the 9–10 age group. Ten Grade 1 (aged 6–7) and fourteen Grade 4 (aged 9–10) were assessed overall. Similar to the studies by Willis and Gathercole (2001) and Higgins *et al.* (2017), this study undertook to measure participants' pSTM capacity and assess this in relation to sentence repetition and sentence comprehension. The pSTM capacity of participants was measured using a Nonword repetition (NWR) task, with sentence processing being measured using sentence repetition and sentence-picture naming tasks. This researcher administered the tasks and documented the participants' responses.

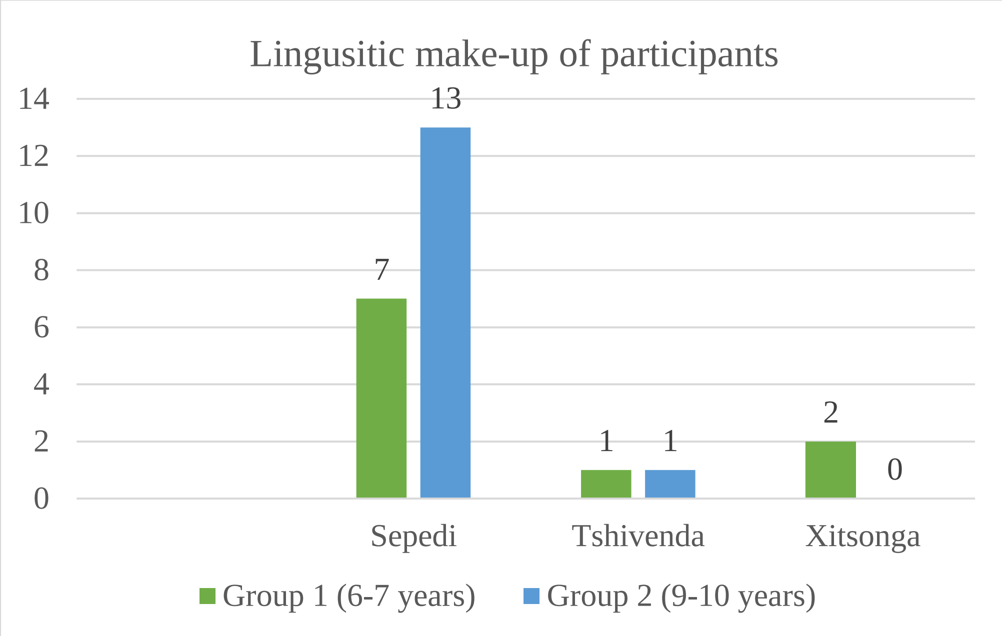
Out of all possible research approaches, this study took a quantitative approach. Creswell (2014) states that a quantitative design is concerned with the use of numbers to investigate close-ended questions. Kothari (2004) echoes these descriptions by stating that quantitative looks at measurements and amounts that have been analysed in relation to pSTM capacity scores (along with sentence repetition and comprehension scores of participants). Although there were other potential research approaches, e.g., qualitative and mixed method approaches, the nature of this study suited the quantitative approach. While the qualitative approach is used to find underlying motives using open-ended questions, interviews, and tests, the mixed method approach combines elements of both quantitative and qualitative designs and brings more analytical depth (Camic *et al.*, 2003). Therefore, the quantitative approach was deemed sufficient, as this study focused on the assessment of certain linguistic skills and did not require narrative/in-depth responses from participants.

A quantitative research approach allows for a focus on numbers and the relationship between variables such as age and gender. In the case of this developmental study, the following relationships were measured and analysed: i) pSTM, ii) age, iii) sentence repetition, and iv) sentence comprehension as independent variables; i) syllable types and ii) sentence type as dependent variables. Ultimately, the study worked to understand if a relationship between pSTM and sentence processing (sentence repetition and sentence comprehension) is present, what the relationship between the pSTM capacity and sentence repetition and comprehension was, while also working to gauge how age would be affected by the relationship between those processes. Given this approach, this study served as an empirical one as it sought to examine the relationships between several variables (Kothari, 2004). Additionally, the study focused on a quasi-experimental design using surveys for data collection.

3.3 Participants

This research investigated the target sample population of 24 South African English second language (L2) speaking children with the first language acquired (L1) coming from the indigenous languages of South Africa, belonging to the Bantu language family (Doke, 2017). The focus of this study was to identify the potential effects of the participants' background in their processing of English sentences. Given that English is the majority medium of instruction in South African schools, it is central to the study. The investigation took place within the Capricorn District of Polokwane, Limpopo, whereby the L1 Bantu languages mostly spoken are Sepedi, isiXhosa, Tshivenda, and Xitsonga. To ascertain the participants' L1s, they were questioned using the Linguistic Background Questionnaire (**Appendix B**), which is mentioned further in **Section 3.4**. The Figure below represents the mean linguistic make-up of the participants.

Figure 10: Distribution of Participants



The Figure above represents the linguistic backgrounds and distributions of the participants who formed part of the study. Potential candidates with Sepedi, Xitsonga, and Tshivenda as first language acquired (L1s) were selected during the pre-selection stage to participate in the study. Given the linguistic make-up of Limpopo, the predicted South African Bantu language speakers took part with Sepedi first language acquired (L1) speakers forming the majority of the sample group. The overall participant background composition is further outlined in **Table 7**.

Table 7: Distribution of participants according to age group, gender, and the average age in months

	Number of participants	***Gender***	***Average age in months***
Group 1 (6–7 years)	10	5 girls 5 boys	6,9
Group 2 (9–10 years)	14	9 girls 5 boys	9,8

The Table above represents the distribution of the participants based on age and sex. Overall, there was an uneven distribution of participants based on age and sex. However, this did not create any constraints or limitations to the overall study and did not create a challenge in achieving its objectives. Therefore, out of 24 participants, there was a total of fourteen Grade

4s forming Group 2 and ten Grades 1s forming Group 1. Within Group 1, there was an even distribution of boys and girls with five each. The Group 1 participants averaged around 6,9 years of age while Group 2 averaged around 9,8 years of age. In Group 4, there were nine girls and five boys who participated. It is important to note that gender was not an important variable within this study.

The participants sampled for this quasi-experiment were non-random and conveniently selected. Convenience sampling refers to the use of naturally formed groups such as organisations, schools and classes (Creswell, 2014). This type of sampling is relevant to my study as the participants selected were from primary schools within the Polokwane Capricorn District. Two schools were initially approached; however, only one was able to participate during the timeline of the study. The approached schools were independent/private schools. The choice to approach these schools was based on accessibility and a relatively swift approval/permissions process.

Participant pre-selection

Participants in the study were from an independent Polokwane college. During the pre-selection process, the administrator/researcher abided by strict coronavirus disease (COVID-19) guidelines as stipulated by the University of the Witwatersrand's Health Research Ethics Committee (HREC) and the government. Following the communication of ethics and participation information, consent forms, and assent sheets, the participants were those that were permitted by their parents to take part; these parents had provided their written consent for their child to take part in the research. Participants were then pre-selected using the linguistic background check. Before this pre-selection process began, the children once again had their letter of assent verbalised to them with a poster of illustrative images by the researcher who acted as the assessment administrator. The participants were reassured of their ability to withdraw from the pre-selection process, and they will be asked to give verbal assent as well. Figure 11 below is the Language Background Questionnaire used to account for the candidates' linguistic backgrounds.

Figure 11: Language Background Questionnaire

Language Background Questionnaire

Information Sheet about child before beginning experiment:

1. When is your birthday?
2. How old are you?
3. What grade are you in?
4. Who is your teacher?
5. What language do you speak at home?
6. Who do you stay with at home?
    a. What language does your mum speak?
    b. What languages does your father speak?
    c. What language does your guardian (gogo, auntie, etc.) speak?

Researcher Comments:

Using the Linguistic Background Questionnaire above, the children's oral proficiency was tested because this study was only focused on the spoken language modality used to test nonword and sentence repetition. It was presented by the researcher and the participants only needed to respond verbally. In addition, their multilingualism and first language acquired (L1) were verified so that they could meet the criteria of the study. Ultimately, this questionnaire was used to determine the oral proficiency of participants based on grammar, vocabulary, comprehension, and fluency as seen in **Table 8**.

Table 8: Participant oral proficiency scoring

Grammar	1	2	3	4	5	6
Vocabulary	1	2	3	4	5	6
Fluency	1	2	3	4	5	6
Comprehension	1	2	3	4	5	6

Table 8 illustrates the scorecard that was used to score and determine which participants would take place in the main assessment tasks. Each of the tested categories was scored on a range of 1 to 6, with the minimum being 1 and the maximum being 6. The lowest possible score for a participant is 4 and 24 is the highest. Participant selection was based on the candidates scoring above the average of 12 points. The following criteria determined if the candidates were able to proceed to the main assessment tasks:

(1) They needed to score at least 12 points.
(2) If a candidate achieved a low score in one category but still achieved 12 and above, they were still permitted to participate.

3.4 Procedure

3.4.1 Site and conditions

The site and conditions of the assessment were integral to the completion of the assessments. The researcher was permitted to proceed with the research on the school premises of the participants, in multiple areas including a classroom, a staffroom, and an office. The conditions of the rooms varied. For most of the procedural stage, the rooms used for assessments were quiet. Given that the research was conducted on school premises, noise from students, teachers, and school bells was unavoidable. The assessments also took place during class time to accommodate the travel arrangements of assenting children.

3.4.2 Pre-assessment procedure

In terms of the assessments themselves, the participants that fit the criteria and passed the oral proficiency test were assessed individually. They were asked to sit by a desk, where they were reinformed of i) who the researcher was, ii) what the research was, iii) what the researcher intended to do with the results from responses of the participants, and iv) what could potentially happen with the data that was captured. The participants were reassured that they would stay anonymous, and if they felt uncomfortable, they would be permitted to stop the assessment at any time and leave. Given the relatively young ages of the participants, accessible and understandable language was used to re-explain what was in the information sheet.

Given the ages of the participants and the low-risk ethical status of the project, it is important to reiterate that requesting verbal assent from the participants was an ongoing process throughout the research procedure. The participants that fit the criteria and passed the oral proficiency test were assessed individually by one administrator (the researcher). All tests were administered to the selected participants in English.

3.4.3 Assessment tasks

This study's assessments included two main tasks: **Task 1** – a nonword repetition (NWR) task to assess the phonological short-term memory (pSTM) capacity of participants, and **Task 2** – two subtests, i.e., sentence repetition and a sentence-picture naming task for sentence comprehension. Sentences presented fit two specific sentence types: i) reversible active sentence (RAS) and ii) XYS constructions.

An RAS in English follows the same sentence construction as that of a passive sentence. Here is an example of an RAS:

"The ball is thrown by the baseball player."

An RAS places what would be an object in an active sentence as the subject. At the centre of the sentence is the action itself, which in this case is the verbal phrase **"is thrown"**. Therefore, the subject would be the noun receiving the actions, i.e., **"The ball"** is the thing that is being thrown. While in turn, the noun in the object position is the thing that is doing the action, i.e., "**the baseball player**" is throwing the ball.

An XYS construction is meant to present a distractor within the sentence within the sentence itself. A clear example of this is the sentence →

"The boy but not the girl is singing a song."

In this case, we are given a noun phrase including two subjects, i.e., a boy and a girl. However, the meaning of the sentence lies with who is doing the action, i.e., **"singing a song".** The one doing the action is the construction is the X; the Y is not doing the action. In this case, our **"X"** is **"the boy"** while our **"Y"** is **"the girl"**. Ultimately, the logic of the sentence rests with the boy singing the song. If a visual were to accompany the sentence, it would be the boy doing the singing and not the girl.

Ultimately, the sentence-processing performance of the participants with either high or low pSTM abilities was compared in relation to the sentence comprehension and sentence repetition scores.

3.4.4 Task 1: pSTM and NWR task

The selected learners chosen to participate had their pSTM tested using a Nonword Repetition (NWR) task of the Comprehension Test of Phonological Processes (CTOPP) (Wagner *et al*., 1999). NWR tasks are used to assess individuals' abilities to recall information and lexical items. In the case of this study, using nonwords that fit the phonotactics of English and are especially syllabically diverse, lets us gauge the phonological recall ability, as phonology focuses on sound and sound patterns, i.e., syllables and syllable structures.

During the task, participants were presented with a nonword (e.g., **"chigspen"** □ **[tʃɪg.spən**) and had to repeat the words to measure their pSTM capacity. The words presented were of varying syllabicity reflecting that of English phonotactics, with the words being presented with increasing difficulty which was accomplished using word length determined by the number of syllables (e.g., from **"fla"** → **[fla]** one syllable to the complex four syllable **"virebision" [vi.re.bi.ʒon]**). This was done to simulate pSTM deficits by taxing storage capacity to see how the participant was able to manage their recall of the nonwords. The nonwords that were used were generated from the pseudoword generator application Wuggy (Keuleers & Brysbaert, 2010). All nonwords were presented through Bluetooth headphones with the words played from the administrator's laptop.

Other distinct examples of nonwords developed for the assessment are the monosyllabic **"molk" → [molk] which follows the CVC structure of English** and the polysyllabic **"jaterdasour"**. The ability of the participant to repeat back the words was judged based on how many out of ten they repeated correctly. For every nonword they repeated correctly, the participant was given a score of 1. If the participant was unable to repeat a word accurately, they were given a score of 0, with 5 out of 10 ultimately being an average score, 0–4 being the minimum, and 10 being the maximum.

A varying number of nonwords were presented according to the cognitive level/age. For instance, for the younger group (Group 1/Grade 1 participants aged 6–7-year-olds) a total of twelve nonwords were presented. For Group 2, a total of fifteen nonwords were presented. The limited number of content words was determined based on many factors including: i) participant capacity due to there being multiple assessments, ii) participant attention span, and iii) participant availability. The nonwords presented and consequently analysed are seen in **Table 9.**

Table 9: List of nonwords presented to both age groups for the nonword repetition (NWR) task

Group 1			**Group 2**		
Monosyllables	Disyllables	Polysyllables	Monosyllables	Disyllables	Polysyllables
Misk	Akler	Tofirmer	Misk	Akler	Tofirmer
Fla	Chigspen	Caderbellac	Fla	Chigspen	Caderbellac
Walm	Flazzer	Emiprivity	Walm	Flazzer	Emiprivity
Jimp	Brocken	Zibberzabberer	Jimp	Brocken	Zibberzabberer
			Pook	Gergin	Unfomnagnable

From the above table, we see a list of the nonwords used in the nonword repetition (NWR) task. Several nonwords were created using Wuggy. Out of the multiple nonwords generated, a selected few were chosen for presentation and analysis. The nonwords used were under the following categories: i) **monosyllables**, ii) **disyllables**, and iii) **polysyllables.** From the extracted data, the analysed nonwords for Group 1 were Rows 1–4, the first twelve nonwords in the list. For Group 2, the entire list of nonwords was analysed.

The phonological short-term memory (pSTM) capacities of the participants were measured based on how many nonwords they were able to recall. For each nonword accurately reproduced, a participant would be given 1 point. If it was incorrect, they were given 0 points. Table 8 presents the results of the average/total number of nonwords that were accurately recalled overall.

3.4.5 Task 2: Sentence repetition and sentence comprehension

In the following subtests, phonological memory load was manipulated in sentence repetition and comprehension by using word length. According to Just and Carpenter (1992), the lengthening of sentences is demonstrated to tax memory when having to listen and repeat the words over. Given that phonology is centred on a word's phonological make-up, lengthening words would tax pSTM. This manipulation of word length was achieved using varying numbers of syllables, i.e., short sentences would have monosyllabic words whereas long sentences would have polysyllabic words. Sentence types were tested using the variables of **sentence length** (short vs long sentences) and **sentence type** (see **Table 10**).

Table 10: Sentence types for sentence-picture naming task

Sentence type		
	Reversible active sentences (RAS)	***X-but-not-Y construction (XYS)***
Example 1	The boy is chased by the girl.	The girl is sitting but not eating.
Example 2	The man is pointed at by the boy.	The door but not the mat is green.
Example 3	The girl is pointed at by the boy.	The girl but not the boy runs.
Example 4	This is the boy that points at the man.	The pan that is not the pen is blue.

Source: Adapted from Willis and Gathercole (2001)

Table 10 shows a list of the sentences that were presented in both **subtest 1** and **subtest 2**. To investigate the possible contributions of pSTM on sentence processing, sentence different types of sentences were constructed. Similar to Willis and Gathercole (2001), two sentence types from the Test of Reception for Grammar (TROG; Bishop, 1982) were adapted into this study to show the possible role that PSTM plays when sentence processing (see **Table 10** for sentence examples). Although taxing the memory of the participants was a factor in analysing repetition and sentence comprehension, this dataset involved compiling sentences based on two separate, complex sentence structures. Sentence length (i.e., word length and varying syllables) was not a factor in compiling the sentences. The sentence types of focus were the Reversible Active sentences (RAS) and the X-but-not-Y sentence constructions (XYS). Although this study was mainly focused on phonological memory contributions in sentence processing, the use of sentence types allowed for a secondary (albeit non-consequential analysis) of syntactic influence on sentence processing.

Subtest 1: Sentence-repetition task

In this assessment task, the participants attempted to repeat sentences orally and proceed with an assessment of comprehension using the same sentences. The 6–7 age group were asked to repeat a total of eight sentences orally, and the 9–10 group age group were also asked to repeat a total of eight sentences. For every sentence repeated correctly, a participant received one mark. For both the 6–7 age group and the 9–10 age group, the maximum score that could be achieved was eight, with an average score being four, respectively. The accuracy of their sentence constructions was noted, and the score was impacted if the constructions created were not exactly the same. All sentences presented were in accordance with **Table 10,** which provides examples of RAS and XYS constructions used in the assessments. See **Appendix B** for additional examples from other studies.

The sentence-repetition task indicates comprehension in that when errors occur while repeating the construct of a sentence, it is found that most of the time the proposition (i.e., the logic) of the sentence remains (Martin, 1975). For example, if a participant is asked to repeat the sentence **“the boy is pointed at by the girl”**, the participant could repeat the sentence using another structure like, **“The girl points at the boy”**. Despite the differing syntactic structures, the participants still present the main idea, which is that “the girl points/the boy is being pointed at”. Therefore, this indicates that the participant understood the sentence. The sentences created for this assessment were created based on the six sentence types as seen in the Willis and Gathercole (2001) study. Out of the six sentence types, only two sentence constructions were used.

Subtest 2: Sentence-picture naming task

Following each participant orally repeating a sentence, a sentence-picture naming task was conducted to assess comprehension. This assessment consisted of the participants being asked to match the sentence initially during the sentence-repetition test to match with a target picture presented. Four images were created to accompany each of the eight sentences. For each of the four images presented to each of the participants, one will be the target image while the others will be syntactic, adjectival, and subject/object distractors (see **Figure 12**, **Figure 13**, and **Appendix C** for examples). Here is a list and explanation of the sentence-picture naming task distractors:

1) For a syntactic distractor, an image would have the subject/object completely different to what is happening in the sentence.
   Example of target sentence: **“The man is pointing at the boy.”**
   Syntactic distractor sentence: **“<u>The woman</u> is pointing at the boy.”**
2) For adjectival distractors, the colours and sizes of images were changed.
   Examples target sentence: **“The girl wearing the pink shoes is dancing.”**
   Adjectival distractor sentence: **“The girl wearing <u>the purple</u> shoes is dancing.”**
3) Subject distractors included different a switch between the object and subject, i.e., if the target was a boy pushing a girl, but the image would have a girl pushing a boy.
   Examples target sentence: **“The boy is being pointed at by the man.”**
   Subject distractor sentence: **“<u>The man</u> is being pointed at by the boy.”**

4) **Object distractors** would be the opposite of subject distractors. The object receiving the action would differ from the sentence itself with the actual subject being wrongfully placed in the object position.
   Example of target sentence: **"The man is pointing at the boy."**
   Object distractor sentence: **"The boy is pointing at <u>the man</u>."**

By presenting the two varying sentence types to repeat and match to pictures, the participants' ability to remember the sentence and match with an image was assessed. The figures below are representations of a sentence-picture naming task. Each sentence presented (see **Table 10**) was accompanied by four images, (see **Figures 12** and **13**, as well as **Appendix C**.

Figure 12: Sentence-picture naming Task 1

*The images accompanying the sentence **"The boy is chased by the girl"** for the sentence-picture naming task.*

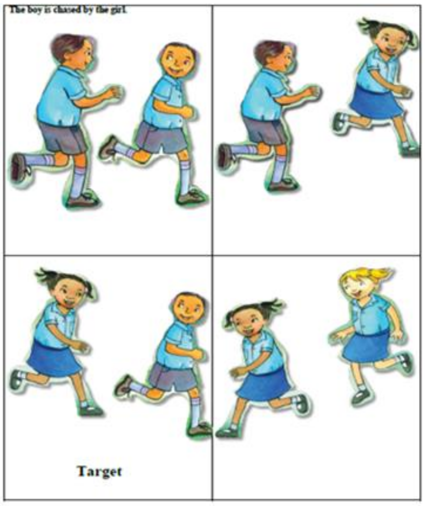


Figure 13: Sentence-picture naming Task 2

*The images accompanying the sentence **"The elephant the cheetah ran after is little"** for the sentence-picture naming task.*

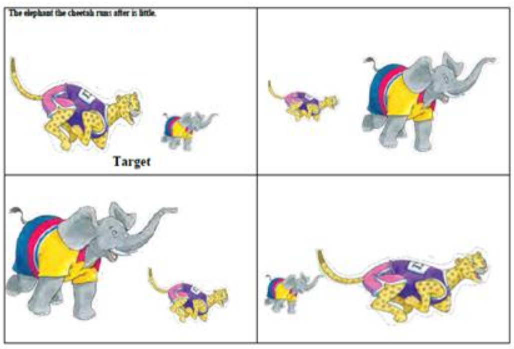
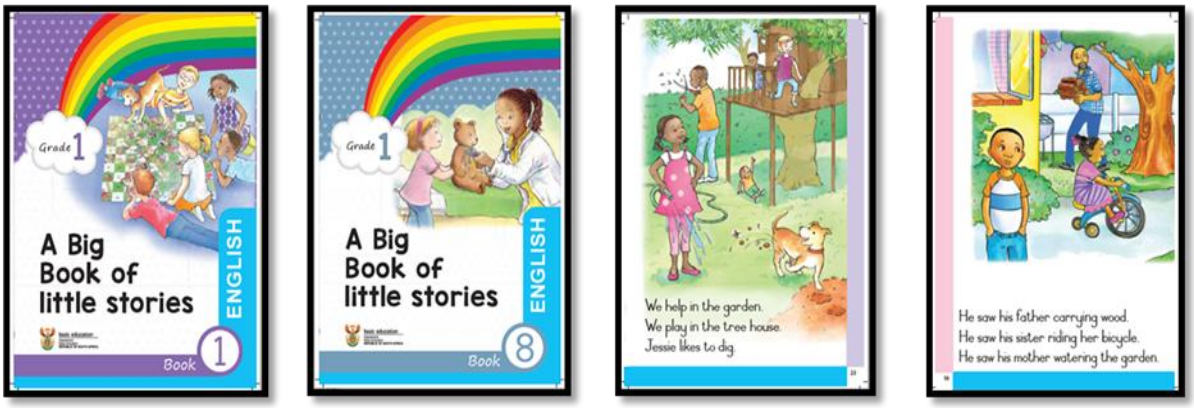


Figure 12 is an example of the RAS, “The boy is chased by the girl”. Correspondingly, Figure 13 represents a long-embedded sentence, “The elephant the cheetah runs after is little”. Although this sentence is not a part of the stimuli used to assess the learners, it greatly encapsulates the sentence-picture naming task. Further examples of sentences and accompanying images used in this subtest can be found in **Appendix D** which shows four similar pictures with only one being the target picture that matches the sentence, “The man is pointed at by the boy”. This sentence was presented, and the participant had to match it with the target picture.

The scoring of the sentences went as follows: Similar to sentence-repetition scoring, for each sentence and picture accurately matched, the participant would earn one point. For both the 6–7 age group and the 9–10 age group, the maximum score was eight, with the average being four, respectively (see **Figure 14**).

Figure 14: Big books used for stimuli development



The stimuli created for these assessments used various images including those from Curriculum and Assessment Policy Statement (CAPS) approved “Big Books” as seen in **Figure 14**. These images were reworked to fit the sentence-picture naming task. “Big Books” were introduced as part of the “Sunshine in South Africa” reading programme initiated by Wendy Pye Limited, which aimed to develop literacy in large classrooms through shared reading (Elley & Cutting, 2001). The images from the “Big Books” and other images found online were configured and reimagined in different ways for the sentence-picture matching task, i.e., with distractor images along with the target images. In addition to the images used from the books, free online stock images used. These images were edited using Adobe Creative Cloud to match the sentences to which they were being attached.

3.4.6 Tools

Experiments, whereby participants need to be tested, require the use of instruments to store the data gained from them. There were three subtests completed during the course of this investigation, for the measures and an experimental measure to assess pSTM and sentence comprehension. Instruments such as video cameras, audio recorders, and a timer have been used to collect data. In this case, the following instrumentation was needed to conduct this experiment:

1) Audio recorder: This is the basic instrument to capture data. The testing is based on oral communication; therefore, an audio recorder was needed to store both the administrator's and the participant’s sentence productions. These sentences were transcribed and analysed in accordance with accuracy and time taken during the recall of sentences and matching in both tasks.
2) A timer/stopwatch: Time was kept because it can account for the difficulty of memory recall in the PSTM task. At the time of the experiment, this was done using a watch/a stopwatch.
3) A video recorder: This was used as well to keep track of other results apart from the oral that could arise. A video recorder captures audio, visuals, and timing. Although this study is focused solely on oral communication, gesture is integral to speech, comprehension, and memory. Seeing that language is multimodal, which means that there are different ways of communicating such as spoken language, gestures, and facial expressions, a video camera can record possible non-verbal productions from students when attempting to recall information. Although gesture is not central to this study, the possible capturing of unsolicited gesturing in the recall of sentences in the PSTM tasks, especially by children which has been corroborated by Cameron and Xu (2011), could indicate the possible pressures on memory through the participants’ recall. Therefore, capturing this on video could add to the findings of this study.

Despite the use of all of these tools, half of the participants did not assent to have their videos taken and for the other half of the participants, their parents/guardians did not provide consent for this. In this case, their responses were audio recorded and saved on a password-protected laptop and external drive.

3.5 Variables

To assess the role phonological short-term memory (pSTM) plays in the processing of sentences, as well as the developmental effects, multiple variables were present in the study and used in the analysis of the results. The independent variables identified were: i) pSTM, ii) age, iii) sentence repetition, and iv) sentence comprehension. The dependent variables were: i) syllable types and ii) sentence type.

3.5.1 Independent variables

i) pSTM

The first independent variable of the study was the participants' pSTM capacity. As mentioned, this capacity was measured using the nonword repetition (NWR) task. All typical individuals have pSTM capacity. The capacity is used to process languages and can therefore demonstrate the difference between individuals. However, pSTM can be hindered and influenced by word and sentence length, hence the use of the NWR task to measure its capacity.

Each participant's pSTM was measured to identify the developmental trends across the entire sample pool and between the two age groups. This measure would in turn be used to show the relation between the capacity itself and the participants' ability to process sentences, i.e., repeat sentences (through the sentence-repetition task) and comprehend them (using the sentence-picture naming task)

ii) Age

Age is independent variables within this developmental study. Age is an independent variable as the different age groups account for potentially different results of sentence processing in relation to pSTM. Moreover, age as an independent variable can account for development trends.

To assess said the developmental trends, age was a variable used to compare the 6–7-year-olds in Grade 1 (Group 1) and the 9–10-year-olds in Grade 4 (Group 2). Based on the participants that were allowed to participate in this study, they were, however, not equally distributed in terms of age and gender to assess the variables' effects on PSTM and spoken comprehension. This did not, however, present a problem to the study as the researcher was still able to address the second research question: does pSTM capacity have an effect on sentence comprehension and repetition change with age?

iii) Sentence repetition

The ability to repeat a sentence is a linguistic skill shared by typical individuals. Sentence repetition is needed to make sense of concepts, to recall them easily, and be able to share/regurgitate information. This processing ability has thus been identified as an independent variable within this study and the scores that come from the task will be reviewed in conjunction with pSTM capacity as well as sentence comprehension. This ability was assessed using the sentence-repetition task.

iv) Sentence comprehension

Similar to sentence repetition and pSTM, sentence comprehension is needed to everyday communication and informs how we respond to others' speech. For typically developing (TD) individuals, sentence comprehension is a ubiquitous capacity. Therefore, it is an independent variable. To measure this capacity, the sentence-picture naming task was used.

3.5.2 Dependent variables

i) Syllables

The varying syllable types were identified as dependent variables in contrast to the pSTM capacity. The pSTM capacity was assessed using monosyllables, disyllables, and polysyllables. These three syllable types could change the pSTM capacity and provide more information on whether or not the capacity itself was poor. In turn, the syllables allowed the research to tax the participants' pSTM capacity and create an overall fair assessment within the distinct age groups and across the age groups.

ii) Sentence type

Constructed sentences within the stimuli were made with two distinct syntactical structures. This was to create variety and attest to sentence complexity and the learners' ability to recall and understand the logic of the sentence. The two sentence types used were the following:

(a) Reversible active sentences (RAS)
(b) X-but-not-Y sentence construction (XYS)

These are complex constructions that were used among both age groups to measure sentence repetition and sentence comprehension abilities. Ultimately, these variables will be used to analyse the data from the study.

3.6 Reliability and Validity

The language data was transcribed on Microsoft Excel for quantitative analysis. A secondary/independent transcription of the collected data was done to verify the language and out rule/identify any presence of gesture during participant recall. This allowed for a more accurate representation of the results and analysis from the study.

3.7 Data Transcription and Analysis

From the data collected, speech was orthographically transcribed on an Excel spreadsheet as per the results of individual participants. In research, data analysis can either be descriptive or analytical. Descriptive refers to the measurement of uncontrollable data and the reporting of the variables founds, whereas, analytical refers to using and analysing data only provided for (Kothari, 2004). The analysis of the data collected in this study was done using exploratory descriptive quantitative analysis. The scores, which were a result of the various tasks used to test the pSTM of participants and their sentence comprehension, were described. Creswell (2014) defines this mode of analysis as the description of "means, standard deviations, and range of scores" (p. 291). The independent variables of pSTM, age, sentence repetition, and sentence comprehension were analysed in relation to the dependent variables of syllable types and sentence types. Moreover, the relationship between sentence processes was analysed in relation to pSTM scores.

With a total number of 24 students (ten Grade 1s and fourteen Grade 4s), the average number of participants does not call for inferential analysis, which is a more advanced form of analysis whereby inferences are made about the group. The use of nonparametric and parametric analysis was determined by whether this was an even distribution of variables from the data collected.

3.8 Limitations

The researcher notes that methodological limitations were present throughout the administering of assessments. Time, site conditions, and sample size proved to limit the extent of this study. Owing to participants only being able to take part in this study during school time, the assessment times had to be cut down to accommodate the learners. In addition to this, the site conditions were not favourable to the collection of data. Given that the participants' responses had to be recorded, a quiet space was needed. However, the spaces allocated to the researcher were not sufficiently quiet. Moreover, the participants' school was the site for data collection;

therefore, disturbances such as other students and school bells all contributed to how the responses were captured.

3.9 Ethical considerations

Given the nature of this study includes human participation, ethical clearance was pursued and obtained in August of 2021 from the Ethics Committee at the University of the Witwatersrand (HREC Non-Medical). See **Appendix A** for proof of ethical clearance. Permission to conduct research on school premises obtained from the two independent primary and colleges in the Polokwane, Capricorn district area. Communication including participation information letters and letters of participant consent and assent were sent out to parents/guardians to be signed. The letters of assent, addressed to both Grade 1 and 4s, included accessible language and illustrative images. The assent form for the Grade 1s had illustrative images, accompanying simple sentences that were read to them, while the Grade 4s were presented with a similar assent form that was easy for them to read and provide verbal assent.

The participants that had been permitted to take part in the research then had to go through the pre-selection process which consisted of a linguistic background check (see **Appendix B**). Before this pre-selection process began, the children once again had their letter of assent verbalised to them with a poster of illustrative images by the researcher who acted as the assessment administrator. The participants were reassured of their ability to withdraw from the pre-selection process, and they will be asked to give verbal assent as well.

3.10 Chapter Summary

To address the main research questions of this study, a sample population group from Polokwane, Capricorn District were assessed. There were ethical considerations made throughout the data collection period. Consent from the school, parents, and guardians was obtained. Assent was verbalised was also obtained and verbalised to all the young participants. All participants were pre-selected to meet the vital criteria of language background and linguistic proficiency. Assessments included the measuring for comprehension of pSTM capacity using the nonword repetition (NWR) task, a sentence repetition and a sentence-picture naming task.

CHAPTER 4: ANALYSIS

4.1 Introduction

The following chapter outlines the results of three separate assessments that were aimed at investigating the effects and contributions that phonological short-term memory (pSTM) has on the oral sentence processing, i.e., sentence repetition and sentence comprehension, of South African second language learned (L2) English-speaking, typically developing (TD) children from African language backgrounds. The data analysed in this chapter addressed the following investigative questions:

1. What is the effect of pSTM on South African L2 English-speaking children's oral sentence processing?
2. Does age have an effect on phonological memory processes, spoken sentence comprehension, and sentence repetition?

To answer these questions, three tests were conducted: i) a nonword repetition (NWR) task, ii) a sentence repetition task, and iii) an sentence-picture naming task.

With phonological processes being fully developed by the age of six, it can be argued that a phonological process such as pSTM can have a stronger influence on sentence processing compared to more complex linguistic capacities still in development. Furthermore, with South Africa's multilingual landscapes and it is even more complicated language policies within education, children in the classroom are confronted with English as the main medium of instruction, while at home and in their communities, they communicate mostly in their native tongues. This calls into question how bilingual children navigate the processing of uttered English sentences and how processes that they have fully developed contribute to their overall understanding of uttered sentences that they perceive.

In response to these arguments, a total of 24 participants, with ten Grade 1 (aged 6–7) and fourteen Grade 4 (aged 9–10) learners, were assessed. For pre-selection, a linguistic background check was administered. Out of the candidates selected to participate, the abovementioned three tasks were presented. The tasks were used to measure pSTM capacity, sentence repetition and sentence comprehension.

The following section gives a quantitative account through the use of mean averages to describe the identified trends. Each research question is answered through the analysis of the following variables:

- pSTM
- Syllable length
- Sentence repetition
- Sentence comprehension
- Sentence type
- Age

4.2 Questionnaire Results

Prior to the procedure process for the research, participants had to be pre-selected to take part in the study's assessments. The participants had to meet the following criteria: i) have a South African Bantu language as their L1 (first language acquired) and ii) pass the English proficiency test. The candidates with parental/guardian consent and that provided verbal assent took part in a linguistic background check (**Appendix B**). This questionnaire worked to assess their English proficiency based on grammar, vocabulary, fluency, and comprehension. As outlined in **Chapter 3**, the candidates were scored on all four of the aforementioned levels of the adopted proficiency scale. Here is an example of a participant's (9–10 years old) scorecard based on their responses:

Along with the answers given in the example above, the participant had to be prompted multiple times to produce a full sentence. This became futile towards the end as one-word answers became the norm. This participant was selected to form part of the main assessment, as they had scored an average of 12 for their proficiency.

Based on the grade scale/scorecard (see **Chapter 3: Methodology**), a candidate had to score an average of 12 in total. For the 6–7-year-old age group (Grade 1), a total of thirteen learners participated in the proficiency test. All thirteen of the candidates who took part in this assessment all scored an average of 12 and above, proving their proficiency and ability to participate in the main assessments of this investigation. However, only ten out of the thirteen participants were selected, as they fit the language-based prerequisite, namely needing to have a South African Bantu language as their first language acquired (L1). The list of the South African L1 languages spoken by the participants are as follows:

- Sepedi
- Xitsonga
- Tshivenda

Most participants spoke Sepedi at home, with Xitsonga and Tshivenda as outliers. For the 9–10-year-old age group, seventeen candidates were tested. All of them passed the proficiency test by scoring 12 and above. However, only fourteen out of eighteen of the learners were chosen to participate as they had South African Bantu language first language acquired (L1) backgrounds.

It is important to note that although the learners that participated did pass the proficiency test, this does not indicate that they were fully proficient, since the reproduction of sentences did include grammatical errors. However, this aspect of language was not central to the study and their proficiency capabilities were thus deemed adequate for this study's assessments.

Overall, all the learners who participated in the pre-selection understood the questions asked and presented appropriate responses. Group 1 ages ranged from 6 to 7 years and Group 2 ranged from 9 to 11 years.

4.3 Research Question 1

To assess the potential contributions of phonological short-term memory (pSTM) on sentence processing, the first research question was addressed:

Research Question 1: What is the effect of pSTM on South African L2 English-speaking children's oral sentence processing?

The following subsection outlines the findings of the nonword repetition (NWR), sentence repetition, and sentence comprehension tasks on a sample size of 24 participants aged 6 to 10.

4.3.1 pSTM

For the first task, the participants' pSTM, a memory capacity, was tested using the NWR task. The NWR task, as outlined in **Chapter 3**, is used to gauge the recall ability of the recipient (which was measured and then compared against sentence repetition and comprehension in later in **this section**). In an NWR task, a list of words with varying syllables that fit the phonotactics of the language central to a study is presented to the participants. In the current study, all the assessments were conducted in English and the nonwords created followed the phonotactical rules of English with syllables varying from one to five syllables. **Table 11** below provides an overview of the three separate syllable types used to measure phonological short-term memory (pSTM), i.e., i) monosyllables, ii) disyllables, and iii) polysyllables.

Table 11: Total mean # of nonwords recalled accurately based on syllable category

	Mean # of nonwords recalled
Monosyllables	4,3
Disyllables	4,4
Polysyllables	3,0
Total	**11,8**

From Table 11, all the participants attempted to reproduce all the nonwords presented. A total of 282 nonwords were recalled accurately out of a possible 330. The participants were able to produce a mean average of 11,8 correct nonwords that were administered to them. The monosyllables (containing one syllable) were predicted to highlight the best results, but the disyllables (containing two syllables within a word). **Figure 15** below presents a visual illustration of the difference in accurate production between the three types of syllable.

Figure 15: Mean # of nonwords recalled for overall participants

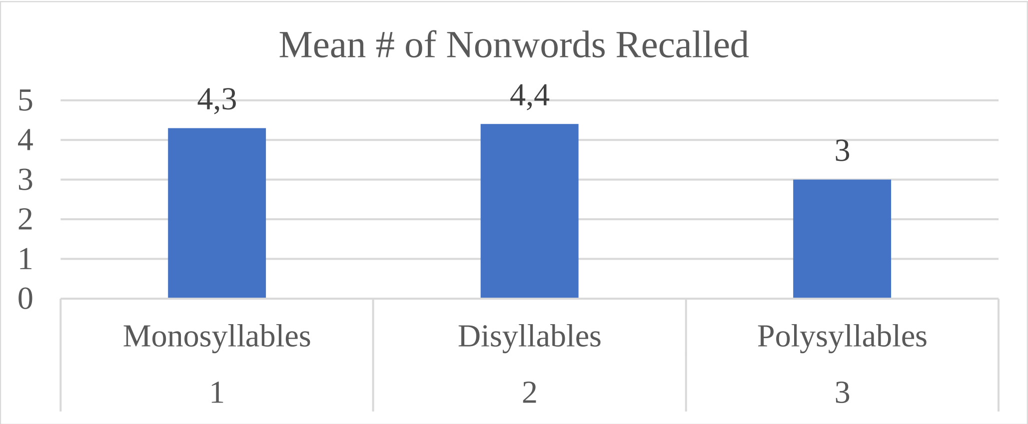


Figure 15 further illustrates the differing numbers across monosyllables, disyllables, and polysyllables accurately produced as seen in **Table 9.** From the onset it is clear that the children selected generally had average to high pSTM capacities based on the NWR assessment. Overall, the recall and reproduction of the disyllables (nonwords with 2-syllable structures), yielded results overall at a 4,4-mean average, while the monosyllabic words (1-syllable nonword) yielded a 4,3 mean average. The most difficult out of the three categories were the polysyllables. The polysyllables presented to the participants ranged from 3 to 5 syllables matching the English phonotactics. A mean average of only 3 was calculated for the polysyllables produced. The result of the polysyllabic reproduction shows a significant accuracy drop from the highest produced disyllables. Although the overall PSTM results showed a high positive rate, it is still important to note that the polysyllabic nonword recall only amassed an above-average result.

4.3.2 Sentence tasks

Sentence processing was analysed on two levels: sentence repetition and sentence comprehension. These were the second and third conditions tested to answer the study's first investigative question. These processes were tested separately through a sentence repetition and a sentence-picture naming task, respectively. As mentioned in Chapter 3, these tasks were conducted simultaneously.

The eight English sentences examined (further in this section) were constructed using two sentence types, namely i) reversible active sentence (RAS) and (ii) X-but-not-Y sentence (XYS) construction (see **Table 10**). The RAS constructions can be characterised in the same manner as passive sentences (see **Chapter 3**). This construction sees the subject of the sentence receiving the action, while the object is doing the action. Here are some examples:

- "The chair is being sat on by the girl."
- "The bottle is being held by the boy."
- "The fire is being extinguished by the firefighter."

In contrast, the XYS sentence construction embeds a distractor subject. The subject (that is, the "X") doing the action is clear, yet the other noun (that is, the "Y") is placed within the subject position as well. Some examples of the XYS construction are:

- **"**The cat but not the dog is meowing."
- "The car but not the wheel is gold."
- "The sky but not the sea is pink."

The same sentences listed in **Chapter 3: Methodology** were used for both tasks. The researcher began by presenting a sentence and asking the participant to repeat it. Once their production of the sentence had been captured, the sentence would be repeated, and the researcher would subsequently ask the participant to match it to an image.

Sentence repetition

Sentence repetition was the first sentence task. This capacity was assessed through the presentation of English sentences and the participants' recall and production of said sentences. The participants were scored based on each sentence they recalled correctly (see **Chapter 3: Methodology**). In some cases, participants did maintain the logic of the sentences; however, the structure was not correct. For example, **Table 12** showcases the types of RAS productions that would lead to a participant losing a score:

Table 12: Examples of incorrectly recalled X-but-not-Y (XYS) and reversible active sentence (RAS) constructions

	Target XYS sentences presented	**Sentences produced by participants**
i.	"The door but not the mat is green."	[The boy but not the mat is green]
ii.	"The girl but not the boy runs."	[The boy the girl not runs]
iii.	"The pan that is not the pen is blue."	[The pan but that's not the pen it's blue]
iv.	"The girl is sitting but not eating."	[The girl she is sitting but she is not eating]
	Target RAS sentences presented	**Sentences produced by participants**
i.	"The man is pointed at by the boy."	[The man is pointing on the boy]
ii.	"The boy is chased by the girl."	[The boy is chasing on the girl]
iii.	"This is the boy that points at the man."	[This is the boy that it's point on the man]
iv.	"The girl is pointed at by the boy."	[The man…the boy is pointed by the girl]

The table above consists of examples of participant repetitions from all four of the sentences presented for the RAS and XYS constructions. All the examples in the table above, were inaccurately reproduced by the participants. Notably, the constructions were not repeated word-for-word by the participants, as seen in the RAS and XYS examples in **Table 12**. The following repetition errors were noted:

i) Forms of the words (morphemes) were either changed. For example, point{ed} becomes point{-ing}.
ii) Unnecessary words were inserted. For example, the insertion of the determiner "she" in the reproduction of the XYS construction "The girl is sitting but not eating." This resulted in the production of the sentence "The girl she is sitting but she is not eating".
iii) Words were omitted. Such as functional words or prepositions being mostly affected, left out of, or substituted in the repetition. For example, the RAS sentence "This is the boy that points at the man" was repeated as "This is the boy that it's point on the man". The preposition "at" was replaced with "on" by a participant.

iv) Recalling a completely different noun. For example, the XYS construction “The door but not the mat is green” was presented, but a participant produced, “The boy but not the mat is green.” The participant recalled a different noun (“boy”) which was a prevalent noun within the other sentences.

Despite the errors, the sentences did, however, maintain the actions (verbs) of each sentence and the majority of the subjects of sentences were accurately recalled.

For the examples presented, the errors produced by the participants through the insertion of incorrect words and the production of different forms of the words initially presented by the researcher resulted in the participants not receiving a score. These incorrect utterances did not maintain the appropriate structure of the sentences, and therefore did not represent adequate sentence repetition skills. **Table 13** presents an overview of the sentences that were accurately reproduced.

Table 13: Results of sentence-repetition scores across the entire sample group

	Total	**Mean #**
Participants	125	5,2

The above table indicates overall sentences that were repeated accurately by 24 participants. 125 out of 192 sentences were recalled. The mean number of sentences recalled was 5,2. Overall, the participants were able to produce an above-average performance for the sample group. However, the results for the production of the sentences varied between sentence types as seen in **Table 14** below.

Table 14: Sentence-repetition results according to sentence types: i) reversible active sentences (RAS) and ii) X-but-not-Y sentence construction (XYS)

RAS		**XYS**	
# of sentences recalled	Mean # of sentences	# of sentences recalled	Mean # of sentences
59	2,5	69	2,9

In the table above, it can be noted that XYS constructions were produced more accurately with a 2,9-mean number of sentences per participant. The RAS proved more challenging with 59 sentences (10 less than the XYS) correctly produced out of a possible 96 sentences, with a 2,5-mean average of sentences repeated as seen in **Figure 16** below.

Figure 16: Mean # of sentences recalled

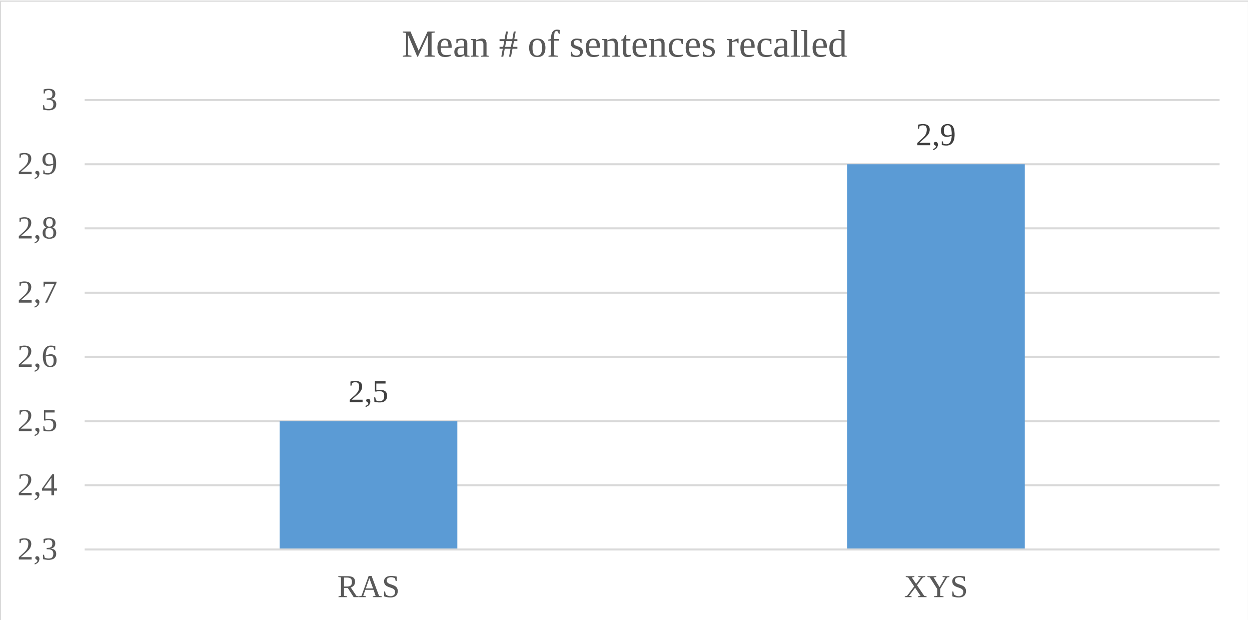


Figure 16 illustrates the mean difference for each sentence type showing a great propensity to XYS constructions. Across the sample population, **Tables 15** shows RAS and XYS sentence examples and how many times they were incorrectly reproduced.

Table 15: Number of incorrect XYS and RAS sentence productions

	Target XYS sentences presented	**Number of incorrect productions**
1.	"The door but not the mat is green."	7
2.	"The girl but not the boy runs."	8
3.	"The pan that is not the pen is blue."	7
4.	"The girl is sitting but not eating."	8
	Total	**30**
	Target RAS sentences presented	**Number of incorrect productions**
1.	"The man is pointed at by the boy."	13
2.	"The boy is chased by the girl."	1
3.	"This is the boy that points at the man."	5
4.	"The girl is pointed at by the boy."	13
	Total	**32**

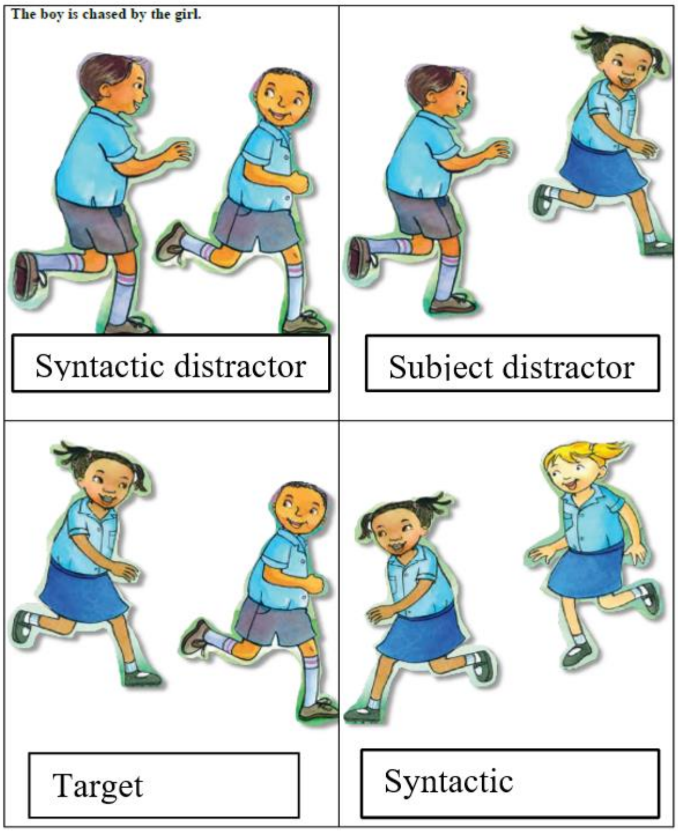
From Table 15 it can be seen that the RAS construction had the most inaccurate recalls. Two sentences presented above-average incorrect responses: i) "the man is pointed at by the boy" and ii) "the girl is pointed at by the boy" both with 13 incorrect productions. Noticeably, two of the most correct sentences were also from the RAS construction. These were the following sentences: i) "The boy is chased by the girl" which only had one inaccurate production and ii)

"This is the boy that points at the man" with only five of the participants getting it wrong. The results from the comprehension side of the spectrum seem to indicate similar trends.

Sentence comprehension

Sentence comprehension was the third capacity of focus during data collection. This subtask consisted of conducting a sentence-picture naming task. Each participant was presented with the English sentence utilised during the repetition task and then asked to match the sentence to an appropriate depiction of it. Four pictures were presented with one being the target, while the other three stood as syntactical, adjectival, subject, and object distractors. Here is an example of the reversible active sentence construction (RAS) used as stimuli for this study's assessment: "The boy is chased by the girl" (see **Figure 17**, and for further examples from another study see **Appendix C)**.

Figure 17: The boy is chased by the girl



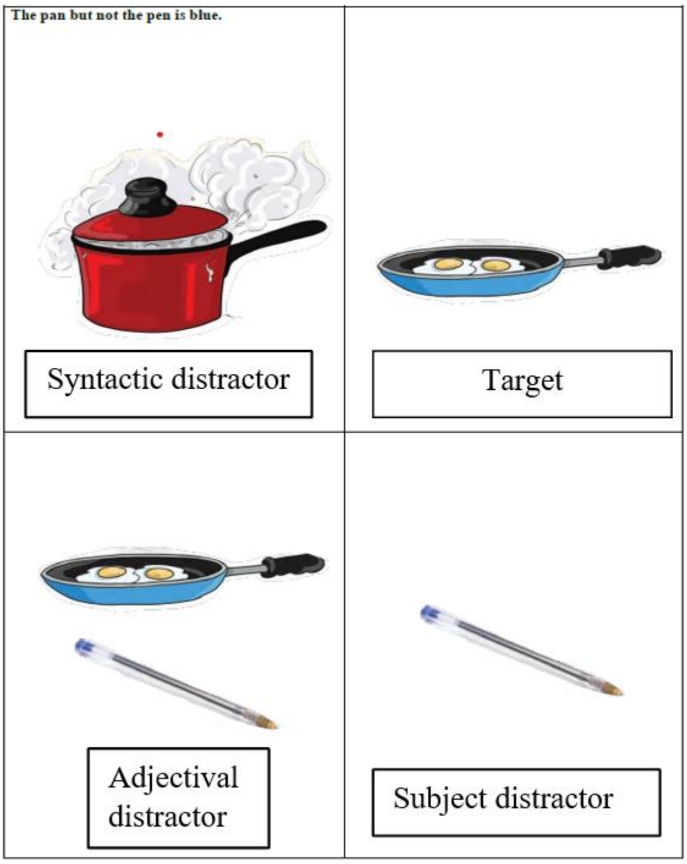
This example formed part of the extracted dataset. Obtaining a negative score would mean choosing the following: i) object distractor whereby the boy is seen doing the chasing; ii) the syntactic distractor where the object and the subject have switched places, i.e., the boy is doing the chasing and not the girl; and iii) the subject distractor which shows a girl being chased and not a boy. In **Table 16**, we see that for the sentence "the boy was chased by the girl", there was a total of seven incorrect matches.

Table 16: Number of incorrect matches for the sentence "the boy is chased by the girl."

Choices	Number of incorrect matches
Image 1	2
Image 2	4
Image 4	1
Total	**7**

In Table 16, the most commonly identified error was Image 2 which was a subject distractor. Image 2 shows a boy doing the action, i.e., chasing the girl. This is the closest to the target as the target image should have shown a boy being chased by a girl, i.e., the girl doing the action of chasing the boy. Distractors also posed a challenge for the participant with the XYS construction as seen below. **Figure 18** is an example of the XYS construction:

Figure 18: Images used for the sentence-picture naming task sentence "The pan but not the pen is blue



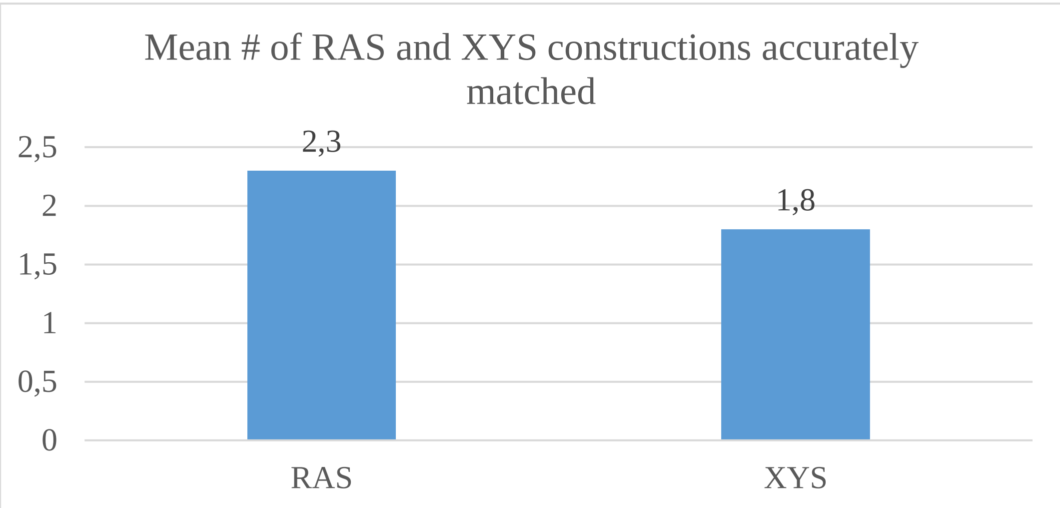
Similar to the RAS construction, a participant's response to Figure 18 would be marked incorrect if they chose the following distractor images: i) a subject distractor which shows a red pot instead of a pan; ii) an adjectival distractor which includes a blue pen, whereas the only item that needs to be blue is the pan; and ii) another subject and phonic (sound related) distractor which only presents a pen instead of a pan. Furthermore, if the participants selected the target image, they were given a score of one. The results of participants' attempt at matching the sentences with an image are listed in the table below.

Table 17: Sentence-picture naming task results

	Total	**Mean #**
Participants	98	4,1

From the table above, it is evident that the sentence-picture naming task resulted in an above-average performance. From a total of 192 sentences and corresponding set of images presented, only 98 of the pictures were chosen correctly by the participants, which was a mean of 4,1. With a contrast of the two sentence types introduced in **Section 4.3.2**, the average/above-average trend was prevalent as seen in **Figure 19** below.

Figure 19: Mean # of RAS and XYS accurately match



As seen in Figure 19 above, the researcher noted a decline in the mean # of correct matches between the RAS sentences to XYS sentences. The figures are outlined in **Table 18** below.

Table 18: Sentence-picture naming task results based on RAS and XYS constructions

RAS		**XYS**	
Number of correct pictures matched	Mean number of correct pictures matched	Number of correct pictures matched	Mean number of correct pictures matched
54	2,3	43	1,8

As Table 18 indicates, the participants had a better understanding of RAS constructions than XYS constructions. With an above average 2,3 mean average of correctly matched sentences and pictures, RAS had the better performance. XYS showed a steady decline with a mean number of correct matches of 1,8. This was a below average result for all of the participants. Similar to the sentence repetition, it was the RAS construction that indicated most of the participants' incorrect responses. **Table 19** below presents an overview of the sentences used in the assessments and the number of incorrect images chosen by the participants.

Table 19: Number of incorrect XYS and RAS sentences and pictures matched

	Target XYS sentences presented	**Number of incorrect choices**
5.	"The door but not the mat is green."	8
6.	"The girl but not the boy runs."	12
7.	"The pan that is not the pen is blue."	10
8.	"The girl is sitting but not eating."	5
	Total	**35**
	Target RAS sentences presented	**Number of incorrect choices**
5.	"The man is pointed at by the boy."	14
6.	"The boy is chased by the girl."	7
7.	"This is the boy that points at the man."	5
8.	"The girl is pointed at by the boy."	14
	Total	**40**

In Tables 18 and 19 above it is evident that the RAS construction presented more challenges overall. Notably, two sentences had the most incorrectly chosen image (fourteen for both): i) "the man is pointed at by the boy" and ii) "the girl is pointed at by the boy".

4.3.3 Sentence repetition and sentence comprehension comparison

The aim of the first question was to understand the possible relationship between phonological short-term memory (pSTM) and sentence processing, i.e., does pSTM affect sentence processing? To answer this question, this section delves further into this investigation by comparing the results of the sentence tasks, i.e., sentence repetition and sentence comprehension, as illustrated in **Figure 20.**

Figure 20: Comparison between sentence repetition and sentence comprehension results

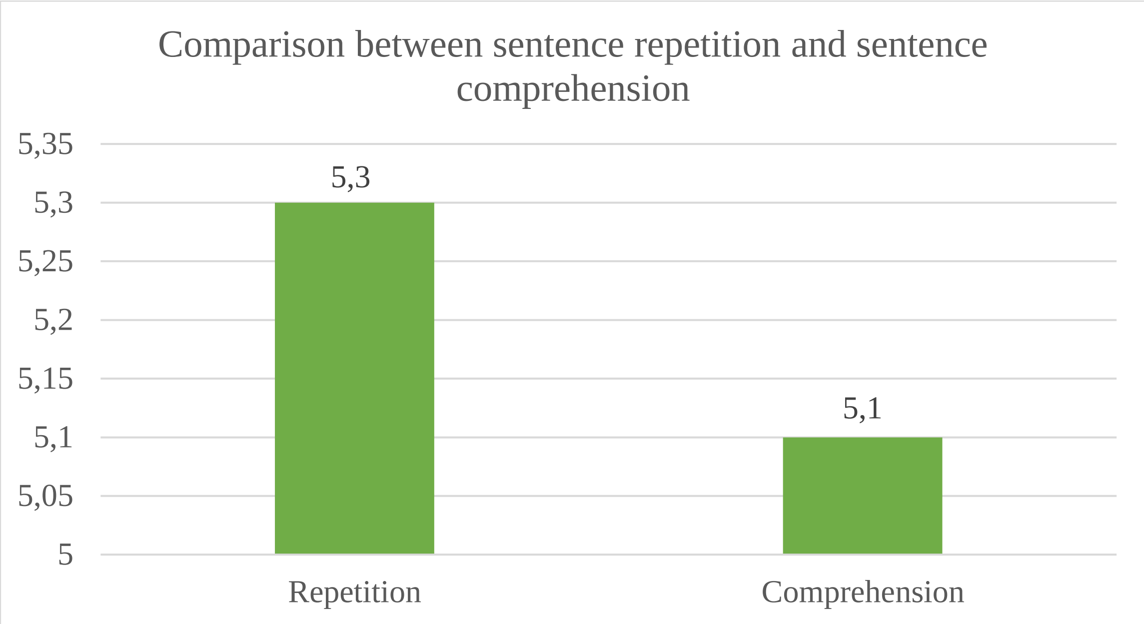
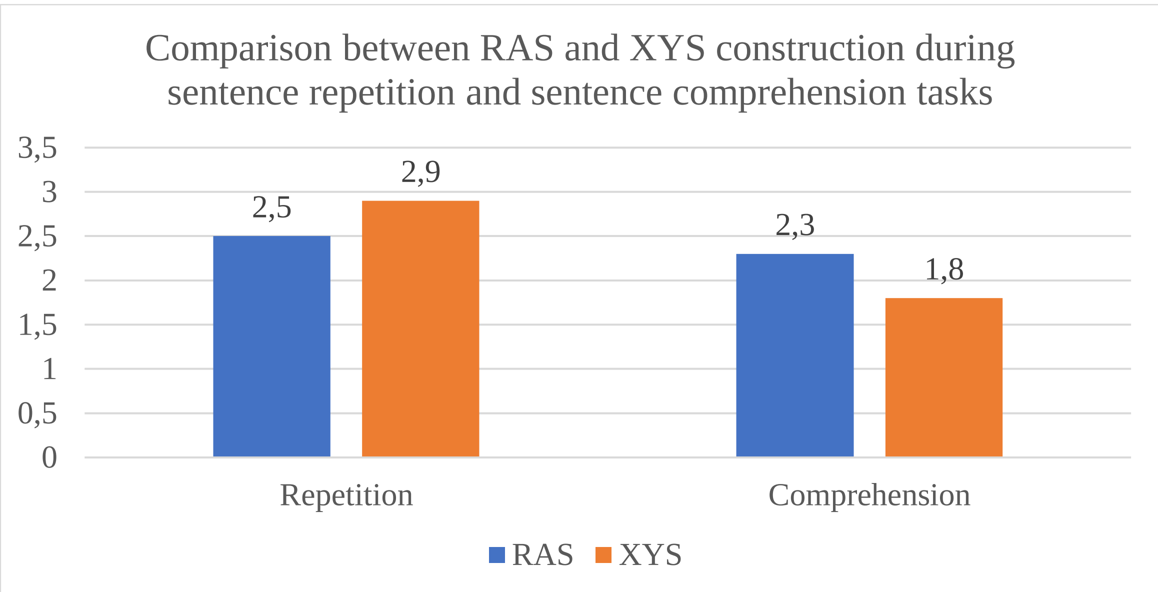


Figure 20 illustrates that the participants struggled more with comprehension than with repetition. The comprehension scores show an average mean of 5,1 among a participant pool of 24, while repetition showed a 5,3 average. While the numbers are close, there is a near equal performance between repetition and comprehension. Had the numbers been more robust, this would have indicated a distinct difference. **Figure 21** expands on these numbers and further illustrates the difference between the sentence types, i.e., reversible active sentence (RAS) and X-but-not-Y sentence (XYS) construction.

Figure 21: Comparison between sentence repetition and sentence comprehension results



In Figure 21, it is evident that the XYS constructions during the repetition task accounted for the most accurate results from the participants. In contrast, the researcher noted that the XYS construction showed the weakest results during the comprehension (sentence-picture naming) task. The XYS construction in the repetition task resulted in a 2,9-mean average, but this decreased to a 1,8-mean average with the comprehension task from the overall results. Evidently, there was a considerable decline in accuracy when it came to the XYS construction which was not mirrored in the RAS construction results.

In the RAS construction result, we found that there was a decrease from the repetition to comprehension results; however, this drop was slight. In the results, the repetition task showed a higher average at 2,5, but the construction results during the comprehension task decreased to a 2,3-mean average. Given the slight decrease, this can be characterised as a stable result with no great change for the overall participants.

In terms of the relationship between the pSTM measurements and the sentence processes, the results presented an interesting dichotomy. As seen in Table 11, pSTM results outlined in **Section 4.3.1** across the sample group displayed high capacities, aligning with previously found developmental trends. Despite the high pSTM results displayed, neither the sentence repetition nor the sentence comprehension outcomes were as high as anticipated to show a concurrent high performance, although the sentence-related results were slightly above average.

Interestingly, the XYS results were higher than the RAS results when it came to repetition. However, the opposite was apparent for the comprehension task. The RAS yielded higher results for comprehension than the XYS construction. Despite these uneven results, the sentence assessments did not display a high performance. It was predicted that if pSTM did play a huge role in sentence processing, then its high-capacity performance would be mirrored in the sentence processing performances. From the stipulated results, this was not that case.

4.4 Research Question 2

To deduce the developmental attributes of this study’s main processes, the participants were selected based on age. The 24-participant sample was divided into two groups: Group 1 (6–7-year-olds) and Group 2 (9–10-year-olds). The section, therefore, focuses on the study’s second research question:

Research Question 2: Does age have an effect on phonological memory processes, spoken sentence comprehension, and sentence repetition?

The following section presents the findings of the NWR, sentence repetition, and sentence - picture naming tasks on a sample size of 24 participants aged between 6-7 and 9-10.

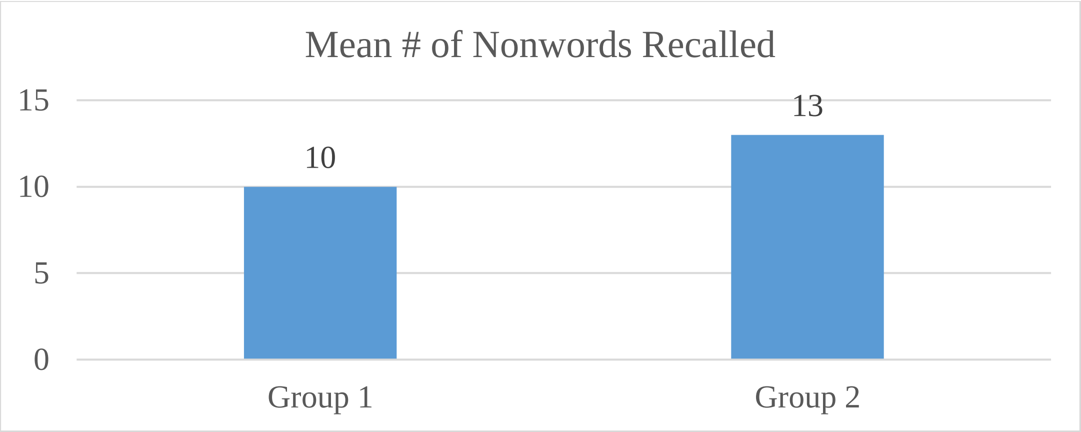
The pSTM of two separate age groups was examined: i) 6–7-year-olds and ii) 9–10-year-olds to deduce the developmental attributes of said linguistic capacity across ages. Group 1 comprised ten 6–7-year-old participants and Group 2 had fourteen 9–10-year-olds. Each participant from Group 1 was presented with twelve nonwords, four for each category, i.e., monosyllables, disyllables, and polysyllables. The results for the NWR tasks are presented in **Table 20**.

Table 20: # and mean # of recalled sentences per group

	Total # of nonwords presented	**Mean # of nonwords recalled**
Group 1	120	10
Group 2	210	13

According to Table 20, Group 1 was presented with an overall 120 nonwords to recall. Each participant in the group was expected to recall a total of twelve nonwords. The mean average of nonword recall was ten. In contrast, Group 2 with 210 nonwords presented to them had each participant attempt to recall fifteen nonwords. The mean average for recall accuracy was thirteen. Average recall was high for both groups. Although Group 2 outperformed Group 1, the margin was slim as both groups had a high nonword recall accuracy rate. These outcomes demonstrate an increase between the groups as seen in **Figure 22**.

Figure 22: Mean # of nonwords recalled per group



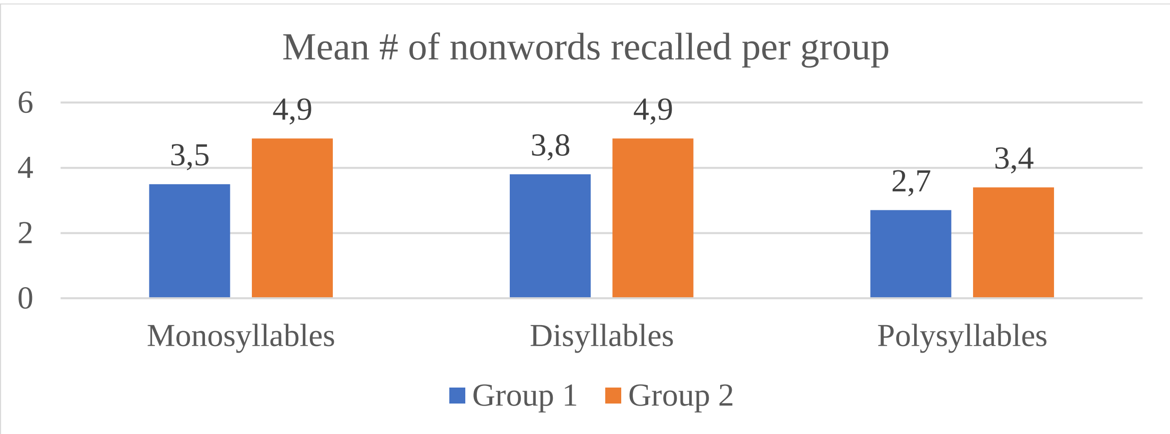
This gap between the mean number of nonwords recalled among the two groups is illustrated by Figure 22 could indicate a clear development increase in PSTM capacity. With age, PSTM capacity should be growing. Similarly, the results are reflected through the three categories used within this assessment: i) monosyllables, ii) disyllables, and iii) polysyllables, as seen in **Table 21**.

Table 21: Mean # of nonwords per syllable type per group

	Monosyllables		**Disyllables**		**Polysyllables**	
	Total #	Mean	Total #	Mean	Total #	Mean
Group 1	4	3,5	4	3,8	4	2,7
Group 2	5	4,9	5	4,9	5	3,4

In the above, we see the means of the accurately recalled nonwords between the two sample groups studied. For each syllable type, i.e., monosyllables, disyllables, and polysyllables, Group 1 was presented with 4 of each to make a total of twelve nonwords presented to them. For Group 2, 15 nonwords were presented with 5 for each category. For the monosyllables, Group 1 was able to recall a mean average of 3,5 out of a possible 4. In contrast, Group 2 showed a 4,9-mean average on recall out of a possible 5 for monosyllables. With disyllables, Group 1 obtained a 3,8 mean average when presented with a total of 4 disyllables. Group 2, in contrast, presented a 4,9 mean average out of a possible 5. Finally, the polysyllables showed a steep decline between both groups. For Group 1, the mean average of nonwords recalled was 2,7 out of 4, whereas Group 2 held a 3,4 mean average out of 5. Although there was a decline in both groups for polysyllables, Group 2 still had the higher mean average, further indicating a trend in phonological short-term memory (pSTM) development.

Figure 23: Group comparison of nonword repetition task results



These numbers indicate that a high pSTM capacity was a prevalent trend for the 6–10 age group, evidencing the development of phonological processes, especially phonological memory. Given the ages, the developmental expectations for the pSTM of the participants was high-level capacity.

4.4.1 Sentence repetition

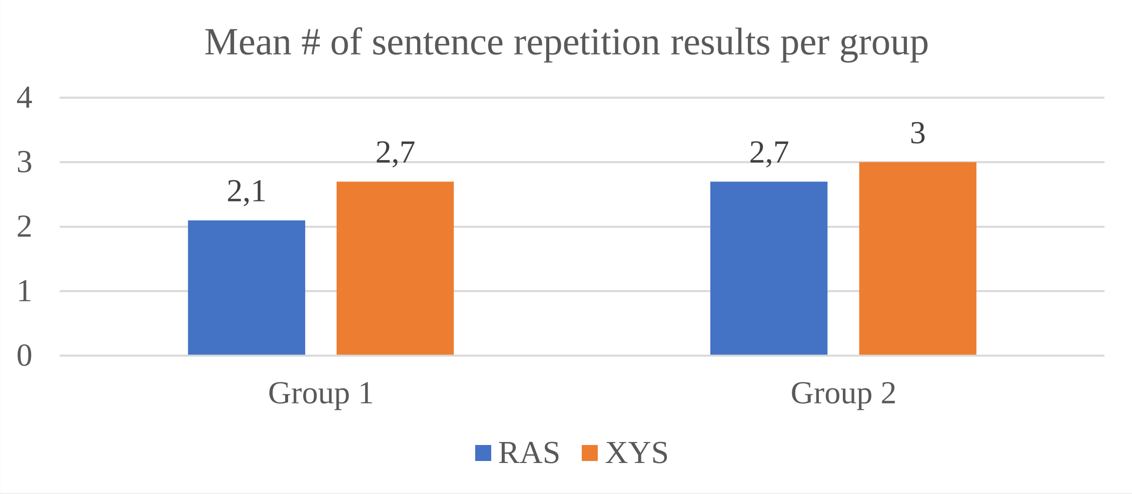
In the second condition, the overall results of repetition showed a developmental trend between the two age groups. Along with that, the results demonstrated a strong reversible active (RAS) number in contrast to the X-but-not-Y sentence (XYS) constructions. The results feature similar trends for Group 1 and Group 2 separately as seen in Table 22.

Table 22: Group comparison of the sentence-repetition results

	Mean
Group 1	4,8
Group 2	6,4

In the assessments for both Group 1 and Group 2, the participants were presented with a total of eight sentences for sentence repetition. The table above indicates an above-average performance from both groups when presented with sentences for repetition. Additionally, there is the rise in accurate sentences recalled from a 4,8 to 6,4 mean average, demonstrating a great difference in performance between the two groups. These scores are as expected as the result is indicative of a development trend regarding repetition accuracy, in that at Grade 4 level (ages 9–10 years old, Group 2), the score needs to be higher than for Group 1. **Figure 24** below illustrates the rise in accuracy from Group 1 to Group 2. As seen in Table 22 above, the results were characterised by a rise in accurate repetitions from Group 1 to Group 2. A narrower representation of the results was presented in Figure 24; the figure also shows an increase in sentences produced based on the sentence types presented to the participants.

Figure 24: Mean # of reversible active sentence (RAS) and X-but-not-Y (XYS) constructions repeated per group



The RAS appeared to be accurately repeated in contrast to the XYS construction. For RAS, Group 1 had a mean total of 2,1, whereas Group 2 had a mean total of 2,7. Correspondingly, the XYS showed the same trajectory, with Group 1 demonstrating a 2,7 mean total and Group 2 with an increase to a mean average of 3. Overall, Group 2 showed a steep incline in repeated sentences, again, indicated the expected developmental trends across age groups. The increase was not large, indicating the level at which children can repeat sentences at the age of 6.

4.4.2 Sentence comprehension

The sample group overall presented interesting and divergent numbers for comprehension. As with sentence repetition, eight sentences were presented to each participant within each group. The eight sentences were equally distributed, falling under the two sentence type categories: i) RAS and ii) XYS. **Table 23** provides an overview of the findings.

Table 23: Sentence-picture naming task results per group

	Mean
Group 1	3,4
Group 2	4,6

The table shows us that the sentence-picture naming task captured low to average results for both age groups. Group 1 obtained a below-average (low) result, with a mean total of 3,4 sentences aptly matched to its target image. This led to an above-average performance with the participants from Group 2 producing a total 4,6 mean average for the task. The results were further narrowed down in **Table 24**, focusing on the sentence type and the impact of that on the comprehension of sentences.

Table 24: Sentence-picture naming task results per group based on sentence types, reversible active sentence (RAS) and X-but-not-Y sentence construction (XYS)

	RAS	**XYS**
Group 1	1,6	1,8
Group 2	2,8	1,8

From Table 24 above, it can be observed that for Group 1, RAS proved to be easier sentence construction to comprehend and attach to the target images compared to the XYS construction. This result presents an interesting contrast, as Group 2 saw a steep decrease from a mean average of 2,8 correct responses for the RAS to a 1,8-mean average of correct responses for the XYS construction.

Table 24 above describes the increased accuracy of the RAS from Group 1 to Group 2, with an increase in accurate sentence-picture matching increasing from a mean average of 1,6 to 2,8. In addition, the XYS construction remained at a 1,8 mean average for both groups. There was a notable unexpected difference in result between the two groups. This interesting finding in Group 2 as represented in **Figure 25**.

Figure 25: Mean # of accurate sentence-picture matching for each sentence type per group

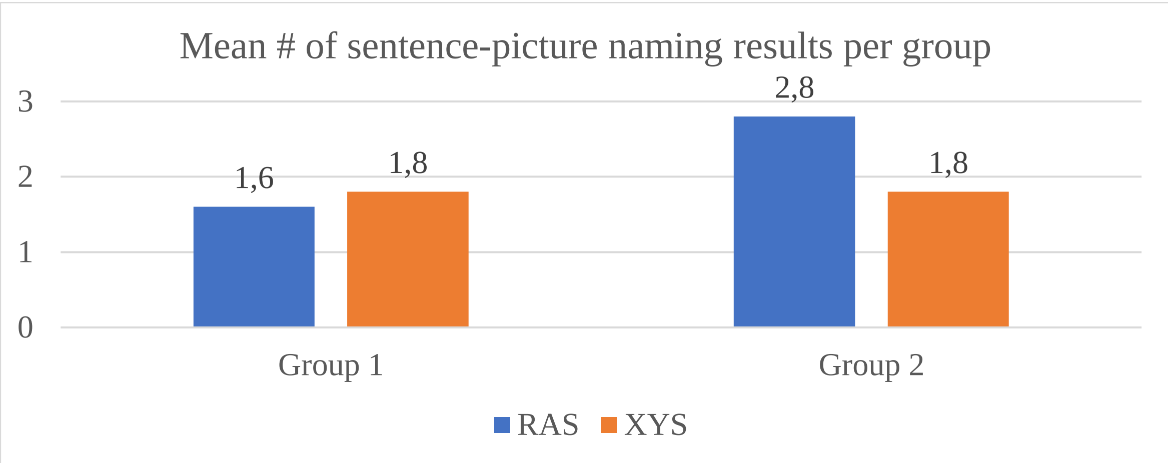


Figure 25 shows a distinct difference between RAS and XYS construction for Group 2 (the 9–10-year-olds in Grade 4), with RAS being markedly higher than XYS. This result is an outlier, since overall, RAS produced the least favourable numbers for Group 2. RAS results showed a

2,8 average accurate response for this variable, while the XYS construction had a 1,8 mean average.

Overall, the assessments provided interesting results for discussion. It is evident that Group 2 outperformed Group 1 in all areas related to phonological short-term memory capacity demonstrated by the nonword repetition (NWR) task, and sentence processing through the sentence repetition and sentence-picture naming tasks.

4.5 Chapter Summary

This chapter set out to answer the dissertation's investigative questions by assessing three conditions: phonological short-term memory (pSTM), sentence repetition, and sentence comprehension. We initially addressed the first research question concerned with the contributions that the pSTM capacity might have on the sentence processing (sentence comprehension and repetition) of typically developing (TD) learners aged 6–10. To respond to the second research questions, the results were comparatively analysed in accordance with the age groups. This allowed us to determine the development trends from the results found.

For the first question, we addressed it by measuring and examining pSTM capacities by using an NWR task. This task was made up of words of varying syllables constructed through the use of English phonotactics. The pSTM capacity was therefore measured against the number of corrected responses given to the nonwords provided. We subsequently measured the sentence processes by testing the participants' ability to reproduce sentences presented to them and then matching those sentences to an image appropriately depicting its logic.

From the assessments, we found that the phonological short-term memory (pSTM) capacities of the sample group were highly developed. Disyllable recall indicated the most accurate responses while polysyllables and monosyllables seemed more challenging. Regarding the sentence tasks, the sentence repetition task produced above-average results. With a focus on the sentence types used to assess the sentence processes, the XYS constructions had more favourable results compared to the RAS. This result was not reflected in the sentence comprehension task, i.e., the sentence-picture naming task. The XYS construction results presented a considerably lower result than the RAS results.

To answer the study's second research question, the analysis delved further into the comparative aspects between the two participant groups. When the sample group was divided into age groups 6–7-year-olds and 9–10-year-olds, developmental trends were apparent throughout all the assessments. These results echoed those of the established phonological and overall linguistic development of children aged between 6 and 10 (Henry, 2011; Gathercole & Hitch, 2019). Similarly, the sentence tasks also illustrated the trend in development for the ages studied.

First, the PSTM capacity showed a steady incline from the younger to the older group. This corresponded closely with the overarching results of the sample group. Disyllables for the younger and older group produced the highest positive results, while the polysyllables and monosyllables – although still above-average to high results respectively – posed more of a challenge. Second, in terms of the sentence processes, the sentence repetition task displayed a similar pattern with the older group outperforming the younger group. By specifically observing the sentence types, it became apparent that both ages groups seemed to do better with the XYS construction than the RAS. However, the older age group also outperformed the younger age group in both sentence types.

Third, we noted similar developmental results reflected in the sentence comprehension task, with the older group producing higher results than the younger group in the RAS recall. However, a discrepancy emerged with the sentence-picture naming of the XYS construction. While repetition of the XYS construction seemed relatively easy for the older group, they found it considerably difficult to attach an appropriate image to the RAS construction. The accuracy between the younger group remained constant with the older group's results.

We found that although pSTM capacities were high across the entire sample group, this high performance was not reflected in the results for the sentence-processing tasks. Still, developmental trajectories were identified throughout the comparative analysis of the groups.

CHAPTER 5: DISCUSSION AND CONCLUSION

5.1 Introduction

The purpose of this study was to investigate the possible contributions of phonological short-term memory (pSTM) on to the processing of oral sentences. To achieve this, typically developing (TD) South African second language (L2) English-speaking children from African language backgrounds were targeted. Participants were sought in the Polokwane, Capricorn District, where the major African languages were Sepedi, Tshivenda, and Xitsonga. This study was determined to address the following research questions:

1. What is the effect of pSTM on typically developing South African L2 English-speaking children's comprehension?
2. Does age have an effect on phonological memory processes, spoken sentence comprehension, and sentence repetition?

Two main assessments (and two subtasks) were completed to address the investigative questions. The following assessments were carried out: i) the nonword repetition (NWR) task for pSTM and ii) the sentence processing tasks which included the subtasks sentence repetition and sentence-picture naming tasks. A total of 24 participants were a part of this investigation, with 10 of the participants falling under the Grade 1 (6–7-year-old) age group and the other 14 falling under the Grade 4 (9–10-year-old) age group.

The results were mapped out in direct response to the investigative questions and the main areas of focus identified for the discussion were that of pSTM capacity, sentence processing, and development. In line with the literature and models used within the study (see **Chapter 2: Literature**), it is evident that the pSTM capacity exists and we see this through the NWR task measure. Moreover, despite the language backgrounds of the English L2 speakers, pSTM capacity (measured using nonwords formed from English phonotactics) among the participants was demonstrated to be high and fully functional. Development elements were also observed in the results across the two main age groups. The precise link between pSTM and the effect it has on oral sentence processing is where the main question come in as there seems to be no connection between pSTM and sentence processing measurements, i.e., sentence repetition and sentence-picture naming tasks. Although in most literature, pSTM is seen as a system independent from speech comprehension, the results explored pSTM's possible contribution to sentence processing, especially as affected by the increase in age in children.

The following discussion is broken down based on this study's research questions, and the main identified themes from the results are elaborated on further under each question-headed subsection. Through this discussion, it is argued that: i) phonological short-term memory (pSTM) is a developed/developing capacity from the age of 6; ii) pSTM has no effect with sentence comprehension but instead has a higher potential contribution to sentence repetition; iii) other aspects of language such as syntax contribute more apparently to the repetition and comprehension of oral spoken sentences; and iv) possible language system interactions may take place for bilinguals when processing language using their pSTM capacities.

5.2 Research Question 1

This investigation sought to assess the possible effects or contributions that pSTM would have on sentence processing. Considering the research question: "What is the effect of pSTM on typically developing (TD) South African second language (L2) English-speaking children's comprehension?" there are many aspects that needed to be considered. First, the pSTM capacity had to be measured; second, the TD South African L2 English participants had to have their sentence processing abilities assessed. The following section addresses the aforementioned research question in line with the results of the assessment.

5.2.1 pSTM

pSTM, as explained by Fiez (2016) and Yoo and Kaushanskaya (2012), stores and rehearses auditory information (phonology and speech sounds) for a temporary period. Therefore, to assess it, the pSTM capacity was tested in this study, utilising the nonword repetition (NWR) task with varied word types (i.e., words with various numbers of syllables). The study focused on syllable length to measure and tax pSTM capacity to demonstrate its existence and performance. Participants were presented with a nonword, which they had seconds to rehearse mentally, and were then expected to reproduce the unfamiliar words.

Performance

The NWR task results indicated the existence of a mechanism used to temporarily store words unknown to the participants; these words were then reproduced in the way that they thought they had heard them. This mechanism is the phonological loop (the basis of pSTM), a component of the working memory model as presented by Baddeley (2000). For the participants to have successfully reproduced or attempted to reproduce nonwords, they would have had to use this mechanism, and this indicated the presence of the phonological short-term memory (pSTM) capacity. In line with the capacity theory (of comprehension) by Just and Carpenter (1992), the idea is that memory is limited or taxed if information input weighs heavily on the capacity. In the case of the pSTM nonword repetition (NWR) task, the process was constrained by the use of different nonwords of varying syllable lengths, e.g., monosyllables, disyllables, and polysyllables.

From our findings, the claim that many scholars have made about the existence of pSTM can be confirmed, with the results indicating the presence of such capacity across the sample groups. This is very much in line with Gathercole and Hitch (2019) who postulate that this capacity is apparent around (or maybe even before) the age of 4. Chapter 2 (the Literature Review) extensively outlined the evolution of the working memory (WM) model by Baddeley (2000) and delved further into breaking down its components including the phonological loop. Research has determined that the phonological loop itself consists of two more components: the subvocal auditory rehearsal component and the phonological short-term store (Fiez, 2016). The high results highlighted the existence of both of these components making up the pSTM capacity. This means that in a limited space of time, participants were successfully able to perceive unfamiliar words, and then rehearse and reproduce them.

Not only was it evident that the capacity was present throughout the 6–10-year-old sample group, but all the participants also demonstrated high pSTM capacity rates. Out of a possible 330 nonwords presented, 282 nonwords were reproduced accurately. As mentioned, the participants overall showed high levels of pSTM capacity. They were mostly able to recall the monosyllables and the disyllables; difficulty (albeit minuscule) only occurred when it came to the polysyllables. The disyllables presented an interesting site of results.

Disyllables

Types of words with two-syllable units are termed *disyllables*, and in the study results, the participants produced more of these than either polysyllables or even monosyllables. This was an intriguing result, as monosyllabic words would be expected to produce the highest success rate given that they would tax the pSTM capacity less than the disyllables would. This result has not been featured in the literature, but there are plausible reasons for this outcome. Two claims that this paper would like to bring forward are: i) the exhibition of advanced phonological processes, i.e., disyllabicity being indicative of the phonological development stages, and ii) the interaction between language systems, i.e., the disyllabic minimality of some Southern African languages (e.g., Sepedi, Tshivenda and Xitsonga as discussed in **Section 2.2.2**).

The high disyllabic results were overarching. Given the results for the disyllabic nonwords, we would like to propose that there is a possible link between this result and the reduplication phonological process that develops in early language development (see **Section 2.4.1**). This process comes to the participants with ease because of their early phonological development. Although these claims do not directly address the research questions of the study, they support the developmental trends of phonological processes (discussed further under **Section 5.3**) and the potential language transfer for bilinguals.

This result can also be reflective of how the South African English-speaking participants are second language (L2) speakers from southern African language backgrounds. As L2 South African English speakers, the participants are bilinguals who cognitively manage language differently from monolinguals. Therefore, it is important to also mention that discursive contentions regarding the relationship between pSTM and bilingualism are relevant here. While some scholars believe that monolinguals perform differently to bilinguals, even outperforming them, in nonword repetition (NWR) and pSTM performance (Grundy & Timmer, 2016; Cockcroft *et al.* 2019; Anjomshoae *et al.,* 2021), other scholars have argued that no true difference exists (Yoo & Kaushanskaya, 2012; Bonifacci *et al.,* 2018). Based on the disyllabic word results, we would like to suggest that bilingualism plays a role in the participants performance as a result of the interaction of the bilinguals' language systems.

We would like to propose the notion that the recall of nonwords yielded high results because possible contributions from the first language acquired (L1). We would like to thus argue that the accessibility and ease in recalling nonwords formed from their second language learnt (L2) was based on the knowledge of the L1. Some southern African Bantu languages (see **Section 2.2**) are known to share certain linguistic similarities. They are known to follow a strict Type 2/CV syllable structure (Doke, 2017) and word length effect is another characteristic shared between them, most especially Sepedi, Tshivenda, and Xitsonga. Doke (2017) asserts that Sepedi (a Sotho language) avoids monosyllables, meaning that morphosyntactically there is disyllabic minimality in the language, which means that each word possesses at least two syllables. This is echoed by Ziervogel and Dau (1961) who state that disyllabic prosodic word minimality requirements is imposed by Tshivenda, along with Vrastanos (2018) who confirms

Xitsonga's disyllabic imposition. This structure is different from English which follows a CVC syllable structure and has a monosyllabic minimality. While good results were attained for monosyllabic nonword recall across the participant groups, disyllables were the most accurately recalled. When considering the propensity of disyllabicity in the Sepedi, Tshivenda, and Xitsonga (the participants' languages), this result could possibly indicate language transfer. This means that the (bilingual) participants' phonological knowledge of their first language acquired (L1) supported their recall of disyllabic nonwords formed using English phonotactics.

Moreover, this could be indicative of separate phonological short-term memory stores, in line with Anjomshoae *et al.* (2021). The authors discovered the little difference in working memory (WM) capacity between adult monolinguals and bilinguals. However, they ascertained that monolinguals used one WM store, while bilinguals used two such stores. This notion supports the results found in this study whereby the nonwords followed the phonotactics and syllable structure of English words, yet disyllables which are more common in Southern Bantu languages than monosyllables were the most produced. To reiterate, Sepedi, Tshivenda, and Xitsonga have been confirmed to avoid monosyllables. Sepedi speakers formed the majority of the participants with twenty out of 24 being from a Sepedi background and the other four being Tshivenda- or Xitsonga-speaking. Therefore, an interaction between language systems and phonological short-term memory stores could be said to have led to the results.

This justification also relates to Henry and Millar (1992) who claim that familiarity of a language/language systems plays a major role in recall ability. Given that disyllabicity is common in the southern African Bantu language family as a word minimality constraint, this can account for the overarching high performance of disyllabic nonword recall. Additionally, this can indicate what Grosjean (2010) refers to as a positive influence the first acquired language has on the second language learnt, that is, first language creates a linguistic base for the other language, particularly during language acquisition. This reflects the notion of positive language transfer whereby L2 learners perform better in the language they are learning because of their familiarity with certain sounds or patterns. This seems to be the case with the southern African Bantu language L1 speakers who are more familiar with disyllables than monosyllables in their L1s. The results displaying the relatively low monosyllable results can indicate what has been termed "negative language transfer". Given that monosyllables are fatal constraints/violations in the central southern African Bantu languages, this can attest to why the participants struggled more with monosyllables than they did with disyllables. All these findings ultimately indicate the possibility of interaction between known language stores.

Overall, the phonological short-term memory (pSTM) capacity was found to be highly present in the participants. While polysyllables created the most challenge for the participants, the taxation of the pSTM capacity illuminated the capacities limitations. In turn, the participants' ability to easily recall monosyllables and polysyllables confirmed the intact capacities needed in various aspects of language development such as that of language learning, given that the children were able to recall words that they had never heard before. Most interesting was the display of possible language system interaction with disyllabic recall outperforming monosyllabic recall, possibly given the familiarity of disyllables because of phonological development and disyllabic word minimality effect in the majority of the L1 Sepedi-speaking participants.

5.2.2 Sentence processing

The ability to be able to perceive information and understand it is referred to as *sentence processing*. As part of the Baddeley (2000) working memory (WM) model, pSTM is a mechanism that has not been clearly linked to (sentence) comprehension, but scholars such as Jacquemot and Scott (2006) demonstrate that other language processes such as reading, and acquisition are clearly linked to pSTM processing. Therefore, to investigate if there was a connection between the pSTM capacity and good sentence processing performance, we conducted sentence processing assessments with sentence repetition and sentence-picture matching tasks.

Sentence repetition

It is evident from the results that sentence repetition yielded higher results than the sentence-picture naming task. The sentence repetition task involved the participants recalling the sentence presented to them by the researcher. These sentences were judged on a word-for-word, structural basis, meaning that the sentence had to be repeated the exact way it was presented. The repetition performance was average to above average; nevertheless, it is important to note that while the sentence was not repeated exactly, i.e., word-for-word, the logic of it still remained. This relates to the idea that although someone may not be able to reproduce a sentence verbatim, does not mean that the logic is not there; the meaning underlying the sentence remains (Martin & Saffran, 1975). In most cases, changes to the sentences were done on a functional word level, while content words remained. However, the participants had to access the temporary representations of those sentences to produce them again. This finding aligns with the claim from Aaronson and Ferres (2014), that function words signify structure, while content words signal meaning. Given this, the notion that repetition through the preservation of sentential logic (Martin & Saffran, 1975) poses of a bit of a challenge is deciphering and supporting, especially given the results discussed further in the sentence-picture naming task.

Despite the participants attempting to repeat sentences but producing inaccurate prepositions, determiners, or other function words, the participants being able to correctly recall content words indicates the presence of the phonological loop. These assessment results indicated the use of another component within the phonological loop of the working memory model (Baddeley, 1986) – the subvocal articulatory rehearsal. This component allows an individual to sequentially rehearse input information for a temporary period for the purpose of recall. Interestingly, Willis and Gathercole (2001) argue that phonological short-term memory (pSTM) may contribute more to sentence repetition than to overall sentence comprehension itself. This notion is also echoed by Hanten and Martin (2000) who discovered that older children with phonological memory impairments exhibited good sentence comprehension skills but had difficulty with sentence repetition. Given our results in this research, this might be the case seeing that comprehension provided more of a syntactical challenge as seen with the sentence-picture naming task.

Sentence-picture naming task

Overall, the task for sentence-picture naming provided near equal to lower results than the sentence repetition task. It consisted of each sentence matching one out of four of the pictures presented to the participants. Sentences were verbally presented to the participants, and they had to store that linguistic information and use it to match the sentence with an image correctly. While these results were slightly above average, the incorrect responses would be a consequence of the distractors that the other three images posed. The distractors were grammatical distractors, i.e., they were i) syntactical – not matching the form of the sentence, ii) subject/object related meaning they would switch the object and subject around, and iii) adjectival meaning that descriptions of certain objects would change. This constrained the participants' ability to select the correct choice, indicating syntactic factors hindering comprehension.

As shown in the results, syntax became a major marker for comprehension difficulties. Structure of the reversible active sentence (RAS) and X-but-not-Y (XYS) construction types used in our study proved this. While both these sentence types are complex, it was the XYS construction that proved more of a challenge than the RAS construction for the participants. This indicated a significant drop from a 2,9 mean for repetition to a 1,8 mean for the sentence-picture naming task. The RAS, used in line with a passive sentence construction (a sentence showing a subject receiving an action and not doing the action) in this paper, was an easier concept for them to manage, especially with the sentence-picture naming task. We can deduce that children are in the process of learning and developing further linguistic skills, i.e., syntactic skills; therefore, the lack of syntactic knowledge hindered their abilities to ensure high levels of oral sentence comprehension.

Although the main objectives of this research were to i) find out if phonological short-term memory (pSTM) has possible effects on oral sentence processing, and ii) find out what role age plays in these processes, the role of syntax became quite pointed. Thus, despite not being the initial plan, the need to understand the challenge of syntax was inevitably borne out of the use of sentences. To provide a varied assessment and response, different structures were employed to assess the students. This provided gravitas to the study that appealed to the different age groups. It also provided the opportunity to gauge the linguistic competence of the participants through the two specific constructions, namely XYS and RAS. In this case, RAS was adopted and presented similarly to a passive sentence, a construction that is explicitly taught in the intermediate phase (IP), i.e., grades 4-6, according to the CAPS IP first additional language English curriculum (DoE, 2011).

While it can be asserted that pSTM is used to temporarily store the verbal sentences, similar to the findings of Willis and Gathercole (2001), the results in this study indicate that syntax plays more of a role during sentence comprehensions terms of the sentence-picture naming task. Despite the repetition of the sentence initially being correct, i.e., the logic of the sentence remaining through recall of content words, once various syntactic distractors were in place, inaccurate images were selected for the repeated sentences. The participants clearly had challenges navigating the distractors that were put in place, i.e., for syntactical, object, subject, adjective, and all sentence-related categories. Therefore, it can be argued that sentence repetition cannot equate to comprehension, as it is a process on its own and does not yield similar results to the sentence-picture naming task. Regardless of this discovery negating the possible major contributions of pSTM and phonological processes in the processing of sentences, it does provide some insight into the development of syntax between the ages. This is further discussed in **Section 5.3**.

5.2.3 pSTM and sentence processing

The connection between phonological short-term memory (pSTM) and sentence processing was not very clear in this study's findings. To review the possible contributions of pSTM on sentence processing, we analysed the pSTM results in juxtaposition with the sentence tasks. We found that the pSTM capacity of the participants was above average to high. The prediction was that, as a temporary store used to perceive and preserve auditory linguistic information, storing individual uttered sentences would ensure accurate recall and comprehension; however, this was not the case. Both the sentence repetition and the sentence-picture naming task generated average results. This is opposed to the idea that if pSTM is high, sentence processing will be equally high – thus indicating a possible correlation and major role played by pSTM in the processing of oral sentences. Unfortunately, owing to all of the participants in this study highlighting high nonword recall performances, we were not able to gauge how low-performing students would be able to repeat sentences or match sentences with the corresponding image.

This study stands in a long line of past studies that, as Jacquemot and Scott (2006) claim, have shown no direct correlation between pSTM and sentence comprehension skills. What the results do indicate are semantic and syntactic influences. We see the presence of developing semantic knowledge through the use of repetition of content words despite the lack of accurate functional and overall structural sentence repetition. Additionally, through the sentence-picture naming task, it is the distractors that cause confusion, resulting in inaccurately chosen images by the participants; this indicates the syntactic difficulties of the assessment. Therefore, pSTM does not have a strong influence on the understanding of sentences by children.

However, it can be argued that pSTM could have more of an impact on sentence repetition than comprehension. The sentence repetition task displayed higher results than the sentence-picture naming task. Additionally, content words were usually repeated, while it was the function words that were forfeited. At the start of the study, there was a rampant notion that becoming more familiar with the phonological structures of English means that a bilingual English second language (L2) speaker is particularly dependent on phonological memory to comprehend oral sentences. However, the study results show this not to be the case. Therefore, although both oral sentence comprehension and repetition produced lower results than phonological short-term memory (pSTM), there could be more inclination to use pSTM to repeat sentences, while comprehension is dependent on other mechanisms and higher-level linguistic skills such as that of syntax and semantics.

5.3 Research Question 2

This study has some developmental implications. While it has sought to find out the contributions pSTM might have during the processing of uttered sentences, it has also considered the age variable, and this impacts capacity (and potentially its relation to sentence processing). Therefore, the study has considered the following research question: “Does age have an effect on phonological memory processes, spoken sentence comprehension, and sentence repetition?”

Despite the lack of correlation between pSTM and sentence processing, the findings do demonstrate developmental implications. Two sample groups were chosen for this investigation: i) Group 1 with Grade 1s (ages 6–7) and ii) Group 2 with Grade 4s (9–10). Both groups were presented with a similar dataset, although the older group was presented with an additional three nonwords to further tax and test their pSTM capacities. From their results, we can observe that all participants throughout the collection of data showed typical language development of pSTM.

First, we noted that from the age of 6, pSTM is developed (as presented in **Section 5.1.1**) and continues to develop through to the age of 10. Thereafter there is predictable ongoing growth through to adulthood. The typically developing (TD) children clearly had intact pSTM capacities. This demonstration of a strong pSTM capacity at the age of 6 aligns with the claim by Gathercole and Hitch (2019) that pSTM development has been demonstrated from the age of 4 or even earlier. Such development also strongly supports the presence of perceptive and phonological skills from a very young age. Keeping in mind the phonological development process previously discussed (see **Section 2.4.1**), phonological abilities are very much cemented from a young age, as confirmed by this study, and this translates to pSTM capacity. The 6- to 7-year-olds exhibiting such strong results in the nonword repetition (NWR) task is indicative of early development. Moreover, the 9- to 10-year-olds displayed even better results, especially given that they were presented with additional polysyllabic nonwords. This was a significant feat for these participants since the polysyllables were notably the most challenging nonwords to recall. Thus, the study supports previous findings regarding pSTM development in TD children.

Second, it was notable how the ability to repeat as well as comprehend sentences develops with children's age. This is most especially evident for typically developing (TD) children which aligns with the claims by Grosjean (2013), i.e., that linguistic skills develop with age; therefore, being able to repeat sentences should develop as well. These trends indicate that as children grow older, their linguistic competencies should typically improve, thus influencing their language processing. Although both groups struggled with the sentence-processing tasks, it was clear that the 9 to 10 age group outperformed the younger group. The outperformance shows the stages of syntactic competence in both regards, which ultimately informs their capabilities in sentence processing. This relates to Gathercole and Willis (2001) who concluded by stating that children's "comprehension data are possibly best understood as reflecting the particular stage of syntactic competence reached by this 4- to 5-year-old age". (p. 355). Therefore, this study provides evidence of sentence processing development.

The reversible active sentence (RAS) construction during the sentence-picture naming task best illustrates the improvement. The RAS construction takes on the form of a passive sentence, with the receiver of the action (verb) in the sentence being placed in the subject position. Notably, the passive sentence construction is explicitly learnt in from grade 5 as per the CAPS Intermediate phase FAL curriculum (DoE, 2011). Children are taught and assessed on how to use the passive voice. Despite the complexity of the structure the grade 9-10 group outperformed the younger group in both sentence repetition and sentence-picture naming task. Moreover, the discovery of how the knowledge of the structure of a language determines how one is able to maintain verbal information is aligned with the claims made by Yoo and Kanushankaya (2012).

The findings encompassing the sentence processing tasks cement the comprehension issue among the young children. Given the recent reports that 81% of grade 4 learners in South Africa cannot read for meaning according to the 2021 PIRLS report (PIRLS, 2023), these findings further reflect that. Interestingly, the X-but-not-Y sentence construction only indicated an incline and outperformance by the older age group in sentence repetition. However, the sentence-picture naming task did not yield such results. In fact, the results remained constant; both age groups indicated similar below average results. Again, this can be indicative of syntactic and semantic issues that come with comprehension and possible top-down language processing in children.

Ultimately, even though no major effect of pSTM on oral sentence comprehension was found (although it possibly contributed to repetition), it is clear that pSTM was present in the participants and was used as a store. Additionally, children do not have fully developed, adult-like linguistic skills, and from the results, pSTM did not seem to be a major contributor to sentence processing. Other competencies (such as syntax and semantics, which are still in development) influenced whether or not participants understood a sentence. What was noted during the nonword repetition (NWR) task was the possible interaction of language systems and memory stores in bilingual children, as supported by the high performance of disyllabic nonword recall. Moreover, the assessment showcased development trends in line with previous studies regarding the development of memory and language. Finally, the constant X-but-not-Y sentence construction result between both age groups during the sentence-picture naming task pointed toward persistent poor comprehension skills among young children. What these findings prove is that more intervention is needed in education and a direct focus on improving higher-level linguistics skills is needed.

5.4 Limitations and Recommendations

Constraints in the scope of this study meant that some aspects of it could not be expanded on. First, the conditions of the research site were not conducive to the assessments. For accessibility, the research with the participants took place on the school grounds. However, this meant that regular school events and activities interfered in terms of sound (bells ringing for break/end of school). These conditions thus became distractors. Additionally, time constraints meant that the assessments had to be cut down to accommodate all selected participants.

Despite these constraints, the study has provided much-needed results and has opened new avenues for further investigation. As noted in the discussion above, analysing a larger sample size with the scope narrowed to a specific southern African Bantu native language could provide more insight into possible phonological language transfer. Moreover, a further narrowing of the scope to bilinguals from the same socio-economic status warrants attention because, in the current socio-economic climate, English holds economic value. This means that many children from African language backgrounds are raised learning English to ensure more opportunities. While this determinant may seem to have a social slant, it is in fact psychosocial, as socio-economic status also informs how one is raised and how language can develop in that very environment.

Furthermore, the assessments themselves can be expanded on. More intensive taxing of the memory capacity during the nonword repetition (NWR) and sentence-processing tasks should be attempted. This can be in the form of lengthening words and sentences. The articulation rate is also an interesting point of analysis that could be expanded on. This can be used to inform the difficulties in recalling words and sentences by participants. In addition, with syntax being a predictor of comprehension (as noted in **Chapter 4 and 5**), additional sentence types (see **Section 2.3.5**) should be used to gauge the extent of this linguistic competence.

Finally, additional comparative investigations of first language speakers versus second language speakers are needed, especially in a South African context. Although a comparative study between monolinguals would have been ideal, the reality of South Africa is that most of the country's people are multilingual. However, this opens a whole new avenue of enquiry because southern African Bantu languages need more linguistic research centred on them; this is especially important with the potential discovery of language transfer during the NWR tasks.

5.5 Conclusion

In this study, we attempted to analyse the possible contributions of phonological short-term memory (pSTM) during oral sentence processing in typically developing (TD) South African second language learned (L2) English-speaking children, as well as gauge the implication of age in said language processes. Given that TD children had not developed higher-level linguistic skills, we attempted to argue that lower-level skills would have more of an effect on sentence processes. Through our findings, it was evident that pSTM has a strong presence and is a developing capacity in 6- to 7-year-olds. It is a cognitive mechanism needed to store and rehearse words and sentences; however, in this dissertation it was clear that it did not strongly affect the sentence processing of the children assessed. What was found were the syntactical and possibly semantic implications of the sentences and how the competency levels of the participants did not allow for high comprehension skills. Hence, this challenged the notion of children utilising a bottom-up process of language to understand spoken sentences. It was thus determined that although pSTM capacity levels were high, sentence processing was not. Regardless of this, it was evident that pSTM potentially had a greater influence on sentence repetition than comprehension (as seen in the sentence repetition and sentence-picture naming tasks, respectively). It was clear, however, that the pSTM capacity and sentence processing skills improve as children grow older; although, this did not mean that the sentence processing skills had improved altogether and presented high results. What was especially intriguing were the findings on bilingualism and its implications, namely, the processing of disyllabic nonwords possibly being influenced by language system interaction. It is apparent that there is still more to be said about this within research, and further insights are needed to understand the implications of bilingualism on pSTM and sentence processing. Ultimately, the underlying problem of sentence comprehension still exists. Given that high performance in comprehension has not been established in this study among young children, more studies and interventions are needed to improve this educational issue especially within the South African context.

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APPENDICES

APPENDIX A: Ethical clearance

UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

Research Office

HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)
R14/49 Madziwo

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER: H21/06/17**
PROJECT TITLE	The Effects of Phonological Short-Term Memory and Speech Perception on Sentence Comprehension in South African EAL Speaking Children
INVESTIGATOR(S)	Ms A Madziwo
SCHOOL/DEPARTMENT	School of Literature, Language and Media/
DATE CONSIDERED	18 June 2021
DECISION OF THE COMMITTEE	Approved Risk Level: Low
EXPIRY DATE	15 September 2024

DATE 16 September 2021 **CHAIRPERSON** ______________________
(Professor J Knight)

cc: Supervisor : Dr R Kunene-Nicolas

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University. Unreported changes to the application may invalidate the clearance given by the HREC (Non-Medical)

I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to submit an amendment of the protocol to the Committee. **I agree to completion of a regular progress report. For Minimal and Low studies, this is due annually on 31 December. For Medium and High Risk studies, this is due twice annually on 30 June and 31 December.**

______________________ 17 / 09 / 2021
Signature Date

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES

APPENDIX B: Linguistic background questionnaire

Information Sheet about child before beginning experiment:

1. When is your birthday?
2. How old are you?
3. What grade are you in?
4. Who is your teacher?
5. What language do you speak at home?
6. Who do you stay with at home?
    a. What language does your mum speak?
    b. What languages does your father speak?
    c. What language does your guardian (gogo, auntie, etc.) speak

APPENDIX C: Examples of sentence types

Six Sentence types by Willis and Gathercole (2001). The Reversible active sentences (RAS) and X-but-not-Y sentence constructions (XYS) were used in the study.

(1) Reversible active sentences

a) Short words:

   The girl is chased by the boy

b) Longer words

   The spider is chased by the giraffe

(2) In/on

a) Short words

   The ring is in the box

b) Longer words

   The ink is in the pen

(3) Above/below

a) Short words

   The cap is above the chair

   The arm is below the chin

b) Longer words

   The triangle is above the flower

   The spaceship is below the window

(4) Embedded sentence

a) Short words

   The box the square is on is pink

b) Longer words

   The spider the table is on is black

(5) X-but-not-Y construction

a) Short words

The door but not the mat is green

b) Longer words

The curtains but not the picture is red

(6) Relative clause

a) Short words

The box is on the book that is brown

b) Longer words

The sticker is on the window that is broken

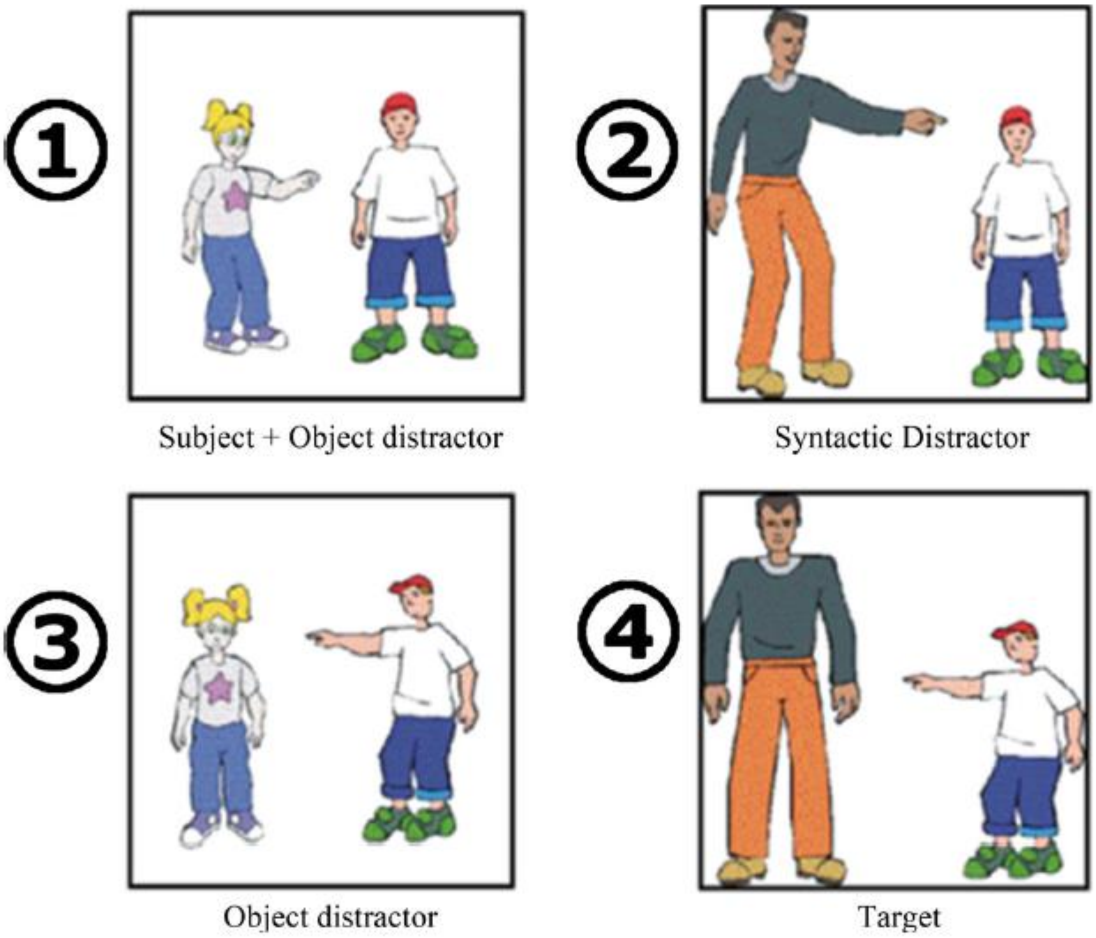
APPENDIX D: Examples of Wuggy generated English-based nonwords:

Word	Match	play	snay	after	adler
milk	misk	play	whay	after	ailer
milk	mirl	play	plag	after	axler
milk	molk	play	plal	after	acler
milk	mirm	play	smay	after	awler
milk	migh	play	wray	after	akler
milk	mibe	play	pliy	after	ayler
milk	mimb	play	plar	after	agler
milk	mict	look	loak	after	apler
milk	mirp	look	lool	seven	moven
milk	mife	look	liek	seven	ruven
fly	fle	look	pook	seven	roven
fly	flo	look	loob	seven	muven
fly	fli	look	loof	seven	puven
fly	scy	look	mook	seven	piven
fly	fla	look	loor	seven	soden
fly	ghy	look	looh	seven	duven
walk	wask	look	sook	seven	daven
walk	wawl	make	mamp	seven	doven
brown	brold	pretty	shotty	morning	murping
brown	brope	pretty	stotty	mother	sether
brown	spown	pretty	flutty	mother	sither
brown	slown	pretty	flitty	mother	ruther
brown	brewn	pretty	flotty	mother	rither
brown	broge	pretty	blutty	mother	murter
brown	brofs	pretty	blitty	mother	munter
brown	brode	pretty	blotty	mother	Musser

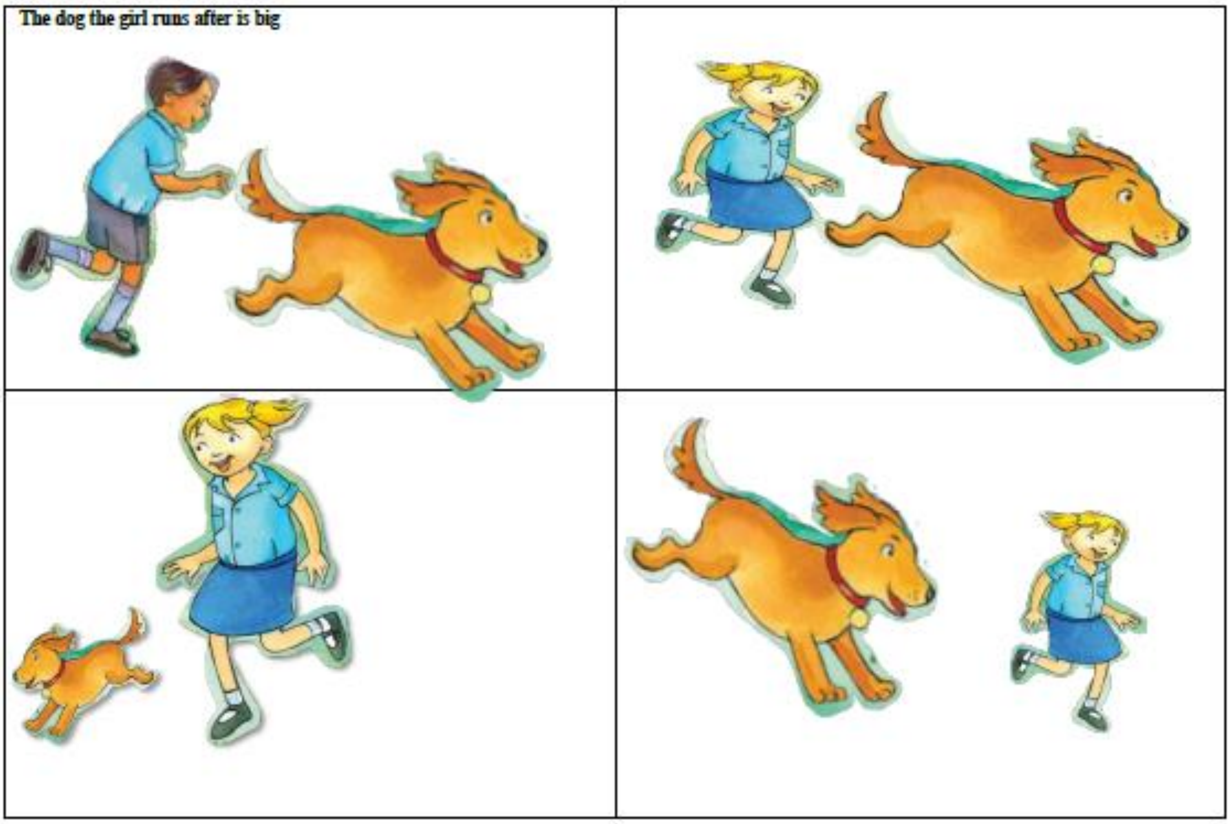
jump	jimp	make	mang	children	chidspen
jump	jult	thank	thunk	children	chidfren
jump	jule	thank	thash	flower	flimer
jump	juss	thank	thare	flower	flumer
jump	juff	thank	snank	flower	fliper
jump	juce	thank	whank	flower	flamer
jump	juch	thank	thams	flower	flaler
jump	juys	thank	thang	flower	flaper
jump	jude	thank	thave	flower	flaser
jump	juth	thank	thabs	flower	sporer
help	herf	thank	quank	flower	spoler
help	herp	going	waing	flower	sposer
help	hevs	going	wiing	morning	serning
help	hett	going	niing	morning	sirning
help	hewd	going	naing	morning	rurning
help	hept	going	luing	morning	rarning
help	hect	going	liing	morning	rirning
help	herg	going	laing	morning	murting
help	hewe	going	vuing	morning	muncing
help	helf	going	vaing	morning	muneing
brown	brorn	going	viing	morning	muoying

APPENDIX E: Examples of sentence-picture naming task stimuli

Robertson and Joanisse (2010) present this example of sentence-picture matching with 4 images, with 1 image being the target and the other 3 being the distractors (cited by Higgins *et al.*, 2017, p). The accompanying sentence to this is: “The man is pointed at by the boy.”



The following are examples of stimuli used in the assessment of this study. They were adapted from the DBE "Big Books".



The student is chased by the puppy.

APPENDIX F: Examples of results

Examples of nonword repetition (NWR) task, sentence repetition, sentence picture naming task results.

NWR task:

	Gr1B1A6	Gr1G2A6
Monosyllables		
misk	1	0
fla	1	0
walm	1	0
jimp	1	0
Disyllables		
akler	1	1
chigspen	1	0
flazzer	1	1
brocken	1	1
Pollysyllables		
tofirmer	1	1
caderbellac	1	0
emiprivity	1	0
zibberzabberer	1	0
Total	12	4

Sentence repetition task:

"Result" stipulates whether participant had a correct response. 1 was awarded for a correct answer; 0 was awarded for an incorrect answer.

The number next to each sentence stipulates the label of the correct picture.

Sentences reproduced by the participants are listed under each participants' column, in line with the target sentence.

Sentences	Gr1B4A8		Gr1B4A6	
	Repetition	Result	Repetition	Result
Reversible active sentences		0		2
The man is pointed at by the boy. 4	The man is pointing on the boy	0	The man is the pointed at the boy	0
The boy is chased by the girl. 3	The boy is chasing on the girl	0	The boy is chased by the girl	1
The girl is pointed at by the boy. 4	The girl is pointing on the boy	0	The girl is pointed by the boy	0
This is the boy that points at the man. 4	The boy points at the man	0	This is the boy that points at the man	1
X-but-not-Y construction		0		3
The door but not the mat is green. 4	The door is mat the mat is green	0	The door but the doors are not the green	0
The girl but not the boy runs. 1	The boy the girl not runs	0	The girl but not the boy runs	1
The girl is sitting but not eating. 2	The girl she is sitting but she is not eating	0	The girl is sitting but not eating	1
The pan that is not the pen is blue. 2	The pan it's blue	0	The pan that is not the pen is blue	1
Total (8)	0		5	

Sentence-picture naming task:

"Chosen" stipulates the picture label.

"Result" stipulates whether participant had a correct response. 1 was awarded for a correct answer; 0 was awarded for an incorrect answer.

The number next to each sentence stipulates the label of the correct picture.

Sentences reproduced by the participants are listed under each participants' column, in line with the target sentence.

Sentences	Gr1B4A		Gr1B5A		Gr1G1A		Gr1G2A	
Reversible active sentences	Result	Chosen	Result	Chosen	Result	Chosen	Result	Chosen
The man is pointed at by the boy. 4	0	4	1	4	0	2	0	2
The boy is chased by the girl. 3	1	2	1	3	0	2	0	1
The girl is pointed at by the boy. 4	0	1	1	4	0	1	0	1
This is the boy that points at the man. 4	0	4	1	4	1	4	0	2
X-but-not-Y construction								
The door but not the mat is green. 4	1	1	1	4	1	4	1	4
The girl but not the boy runs. 1	0	4	1	1	0	2	0	2
The girl is sitting but not eating. 2	0	2	1	2	0	1	0	4
The pan that is not the pen is blue. 2	0	2	0	3	1	2	1	2
Total (8)	2		7		3		2	