# A PSYCHOLINGUISTIC INVESTIGATION OF ORTHOGRAPHIC NEIGHBOURHOOD EFFECTS IN READING AND SPELLING IN ISIXHOSA

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# PLAGIARISM DECLARATION

I, Paige Cox (student number; g17c3743), hereby declare that this thesis is my own original work and has not, in its entirety or part, been submitted at any university for a degree.

Signed:____________ Date: 28/02/2023

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# ABSTRACT

Despite increased research interest in recent years in the metalinguistic skills underpinning reading in the Southern Bantu languages, little work has been done on the underlying microlinguistic layer. This refers to the actual mechanical underpinnings of linguistic skills; zooming in on micro-language structures so as to explicate our understanding of how reading works. One such microlinguistic phenomenon is the effect of orthographic neighbours on reading and writing. Research has found predominantly faciliatory neighbourhood effects for English word reading (Andrews, 1997; Siakaluk, Sears & Lupker, 2002; Yarkoni, Balota & Yap, 2008). Specifically, words with more orthographic neighbours have faster response times in lexical decision and naming tasks. However, in languages such as Spanish and French, inhibitory neighbourhood effects are reported (Grainger & Jacobs, 1996; Carreiras, Perea & Grainger, 1997). These findings highlight the language-specific nature of orthographic neighbourhood effects (Andrews, 1997), and the necessity for language-specific investigations of these effects. This thesis investigates the linguistic properties of orthographic neighbours in isiXhosa, thereby developing a database of orthographic neighbourhoods in isiXhosa. Further, this research explores the interaction between orthographic neighbourhood density and neighbourhood frequency with three literacy skills: lexical decision response time, word reading accuracy, and spelling accuracy. Data were collected from 97 isiXhosa grade three learners from five schools in KwaNobuhle Township in the Eastern Cape. A corpus of 170 000 tokens of isiXhosa words (Rees & Randera, 2017) was used to compile a database of orthographic neighbourhoods for 30 real, and 30 pseudowords which ranged in orthographic neighbourhood density and neighbourhood frequency, whilst controlling for word length and word frequency. Using this database, lexical decision, word reading, and spelling tasks were designed and administered to the participants. Findings indicate a significant inhibitory effect of orthographic neighbourhood frequency on spelling accuracy. Words with high neighbourhood frequencies are more likely to be spelt incorrectly. There was no observed effect of orthographic neighbourhoods on lexical decision response time and word reading accuracy. These results are interpreted within connectionist and search models of orthographic processing. Specifically, the findings indicate a partial reliance on lexical processing strategies when spelling. That is, orthographic neighbours compete for lexical access when spelling. Education practitioners may wish to present learners with lists of orthographic neighbours when introducing novel words so as to make explicit the fine grain differences between words in the language. This also means that

future research will need to develop a larger repository of orthographic neighbours in isiXhosa that can be made available for pedagogical purposes.

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| | |
|---|---|
| DRC | Dual Route Cascaded model |
| EGRA | Early Grade Reading Assessment |
| LD | Levenshtein Distance |
| LSK | Letter-sound knowledge |
| N | Neighbourhood |
| NF | Neighbourhood Frequency |
| OLD20 | Orthographic Levenshtein Distance 20 |
| OLDF | Orthographic Levenshtein Distance Frequency |
| ORF | Oral Reading Fluency |
| SD | Standard Deviation |

# CHAPTER 1: INTRODUCTION

This thesis investigates the linguistic properties of orthographic neighbours in isiXhosa, and the role that orthographic neighbourhood effects play in word reading and spelling in isiXhosa grade three learners. This is a topic that has been well explored in languages such as English (Siakaluk, Sears & Lupker, 2002; Bowers, Davis & Hanley, 2005a, 2005b; Barnhart & Goldinger, 2015; Lim, 2016; Parker *et al.* 2021), Spanish (Carreiras, Perea & Grainger, 1997; Goswami, Gombert & De Barrera, 1998; Martín & Pérez, 2008), and French (Grainger *et al.* 1989; Grainger & Segui, 1990; Grainger & Jacobs, 1996; Mathey & Zagar, 2000; Marian *et al.* 2012) and even in non-alphabetic languages such as Chinese (Tsai *et al.* 2006). However, as of yet no research has looked into this phenomenon in the Southern Bantu languages. As such, this research aims to fill this gap. This chapter provides the background to the current study, contextualizing it within the South African literacy landscape. It also introduces the research questions of the thesis and the aims in answering these, as well as outlines the methodology and main findings of the study.

## 1.1 Background to the research

The relevance of literacy research within the South African context is by now well known, as the South African literacy crisis has been acknowledged substantially in academic sources, and wide-spread in popular media sources (Biesman-Simons *et al.* 2020). It has also been on the lips of many government representatives, with the current president declaring reading for meaning as an “apex priority” (DBE, 2021) for the country. As a researcher in the field of literacy this affords one both the opportunity and responsibility to produce high quality, relevant research that will facilitate solutions to this crisis.

Over the last two decades, many psycholinguistic and educational studies have focused on trying to understand the contributing factors of this crisis. However, the main focus has been on macro-social factors, specifically teaching and classroom literacy practices, reading methodologies, and ethnographic approaches (De Vos, Van der Merwe & Van der Mescht, 2014; Van der Berg *et al.* 2016; Pretorius, 2018). There has also been a developing interest in cognitive and linguistic factors of literacy, namely, phonological awareness, orthographic awareness, and morphological awareness, among others (Wilsenach, 2013, 2019; De Vos, Van der Merwe & Van der Mescht, 2014; Pretorius, 2018; Schaefer, Probert & Rees, 2020).

What remains less clear is the underlying microlinguistic layer. This refers to the actual mechanical underpinnings of linguistic skills; zooming in on micro-language structures so as to explicate our understanding of how reading and writing work.

One such microlinguistic phenomenon is the effect of orthographic neighbours on reading and writing. Orthographic neighbours are words which are similar in spelling, for example the words *cheat, cheater, chest, chat,* and *wheat* (Yarkoni, Balota & Yap, 2008). As mentioned earlier, this phenomenon has been well studied in languages such as English, French, and Spanish. The reason being that these orthographic neighbours interact with how words are processed in the brain when reading and writing (Andrews, 1997). That is, when a word is seen on the page, or when it must be written down, the neighbours of that word are simultaneously activated in the lexicon. Thus a word is never processed in isolation, instead the reader or writer has a whole wealth of orthographic information, including neighbours, which they drawn on.

When studying orthographic neighbours, researchers are primarily interested in neighbourhood effects, of which there are two: orthographic neighbourhood density and neighbourhood frequency (Andrews, 1997). Neighbourhood density is a complex metric which will be unpacked thoroughly in Chapters 2 and 3, however in simple terms, it is a measure of the average closeness of a word's neighbours to that target word (Yarkoni, Balota & Yap, 2008). In other words, how many letters on average do the neighbours of a word differ from the spelling of that word. Words with a lot of neighbours that are close in spelling will be characterized as having a dense orthographic neighbourhood. For example, the word *condition* has a lot of close neighbours such as *conditions, coalition, cognition, conditional, etc.* (Yarkoni, Balota & Yap, 2008). Those words with more distant neighbours will be characterized as having a sparse orthographic neighbourhood, for example, the word *pistachio,* which has only distant neighbours such as *pistil, pigtail,* and *pitch* among others (Yarkoni, Balota & Yap, 2008). The other neighbourhood effect of interest, neighbourhood frequency, is an average measure of the frequency of a word's neighbours (Yarkoni, Balota & Yap, 2008). For example, one would take the average word frequency of the neighbours of *condition* and *pistachio* in order to calculate their neighbourhood frequency. By quantifying the neighbourhood density and frequency of words, it allows one to test for the unique effect of these variables on word reading and spelling.

Research has found that these neighbourhood effects can facilitate reading and writing, resulting in shorter reading/writing times, and/or aiding in accurate decoding and encoding (Huntsman & Lima, 2002; Siakaluk, Sears & Lupker, 2002; Barnhart & Goldinger, 2015). On the other hand, some researchers have reported inhibitory effects of orthographic neighbourhood density and/or frequency, whereby reading/writing times are slowed, and accuracy is hindered (De Moor & Brysbaert, 2000; Newman, German & Jagielko, 2017). These seemingly contradictory results in the literature have created a complex picture of this phenomenon, which the researcher must wade through in an attempt to find conclusive trends.

Two primary explanations which have been put forward for these contradictions are the inconsistency in methodologies adopted across studies, which has resulted in task and stimulus effects, and the language-specific nature of orthographic neighbourhood effects (Andrews, 1997; Bowers, Davis & Hanley, 2005a). The methodological explanation is largely owed to the extensive number of known and unknown confounding factors which could influence reading and writing (Bowers, Davis & Hanley, 2005a). Researchers have also acknowledged that different measures for reading and writing may have task specific effects that in turn cloud results surrounding orthographic neighbours (Grainger & Jacobs, 1996; Andrews, 1997; Bowers, Davis & Hanley, 2005a). These issues motivate the need to make carefully selected methodological choices when embarking on research into this topic.

The second explanation for contradictory findings in the literature, that orthographic neighbourhood effects appear to be language-specific, is of particular interest to this study. For example, there has been “a tendency for faciliatory effects in English and inhibitory effects in French and Spanish” (Bowers, Davis & Hanley, 2005a: B46) in the literature on orthographic neighbours. However, even these conclusions need to be taken with caution, as will be demonstrated in Chapter 2. Cross-linguistic differences in the effect of orthographic neighbourhoods are owed to the unique orthographic and structural properties of each language. For example, research on English neighbours acknowledges the role of orthographic bodies as in the words: *time, lime, rime,* and *mime*. In fact, 46% of four-letter words in the English language share an orthographic body, and these body neighbours help to facilitate word reading (Andrews, 1997). In comparison, languages such as French and Spanish do not have a large number of orthographic body neighbours (Andrews, 1997). Rather, the consistent spelling to sound conversions in these languages results in a large number of phonological neighbours (words that sound similar) which appear to hinder reading (Andrews, 1997; Carreiras, Perea & Grainger, 1997; Peereman & Content, 1997; Ziegler & Muneaux, 2007; Marian, 2017). Thus orthographic neighbourhood effects need to be interpreted with the specific structural properties of the language(s) in mind.

This brings the focus of this introduction back to the language of interest in this study, isiXhosa, as the effects of orthographic neighbours for reading and writing in isiXhosa are yet to be explored. Mention of this issue has been made in De Vos, Van der Merwe, and Van der Mescht (2014: 18), who suggest that the agglutinative, conjunctive orthographies of some Southern-Bantu languages, including isiXhosa, "could result in a relatively high number of orthographic neighbours." The authors note that these neighbours could have a negative impact on reading speed and automaticity (De Vos, Van der Merwe & Van der Mescht, 2014). The present research aims to investigate these assumptions to uncover how orthographic neighbours interact with word reading and spelling in isiXhosa. In doing so, the research seeks to situate these findings within existing models of orthographic processing. This will provide a more comprehensive understanding of the influencing linguistic factors which underlie reading and spelling in isiXhosa, which in turn can inform sound pedagogical practice.

Research on word reading and spelling in isiXhosa has highlighted the unique challenges which the language's orthography pose for the novice reader and writer. For example, even though the language is characterized by a consistent spelling to sound system, which has been shown to facilitate reading acquisition, it contains many complex graphemes (groups of letters that represent one sound) which have significant consequences for reading and spelling acquisition (Probert & De Vos, 2016; Daries & Probert, 2020). Further, the conjunctive nature of isiXhosa's orthography compounded by its agglutinative morphology results in a large number of long words which pose challenges for the novice reader and writer (De Vos, Van der Merwe & Van der Mescht, 2014). These structural characteristics are likely to determine the linguistic properties of neighbours in isiXhosa. For example, owing to the agglutinative morphology of isiXhosa, there is likely to be a large number of words which share a root morpheme, and which differ by one or more affixes, for example: *ufunda* (he/she reads/learns), *umfundi* (learner), *abafundi* (learners). Research has shown that in highly inflective languages like Spanish, orthographic neighbours slow down word reading (Vitevitch and Rodríguez, 2004; Marian, 2017). This is because in Spanish orthographic neighbours often have similar meanings. For example, the words *niño* (little boy) and *niña* (little girl) (Marian, 2017). Thus, the overlap of orthographic neighbours and 'meaning neighbours' has negative effects for reading speed. A similar effect could be found in isiXhosa where orthographic neighbours may also impact meaning and thus the speed and/or accuracy of reading and/or spelling could be hindered.

In addition to the influence of agglutination, the transparent nature of isiXhosa may lead to an overlap of phonological neighbours with orthographic neighbours. For example, *nesilwanyana* (and the animal) and *nezilwanyana* (and the animals) which differ by one letter and one phoneme, unlike in English where for example, the words *shove* [ʃəv] and *stove* [stoəʊv] differ orthographically by one letter but differ phonologically by two phonemes. Exceptions could be aspirated phonemes such as /$k^h$/ in the words *ziinkukhu* (they are chickens) and *ziinkulu* (they are big) in which there is a two-letter difference but one phoneme difference. What this means is that for the most part, orthographic and phonological neighbours are identical in isiXhosa. Previous research has shown that phonological neighbours interact with reading and writing as well (Storkel, Armbrüster & Hogan, 2006; Adelman & Brown, 2007). The current study aims to conduct a linguistic analysis of orthographic neighbours in isiXhosa, to uncover the layers of linguistic complexity which may underlie this phenomenon. These findings will inform an investigation into the influence of neighbourhood effects on literacy skills in isiXhosa.

Orthographic neighbourhood effects are interpreted using different models of orthographic processing, for example search processing models, parallel processing models, and connectionist models. These models are largely founded on European languages such as English and French, and research has shown that linguistic models cannot always be directly applied to other languages since different language structures will have unique consequences for reading and writing, and hence for modelling these skills (Probert, 2019; Schaefer, Probert & Rees, 2020). The current thesis aims to situate orthographic neighbourhood effects in isiXhosa within existing models of orthographic processing.

Although researchers have long been unpacking the macro-social factors and the cognitive linguistic factors at play, in attempts to better understand the literacy crisis in South Africa and provide solutions, a microlinguistic study of this nature is especially relevant for this context. The findings of this study will provide critical input to theoretical models of reading and spelling. Further, they will provide empirical evidence to guide pedagogical practices for teaching spelling and word reading in isiXhosa. This research is guided by four research questions which are presented below, along with the hypotheses to be tested.

## 1.2 Aims of the present study

This research falls within the psycholinguistic field of literacy; however it draws on multiple other linguistic subdisciplines in its methodology including computational linguistics, corpus linguistics, phonology, and morphology. In so doing, it aims to provide a comprehensive linguistic understanding of orthographic neighbours in isiXhosa, and to contribute to linguistic theory by situating neighbourhood effects in isiXhosa within existing models of orthographic processing. These findings may contribute to pedagogical practices surrounding reading and writing in isiXhosa.

In an attempt to reach these goals, the dissertation is guided by the following research questions:

**1.** What are the linguistic properties of orthographic neighbours in isiXhosa?

**2 a**. What role do orthographic neighbourhood effects play in word reading in isiXhosa grade three learners?

**b.** What role do orthographic neighbourhood effects play in lexical decision response time in isiXhosa grade three learners?

**3.** What role do orthographic neighbourhood effects play in spelling in isiXhosa grade three learners?

**4.** Which models of orthographic processing best capture the patterns of orthographic neighbourhood effects in isiXhosa?

The first research question addresses a primary aim of the research, which is to characterize orthographic neighbours in isiXhosa according to their linguistic properties. This question draws on multiple linguistic subdisciplines including orthography, morphology, and phonology, and uses computational tools to draw conclusions. These findings will provide a linguistic understanding of neighbours which can be used to interpret the results for research questions 2 and 3. It is hypothesized that orthographic neighbours in isiXhosa will be characterized by a high degree of overlap between semantic and orthographic similarity, as well as between phonological and orthographic similarity. Since isiXhosa words do not follow an onset-rime pattern, rime neighbours will not be salient in isiXhosa, however syllable neighbours – words that differ by one or more syllables - may be present, owing to the highly syllabic and transparent nature of isiXhosa.

The second research question is two-fold, as each sub-question addresses the results of a different word recognition assessment. Question 2a concerns a word reading task where reading accuracy is the main focus, whereas 2b concerns a lexical decision task where speed of lexical access is measured. The use of two assessments for word recognition is purposeful, owing to the large discrepancy in the literature concerning neighbourhood effects in word reading across tasks. It is hypothesized that orthographic neighbourhood effects in word reading (lexical decision and word naming) will be similar to those reported for languages other than English. That is, orthographic neighbourhood density will have a faciliatory effect in word reading, and orthographic neighbourhood frequency will have an inhibitory effect.

Question 3 will investigate the relationship between neighbourhood effects and spelling accuracy. These findings will provide empirical evidence for understanding how orthographic neighbours interact with literacy skills in isiXhosa. It is hypothesized that orthographic neighbourhood effects for spelling will be similar to those of word reading with faciliatory neighbourhood density effects and inhibitory neighbourhood frequency effects.

Finally, research question 4 frames the results of questions 2 and 3 within psycholinguistic theory. It compares these results with the literature presented in Chapter 2 concerning models of orthographic processing, to explore whether existing models can successfully account for neighbourhood effects in isiXhosa. This will contribute to a theoretical understanding of reading and spelling in isiXhosa. It is hypothesized that connectionist models of orthographic processing will best explain the results of the study, as these models can account for both faciliatory and inhibitory neighbourhood effects.

In order to answer the abovementioned research questions, the present study uses computational analysis tools in Python, RStudio and MS Excel, to explore the linguistic properties of orthographic neighbours in isiXhosa. It additionally makes use of a cross-sectional correlational research design to investigate the quantitative effects of orthographic neighbours in reading and writing in isiXhosa. Three literacy tasks; a word reading task, lexical decision task, and spelling task were designed and developed for the present study. The sample consisted of 97 grade three learners from five schools in KwaNobuhle township outside Kariega (previously called Uitenhage) in the Eastern Cape.

## 1.4 Summary of main findings

The main finding of this study is that orthographic neighbourhood frequency, but not density, has an inhibitory effect on spelling in isiXhosa when word length and word frequency are controlled for. This means that words which have a predominance of higher frequency neighbours are more likely to be spelt incorrectly. This finding can be interpreted within connectionist and serial processing models of orthographic processing. The interaction of orthographic neighbours in spelling suggests that spelling in isiXhosa relies partly on lexical processing of orthographic units. That is, the writer takes auditory input and maps this onto whole orthographic representations in the lexicon before writing down a word. These orthographic representations experience competition from higher frequency neighbours resulting in spelling errors. The reliance on lexical processing may be the writer's way of navigating feedback (sound to spelling) inconsistency in the language.

An additional finding was that orthographic neighbours did not affect word reading accuracy or lexical decision response time. Thus a null effect was reported. This finding is interesting as it is inconsistent with the findings of other studies on neighbourhood effects. The lack of a neighbourhood effect for reading may be interpreted as evidence for the reliance on sublexical processing when reading in isiXhosa rather than accessing whole word orthographic representations in the lexicon, as orthographic neighbours interact at the lexical level of orthographic processing. This is consistent with other studies on isiXhosa word reading which have found a preference for sublexical strategies when reading (Probert & De Vos, 2016). The reliance on sublexical processing when reading is likely as a result of the language's feedforward (spelling to sound) consistency.

The findings of this study may inform pedagogical practices surrounding spelling in particular. As it appears spellers already rely on lexical processing of words, possibly to navigate feedback inconsistencies in the language. Education practitioners may wish to present learners with lists of orthographic neighbours when introducing novel words so as to make explicit the fine grain differences between words in the language. This also means that future research will need to develop a larger repository of orthographic neighbours in isiXhosa that can be made available for pedagogical purposes.

### 1.5 Summary and structure of the thesis

Chapter one has served as a roadmap for the thesis, providing the background to the study, and a discussion of the aims and hypotheses which guide the study. It further provided an overview of the methodology and highlighted the main findings. Key terms used in the study were outlined in this chapter which included orthographic neighbourhood density; defined as the average closeness of a word's neighbours to that target word, and orthographic neighbourhood frequency; defined as the average word frequency of a word's orthographic neighbours. It was argued that there is a gap in the research on orthographic neighbourhood effects in isiXhosa and their effect on reading and writing. This thesis will contribute to understandings of the linguistic properties of orthographic neighbours in isiXhosa and to the orthographic neighbourhood effects in reading and writing in isiXhosa grade three learners.

The second chapter, the theoretical overview, will provide the reader with a review of the literature on the various core components which make up this thesis. These include looking broadly at the interaction of orthography with literacy skills and reviewing the linguistic structure of isiXhosa. Further, examining the two literacy skills of interest to the study: word reading and spelling, and their interrelationship, as well as reviewing current literature on word reading and spelling in isiXhosa. This is followed by a detailed introduction to orthographic neighbours and neighbourhood effects. An extensive review of the current literature on neighbourhood effects and literacy is provided, as well as a cross-linguistic exploration of orthographic neighbours. Finally, the chapter discusses various psycholinguistic models of orthographic processing which have been put forward to explain neighbourhood effects, before ending with the hypotheses of the thesis.

In Chapter 3, the methodology of the thesis is presented. This chapter discusses the rationale for the various methodological choices which were made. The measures of the study, orthographic neighbourhood density and neighbourhood frequency are explained. And the method by which they are computed is detailed. This chapter also addresses the development of the literacy assessments used in this study, including a word reading, lexical decision, and spelling task. These assessments were evaluated in a pilot study which is also reported on in this chapter. The pilot study was critical in informing the main data collection. Chapter 3 also provides an overview of the data analysis procedures which are used in Chapters 4 and 5.

The results and discussion of the thesis are split into two chapters with each addressing a key aim of the research. Chapter 4 addresses research question one, pertaining to the linguistic properties of orthographic neighbours. The chapter reports on the results of a computational analysis of the different linguistic properties of orthographic neighbours in isiXhosa. This includes the use of string comparison in order to quantify the morphological and phonological characteristics of orthographic neighbours. Chapter 5 addresses research questions two through four, pertaining to the interaction of neighbourhood effects with reading and spelling. This chapter reports on the results of the three literacy assessments; word reading, lexical decision, and spelling. Multilevel regression analyses are performed in order to test for a relationship between the results of these literacy assessments and neighbourhood density and neighbourhood frequency. These findings are then framed within existing models of reading and spelling.

The thesis is concluded in Chapter 6 with a summary of the main findings. The implications of these findings for pedagogical practices are teased out, and recommendations for further research are highlighted.

# CHAPTER 2: THEORETICAL OVERVIEW

## 2.1 Introduction

Chapter 2 provides a review of the theoretical underpinnings of this thesis. It discusses the various core ideas which make up this research, introducing each topic with a general overview before relating each to isiXhosa. Section 2.2 and 2.3 provide an overview of orthography and the interplay of orthography and literacy, which is followed by a discussion on the orthographic structures of isiXhosa (Section 2.4). In Sections 2.5, 2.6, and 2.7 the literacy skills of interest to this study are explored; word reading and spelling, as well as their interaction. Thereafter these skills are discussed in relation to isiXhosa in Section 2.8. This is followed by an introduction to orthographic neighbours and neighbourhood effects (Section 2.9). These effects are also discussed in relation to literacy skills. Section 2.10 provides a cross-linguistic overview of orthographic neighbours. Finally, various psycholinguistic models of orthographic processes are described in Section 2.11.

## 2.2 Orthography

Orthography is intrinsically connected to attempts at understanding how reading and writing work in the brain. This is because the written code of a language can be seen as the mediator between all other systems of language that are involved in reading and writing; the phonological, the auditory, the structural, and meaning making systems. No matter what theoretical view one takes, reading is not possible without the ability to decode written symbols on the page, and writing relies on our ability to produce these symbols (Wolf, 2008). Our ability as humans to interpret a visual code and take meaning from that code is a learnt behaviour.As Wolf (2008: i) says in the first line of her novel Proust and the Squid, “the act of readingis not natural,” in other words, we do not have a reading brain in the same way that we have alanguage brain. That is to say, reading, and by extension writing, are skills which must be explicitly taught. Further, they must be taught with the specific characteristics of the language’s orthography in mind.

Before developing a discussion on orthographies, one must first consider the difference between a writing system and an orthography. These two terms are often used interchangeably in the literature however, there are some distinctions. A writing system is defined simply as written language, with symbols that are mapped onto specific linguistic units (Joshi & Aaron, 2005). For example, English has an alphabetic writing system in that the written symbols are mapped onto individual sounds in the language (Joshi & Aaron, 2005). Whereas, Chinese has a logosyllabic writing system with symbols that represent both real world objects and concepts, as well as syllables in the language (Wolf, 2008). An orthography on the other hand, is a visual code which is governed by the "phonological, syntactic, morphological and semantic features of the language" (Joshi & Aaron, 2005: 14). For example, both English and isiXhosa have an alphabetic writing system, yet their orthographies differ in terms of which letters represent which sounds, how morphemes and words are constructed from those letters, and how those words are arranged in syntactic structures. One particular distinction which demonstrates the interconnectedness of orthography with other linguistic domains is the conjunctive-disjunctive distinction discussed in the following section.

### 2.2.1 Conjunctivism versus disjunctivism

Conjunctivism and disjunctivism are orthographic conventions which are concerned with how a language divides up words in written language. More specifically, they look at the relationship between orthographic words and linguistic words in a language (Probert & De Vos, 2016). Defining a 'word' has long been a source of contention in linguistics (Prinsloo & De Schryver, 2002; Louwrens & Poulos, 2006). However, there is a somewhat clear distinction between a linguistic word and an orthographic word. A linguistic word is defined as a "linguistic element" that can stand alone in our minds as a free abstract form (Louwrens & Poulos, 2006: 392). For example in Northern Sotho, *ba bararo* (three of them (women)) is one linguistic word because the two units cannot be separated, both have to appear together to form a meaning (Louwrens & Poulos, 2006). In comparison an orthographic word is a written unit which is separated on either side by a white space (Trask, 2005; Louwrens & Poulos, 2006), thus *ba bararo* would be considered two orthographic words.

In conjunctive orthographies, there is a one-to-one correspondence between a linguistic word and an orthographic word (Taljard & Bosch, 2006). Whereas disjunctive orthographies typically, but not always, have multiple orthographic words representing one linguistic word. For example, the following table (Table 1) by Taljard and Bosch (2006: 433), shows a distinction between Northern Sotho (N.S) and English (disjunctive orthographies), and isiZulu (Z) (conjunctive orthography).

Table 1: Crosslinguistic comparison of Northern Sotho, isiZulu, and English orthographies (Taljard & Bosch, 2006: 433)

| | Orthographical representation | Morphological analysis | | | | |
|---|---|---|---|---|---|---|
| N.S | ke a ba rata | ke | a | ba | rat- | -a |
| Z | ngiyabathanda | ngi- | -ya- | -ba- | -thand- | -a |
| | "I like them" | s.c. 1p.sg | PRES | o.c. cl 2 | verb root | inflectional ending |

In Table 1, the Northern Sotho example shows four orthographic words which together correspond to one linguistic word. In comparison the isiZulu example shows one orthographic word which corresponds to one linguistic word. The English example shows three orthographic words which correspond with three separate linguistic words. These distinctions can be understood when examining the mapping of word classes to orthographic units. In English each word in the sentence *I like them* belongs to a different word class, determiner, verb, and noun respectively. Whereas the singular orthographic word in the case of isiZulu and multiple orthographic words in the case of Northern Sotho, are all classified under one word category, in this case as a verb (Louwrens & Poulos, 2006). Thus even though *ke a ba rata* (I like them) appears as four orthographic words in Sotho it qualifies as one linguistic word with inflections marked on the verb for subject, tense, and object. Similarly, in isiZulu *ngiyabathanda* (I like them) is classified as a verb and as such is one linguistic word and one orthographic word. The distinction between the Sotho and isiZulu example being that inflections are written attached to the verb root in isiZulu (conjunctively) but are written separate to the verb root in Sotho (disjunctively).

The manner in which an orthography divides up words is usually, amongst other factors, a consequence of other linguistic features present in the spoken language, which then manifest themselves in the written language. For example, a commonly cited argument in the literature is that the absence of various morphophonological processes in Sotho languages makes a conjunctive orthography impractical (Taljard & Bosch, 2006; Louwrens & Poulos, 2006). Whereas for a language such as isiXhosa which frequently undergoes morphophonological processes such as "vowel elision, vowel coalescence and consonantalization" (Taljard & Bosch, 2006: 433; Wilkes, 1985), a conjunctive orthography is more practical. For example, the adjective root *-hlanu* [ɬanu] (five), undergoes fortition when the adjectival marker *ezin-* is attached to it, as in *ezintlanu* [ezintɬanu]. Here thefricative /ɬ/ has strengthened to the affricate /tɬ/ because of the proximity of the nasal when the prefix is added to the root word, such a phonological change is argued to be best captured by a conjunctive orthography.

It is necessary to note at this point out that the history of Southern Bantu language orthographies is a contentious one, particularly with regards to the choices made regarding disjunctivism and conjunctivism. There are those who argue that these languages' written history is steeped in colonial influence, and others who argue against these claims. For the purpose of this thesis it is necessary to acknowledge this contention, however a detailed and nuanced discussion is far beyond its scope. Regardless of this, the conjunctive-disjunctive distinction is a useful demonstration for the argument here that orthographies are intrinsically connected to other linguistic domains. Further, these linguistic interconnections are demonstrative of the various layers which need to be considered in a discussion on orthography, and by extension on orthographic neighbours. Another key orthographic feature that must be explored here is the principle of orthographic depth.

### 2.2.2 Orthographic depth

Orthographic depth, in relation to alphabetic languages, refers to the degree of consistency between graphemes and phonemes (Caravolas, 2005). In essence it concerns the level of regularity between the sound system of the language and its orthography. Orthographic depth is also often used interchangeably with the term orthographic transparency, with shallow orthographies being more transparent, and deep orthographies, more opaque. Alphabetic languages can be categorized on this scale according to their depth/transparency. For example, Table 2 from Viise, Richards and Pandis (2011) illustrates the degree of orthographic depth across 15 European languages, with deep orthographies rated as 1, and shallow orthographies weighted as 5.

From Table 2, English is considered to have a relatively deep/opaque orthography. This is because the mapping between phonemes and graphemes is more irregular in comparison to other languages such as Spanish, Dutch, or Finnish amongst others (Caravolas, 2005; Viise, Richards & Pandis, 2011). For example, in the English words *fought, caught, short,* and *stalk,* the vowel sound /oː/ is represented orthographically by four different graphemes: {ough}, {augh}, {or}, and {al}. This is also true for the reverse mappings from grapheme to phoneme, for example the grapheme {ea} can be pronounced /ɪː/ as in *heat* or /ə/ as in *health* or /ɪə/ as in *ear*. These inconsistencies are largely owed to the preservation of older forms from the origins of English, which include borrowed words from French and Latin (Caravolas, 2005), as well as a trade-off between the need to encode morphological information to the detriment of phonological consistency, for example, in the words *muscle* and *muscular* (Wolf, 2008).

Table 2: Ratings of orthographic depth for 15 European languages (Viise, Richards & Pandis, 2011: 426)

| **Rating** | **Language** |
|---|---|
| 5 | Finnish |
| 4 | Spanish, Italian, Portuguese, Hungarian, Slovenian |
| 3 | German, Dutch, Swedish, Norwegian, Icelandic, Greek |
| 2 | Danish, French |
| 1 | English |

On the other end of the orthographic depth scale are languages like Finnish, Spanish, Estonian, and Serbo-Croatian (Caravolas, 2005; Viise, Richards & Pandis, 2011), as well as the Southern Bantu languages, including the language of this study, isiXhosa. These languages have a more consistent and regular orthography in comparison to languages like English. For example in Estonian there are nine vowel graphemes and nine vowel phonemes, excluding long vowels which are represented by two vowel graphemes e.g. /uu/ (Viise, Richards & Pandis, 2011). The mapping between these graphemes and phonemes is very consistent and regular (Viise, Richards & Pandis, 2011). Therefore the grapheme {a} has the same pronunciation across different phonetic contexts, such as in the words: *kattus* (to cover), *kala* (fish), and *kalla* (to pour) (Viise, Richards & Pandis, 2011).

The phenomenon of orthographic depth is often asymmetric, in that grapheme to phoneme mappings (print to sound) may be more or less consistent than phoneme to grapheme (sound to print) mappings, depending on the language in question. This asymmetry is also referred to as feedforward and feedback consistency (Bosman, Vonk & Van Zwam, 2006). For example, in English, the phoneme /s/ can be written as {s} as in *sea* or {c} as in *circus* and therefore is feedback inconsistent. As a general rule, alphabetic languages have less consistent phoneme to grapheme mappings, or less feedback consistency, than grapheme to phoneme mappings, or feedforward consistency (Moll & Landerl, 2009: 361). However the degree of asymmetry varies cross-linguistically. For example, French words are 2.8% feedback consistent, and 81.2% feedforward consistent whereas English is 27.7% feedback consistent and 69.3% feedforward consistent (Bosman, Vonk & Van Zwam, 2006). Therefore, although both English and French are considered to have relatively opaque orthographies (Viise, Richards & Pandis, 2011), French would be considered to have a high degree of feedforward consistency in comparison to English, that is, the mapping of graphemes to phonemes in French is considered relatively transparent (Borgwaldt, Hellwig & de Groot, 2004). In the reverse, French is highly feedback inconsistent in comparison to English, that is, the mapping of phonemes to graphemes in French is very opaque in comparison to English (Borgwaldt, Hellwig & de Groot, 2004). Thus to label a language's orthography as opaque or transparent is somewhat oversimplified as one needs to consider the direction of transparency to get a fully accurate description of the orthography. The direction of inconsistency between sound and print units has varying effects on the skills and cognitive processes underlying writing, which involves encoding from sound to print, versus reading, which involves decoding from print to sound. These effects are discussed in more depth in the following section.

## 2.3 Orthography and literacy

Two key elements that link orthography and literacy (reading and writing) development in languages with alphabetic writing systems, are the alphabetic principle and connected to this, the principle of orthographic depth, described in Section 2.2.2. The alphabetic principle is concerned with the connections between letters on the page and sounds in the language (Liberman, Shankweler & Liberman, 1989). This principle forms an umbrella term for two critical early literacy skills, namely, phonological awareness and letter-sound knowledge (Liberman, Shankweler & Liberman, 1989; Wilsenach, 2019). Phonological awareness is defined as "a sensitivity to the sounds and sound structure of a particular language" (Wilsenach, 2019: 1). It is the awareness that oral language can be broken up into words, which can be broken down into syllables and subsequently into individual phonemes.

Importantly, it also acknowledges the ability of the language user to manipulate these sounds to form new words and new utterances (Wilsenach, 2019). Equipped with this knowledge, a novice reader and writer must then develop their awareness of letter-sound relationships, which is the knowledge of which letters map to which sounds (Schaefer & Kotzé, 2019). Mastering these two skills, means mastery of the alphabetic principle, which is an imperative foundation for decoding. It is widely acknowledged in the literature that "an understanding of the alphabetic principle is the cornerstone of alphabetic literacy" (Caravolas, 2005: 498). This is true for all readers and writers, regardless of other orthographic properties of the language being read or written in (Mann & Foy, 2003; Castles & Coltheart, 2004; Caravolas, 2005; Hulme *et al.* 2005; Wilsenach, 2013, 2019; Goswami & Bryant, 2016).

The principle of orthographic depth, as discussed in Section 2.2.2, is another key feature for reading and writing. According to Aro (2004: 4), "from the perspective of reading acquisition, the most interesting aspect of variation between orthographies is related to orthographic depth." Researchers explain this link with reference to the Orthographic Depth Hypothesis (ODH) which posits that learners use different strategies when reading based on the orthographic depth of the language they are reading in. For example, readers of opaque orthographies cannot rely on grapheme to phoneme mappings to successfully decode written text, and as such must read words as whole orthographic units (Ziegler & Goswami, 2005). Whereas readers of transparent orthographies tend to rely more on consistent grapheme to phoneme relationships when decoding (Ziegler & Goswami, 2005).

The asymmetry of orthographic depth, as mentioned in Section 2.2.2, must also be considered when examining the effects of orthography on reading and writing processes. For example, languages like French and German are relatively feedforward (print to sound) consistent, and mostly feedback inconsistent (sound to print) (Aro, 2004; Moll & Landerl, 2009). Thus, they are relatively orthographically transparent in one direction, but less transparent in another. The effect of this asymmetry on reading and writing can be understood with reference once again to the Orthographic Depth hypothesis. Readers of these languages can rely on decoding written text letter by letter, because of the consistent print-sound correspondences. However, when writing, encoding from sounds to written text cannot be achieved through direct phoneme to grapheme mappings. As such, writers of French and German must rely on knowledge of larger orthographic and phonological structures such as syllables or words (Moll & Landerl, 2009).

The interaction between orthographic depth and reading and writing has been investigated in many empirical studies (Holopainen, Ahonen & Lyytinen, 2001; Aro, 2004; Caravolas, 2005; Viise, Richards & Pandis, 2011). Researchers have come to two main conclusions regarding this interaction. Firstly, mastery of the alphabetic principle develops slower for those learners of deep orthographies than for those of transparent orthographies (Aro, 2004; Caravolas, 2005). And secondly, as a consequence of this, the orthographic depth of a language has a significant influence on the rate of reading and spelling acquisition (Katz & Frost, 1992). Evidence for these findings can be found in multiple cross-linguistic studies. For example, in a study on Finnish grade one children, Holopainen, Ahonen and Lyytinen (2001) found that the majority of Finnish first graders could read pseudo words with 90% accuracy after only 4 to 9 months of reading instruction, significantly sooner than readers of English. Further, in a study on 13 different European orthographies, readers of transparent orthographies had a significant advantage in reading fluency and accuracy at the end of grade one, whereas readers of French, Portuguese, Danish and English (languages with relatively opaque orthographies) were significantly behind (Aro, 2004). Similar findings have been reported for spelling acquisition. For example, Viise, Richards and Pandis (2011) found that learners of Estonian- a language with very regular sound to print mappings- had a higher level of spelling proficiency in grade one in comparison to English learners. It is interesting then that learners of Southern Bantu languages, like isiXhosa, are continuously underperforming in literacy assessments, despite the apparent advantage of transparent orthographies for early literacy acquisition (Howie *et al.* 2017).

### 2.4 An overview of isiXhosa structure

The following section reviews the structure of the isiXhosa language, including the phonological, orthographic, and morphological domains. Knowledge of these structural systems is pertinent to our psycholinguistic understanding of how reading and writing works in isiXhosa. Further, in exploring what orthographic neighbours look like in isiXhosa, one must first review the known linguistic structures of the language.

IsiXhosa is the second most spoken language in South Africa, according to Statista (2022) in 2018, 14.8% of households in South Africa spoke isiXhosa. Spoken mainly in the Eastern and Western Cape provinces, it falls under the Nguni language group within the larger Southern Bantu language family. IsiXhosa shares many similarities with the other Nguni languages, isiZulu and siSwati and isiNdebele, and all four languages are considered to be largely mutually intelligible (Oosthuysen, 2015).

IsiXhosa has an alphabetic writing system and uses the same 26 letter Latin alphabet as English (Oosthuysen, 2015). However, these letters represent different phonemes in English and isiXhosa. It has a relatively simple vowel system with five short vowels /i,e, a, o, u/ with long vowel equivalents, /i:, e:, a:, o:, u:/. These are represented orthographically by two adjacent vowel graphemes, for example *oomama* [o:mama]. By comparison, its consonant system is much more complex, it has 77 consonant phonemes (Doke, 1967; Saul, 2013) with many complex graphemes (Schaefer, Probert & Rees, 2020). Complex graphemes are the use of multiple letters to represent one phoneme in the language, for example the trigraph {tsh} in *intshontsho.* The consonant system also has many aspirated sounds represented orthographically by a digraph for example, /$t^h$/ in *thatha* and /$p^h$/ in *mhlophe.* An additional layer of complexity is the click consonant sounds in isiXhosa. The click sounds are divided into three categories based on their articulation, dental clicks /ǀ/, alveolar clicks /!/, and lateral clicks [ǁ], (Gxilishe, 2004; Oosthuysen, 2015; Probert, 2016). Clicks can be represented by simple graphemes such as, {c} in *uncedo*, or more complex graphemes such as {ngx} in *ingxowa*. Research has shown that the complex consonant graphemes in isiXhosa have significant consequences for reading and spelling acquisition (Daries and Probert, 2020). These will be explored in more detail in Sections 2.5 and 2.6.

Another linguistic characteristic of isiXhosa is its transparent orthography. As discussed in Section 2.2.2, a transparent orthography has consistent links between graphemes and phonemes such that the grapheme {b} in *abantu* is pronounced the same as in the word *bala* regardless of the neighbouring phonological environment. However, there is of yet no clear idea as to the exact degree of transparency in the language, nor to the degree of asymmetry within this transparency, specifically in comparison to other languages. As mentioned, the vowel system in isiXhosa is considered very transparent as the vowel phonemes are consistently represented in the orthography (Diemer, 2015). Exceptions are the allophony of /e/ and /o/ (Diemer, 2015) and nuances in word position, with vowels in the penultimate syllable position pronounced as long vowels (Van der Stouwe, 2009). However, the consonant system of isiXhosa is more complex. As stated earlier, isiXhosa has 77 consonant phonemes (Doke, 1967; Saul, 2013) and 21 letters to map these onto (see Diemer (2015) for a full inventory of the phonemes and graphemes in isiXhosa). The orthography deals with this by combining consonants into groups of two or more graphemes, for example the phoneme /ŋᶢǁ/ in *ingxolo* (noise) is represented by the graphemes {ngx}. This results in a large number of consonant grapheme to phoneme correspondences which need to be learned by the reader and writer of isiXhosa. However these correspondences are still very consistent and so much like the vowelsystem, the consonant system is also considered quite transparent.

This transparency has consequences for both reading and writing in isiXhosa. As mentioned in Section 2.3, readers and writers of transparent orthographies benefit from consistent grapheme to phoneme correspondences, which is demonstrated in the high level of decoding and spelling accuracy after only a few months of schooling (Seymour *et al.* 2003; Aro, 2004; Viise, Richards & Pandis, 2011). In the case of isiXhosa, the benefits of the language's transparent orthography may be subdued by the large number of grapheme to phoneme correspondences (albeit consistent) that need to be acquired. Further, this transparency has consequences for the study of orthographic neighbours in the language since words that are spelt similarly may also sound similar. This aspect is discussed further in Section 2.10.

In addition to its transparency, isiXhosa also has a conjunctive orthography, this means that it has a one-to-one correspondence between linguistic words and orthographic words. As mentioned in section 2.2.1 and 2.4, the linguistic choices underlying isiXhosa's conjunctive orthography relate to the frequency of morphophonological changes in the language. For example, the bound morpheme *ngu* can be added to a word such as *umakhulu* (grandmother) to form *ngumakhulu* (she is a grandmother). In this example, the noun class prefix *u* is dropped from the noun with the addition of the morpheme *ngu*. Such that the word is not realised as **ngu umakhulu,* nor **nguumakhulu,* nor even as *ngu makhulu*. Rather, this morphophonological change (elision of the phoneme /u/ as a result of the process of affixation) is accommodated by a conjunctive orthographic representation *ngumakhulu* which corresponds directly to both the phonetic and linguistic word. Research has shown that conjunctive orthographies require different word reading strategies than disjunctive orthographies (Probert, 2019).

Lastly, isiXhosa has an agglutinative morphology, this means that the language consists of mainly bound morphemes (Hendrikse & Poulos, 2006). Further, words are arranged by stacking affixes on either side of a root morpheme. For example, the word *ndandihamba* (I was going) is made up of four morphemes, *nda-* (past tense), -*ndi-* (1st person singular), *hamb-* (to go), and -*a* (final vowel). The agglutinative nature of isiXhosa does however have consequences for word length. When combined with its conjunctive orthography, this results in extremely long orthographic words, for example *wawungawakholelwa,* which can be broken down as follows (2):

{2} Wawungawakholelwa [Orthographic representation]

wa - wu - nga - wa - khol -el - w - a

SM.PST.2sg - IPFV.2sg – NEG – OM.6 – believe – APPL – PASS - FV

“You were not believing them”

Morphological analysis key: **SM=** subject marker; **PST=** past tense; **2sg=** noun class 2 singular; **IPFV=** imperfective aspect; **NEG=** negation; **OM.6=** object marker noun class 6; **APPL=** applicative; **PASS=** passive; **FV=** final vowel)

These long words, as a consequence of isiXhosa’s agglutination, create unique challenges for the novice reader and writer to navigate. These are discussed further in Section 2.8, along with the impact of isiXhosa’s other orthographic properties, i.e. complex graphemes, transparency, and conjunctivism, on reading and writing. It is necessary to first explore the known effects of the language’s orthography on literacy skills before delving into the unexplored effects of orthographic neighbourhoods.

## 2.5 Word reading

This section discusses word reading as a fundamental literacy skill. It also considers underlying factors which influence word reading, specifically word factors such as word frequency, word regularity, and word length. Following this, the various strategies readers use when faced with a word on the page are explored. These strategies are then framed within a discussion of the Dual Route Cascaded Model (Coltheart *et al.* 2001). Lastly, the ways in which word reading is studied are outlined.

Word reading, also called word recognition, is a primary focus in studies of literacy (Treiman, 2005; Cortese & Balota, 2012). Psycholinguists often consider the word as the primary unit for reading, and fluent word reading is often used as a proxy for fluent text reading in general. In line with this, multiple psycholinguistic models of reading are based on word reading. Cortese and Balota (2012: 159) acknowledge word reading as “the place where form meets meaning.” This means that word reading involves the interaction of linguistic form, that is the orthographic and phonological realisation of a word, with comprehension of that form. The word is further likened "as important to developments in cognitive psychology as the cell has been to developments in the biological sciences" (Cortese & Balota, 2012: 159). This assumption is based on empirical evidence, with research showing word reading as a strong predictor of oral reading fluency and comprehension (Verhoeven, 2000; Eason *et al.* 2013). For example, in a longitudinal study on English literacy, Byrne, Freebody and Gates (1992) found that word reading was significantly correlated to comprehension, and this relationship remained stable from grades two to four. This finding is similar to Knoepke *et al.*'s (2014) study on early grade German literacy, who also report a stable relationship between word reading skills and comprehension from grade two to four. Further, in a study on school achievement at the end of Primary school in Finnish, Savolainen *et al.* (2008) found that word reading was a significant predictor of reading comprehension and general school achievement. The relationship between word reading and comprehension is said to be mediated through oral reading fluency (text reading) (Rasinski, 2004). This is supported by Kim's (2015) study on Korean speaking children who found that word reading was strongly correlated to oral reading fluency, and through this relationship, reading comprehension was also impacted by word reading. These studies demonstrate the importance of word reading for higher order literacy skills like oral reading fluency and comprehension. There are a number of underlying factors which need to be considered which impact word reading.

### 2.5.1 Underlying factors of word reading

Word reading as a skill, involves a number of underlying cognitive processes, and relies on oral language skills, metalinguistic skills, as well as linguistic factors such as orthography (Probert, 2016). The current study focuses on the interaction of orthography with word reading. Within this interaction there are a number of orthographic or word phenomena to consider. These include amongst others, word frequency, word regularity, word length, and orthographic neighbourhood effects (Cortese & Balota, 2012). Orthographic neighbourhood effects are discussed in full in Section 2.9, as these form the key variables of interest to this study. However the other three phenomena are discussed below in Sections 2.5.1.1 to 2.5.1.3. As critical factors underlying word reading performance, two of the three phenomena are included in the study as control variables. This is so that the unique contribution of orthographic neighbours to word reading can be isolated. Word regularity was not included as isiXhosa has a very regular spelling to sound relationship as discussed in Section 2.4.

#### *2.5.1.1 Word frequency*

A word's frequency, in Psycholinguistic studies, is in its simplest form measured as the number of times a word appears within a corpus (Cortese & Balota, 2012). It essentially forms a metric of a word's familiarity to a reader. Word frequency has been found to have robust effects on word reading (Cortese & Balota, 2012) and is considered the most controlled variable in studies on word reading, with higher frequency words read faster than lower frequency words (Duyck *et al.* 2008). This is known as the word frequency effect. The effect is explained differently according to different models of word reading; however all models acknowledge that the frequency effect is owed to the way in which frequent words are organized in the lexicon (Duyck *et al.* 2008). The idea is that higher frequency words are more likely to be available to the reader to access in the lexicon when reading, as they are exposed to high frequency words more often than low frequency words. Evidence for the frequency effect can be found in eye tracking research which reports shorter fixation times (instances where the eyes fixate on a particular word) for high frequency words than low frequency words (Rayner, Sereno & Raney, 1996; Pollatsek *et al.* 2008). As well as in lexical decision and naming tasks which show longer latencies (time taken to respond to/read a word) for low frequency words than high frequency words (Schilling, Rayner & Chumbley, 1998; Duyck *et al.* 2008; Ferrand *et al.* 2010). Word frequency has also been found to interact with other word factors such as word regularity and word length (Ziegler, Perry & Coltheart, 2003; Strauss, Grzybek & Altmann, 2007).

#### *2.5.1.2 Word regularity*

Word regularity is similar to the concept of orthographic transparency (as explained in Section 2.2.2), in that it refers to the consistency of print to sound mappings in a language. Specifically it relates to the consistency with which an orthographic body is pronounced/spelled in the language (Kessler & Treiman, 1997; Siew & Vitevitch, 2019). For example the orthographic body *-int* in English is more commonly pronounced as [ɪnt] as in the word *mint* rather than [aɪnt] as in the word *pint* (Balota *et al.* 2007). Languages such as English tend to have many irregularly spelt and pronounced words, for example words such as *quay, tough, yacht,* and *once* all violate the grapheme-to-phoneme conversion (GPC) rules of the language. As such the reader cannot decode these words through mapping each grapheme to its corresponding phoneme. The regularity effect predicts that irregular words are more difficult to read than regular words. Therefore reading *pint* will be more difficult than reading *mint* (Balota *et al.* 2007). Evidence for this effect can be found in various empirical studies, for example, Lacruz and Folk (2004) found that in English, irregular words were processed slower than regular words in a lexical decision and word naming task. Further, in Ziegler, Perry, and Coltheart's (2003) study on French, they found that irregular words had larger word naming latencies (time taken to read a word) than regular words. The regularity effect has often been found to interact with the word frequency effect, with irregular words being easier to read if they have a higher frequency but more difficult if they have a low frequency (Lambert *et al.* 2011).

However the interaction between word regularity and word frequency in reading differs across languages. For example, in French, the regularity effect does not seem to interact with word frequency as it does in English (Content, 1991; Ziegler, Perry & Coltheart, 2003). The interaction in languages such as English is owed to the irregularity of print to sound mapping which is compounded by lower frequency words. However, in the case of French, the language has more regular print to sound mappings than English, which facilitates word reading. In word reading tasks, readers can access this knowledge for successful word decoding, regardless of word frequency (Goswami, Ziegler & Richardson, 2005; Lambert *et al.* 2011). Thus the high regularity of French words mitigates any interaction with word frequency when reading. The same can be said of languages such as Italian and Spanish which also have stable print to sound mappings which support successful word reading regardless of word frequency (Lambert *et al.* 2011). The word regularity and word frequency effects are yet to be studied extensively in isiXhosa. The current study acknowledges this gap by using word frequency as a control variable. As already explained, word regularity was not included as a variable because of the language's high degree of regularity. A final word factor which must be considered for word reading is word length.

#### *2.5.1.3 Word length*

The number of characters (letter or syllables) in a word has been shown to have a significant effect on word reading, with longer words having longer latencies and higher error rates (Coltheart *et al.* 2001; Balota *et al.* 2004). Evidence for this effect can be seen in eye tracking studies, which show longer fixations for longer words (Rayner *et al.* 2011; Slattery & Yates, 2018). This effect is explained through the fact that longer words have more symbols (letters or syllable units) to decode which results in slower word recognition times. In addition to this, shorter words are much more available in working memory than longer words and thus can be recalled faster when reading (Jalbert *et al.* 2011; Guitard *et al.* 2018). The availability of shorter words in working memory is also compounded by word frequency. According to Zipf's law of abbreviation, higher frequency words tend to be shorter in length (Bentz & Ferrer-i-Cancho, 2016). Thus shorter words benefit both from shorter decoding times and higher frequencies which result in faster and or more accurate word reading.

Word length is measured in different ways in the literature, with some researchers preferring to measure word length as the number of letters or characters in a word (Spieler & Balota, 1997; Balota *et al.* 2004), and others measuring it as the number of syllables (Bijeljac-Babic *et al.* 2004; Guitard *et al.* 2018). The different metrics have shown differing effects on word reading in the literature. For example, New *et al.* (2006) found a U-shape curve explained the relationship between word length in letters and lexical decision response time latencies. Figure 1 from New *et al.* (2006) illustrates this effect. Short words between three and five letters long were found to have faciliatory effects, that is as word length increased from three to five letters, reaction times were faster (New *et al.* 2006). Medium length words between five and eight letters exhibited no effect on response time, and longer eight to 13 letter long words exhibited an inhibitory effect (New *et al.* 2006).

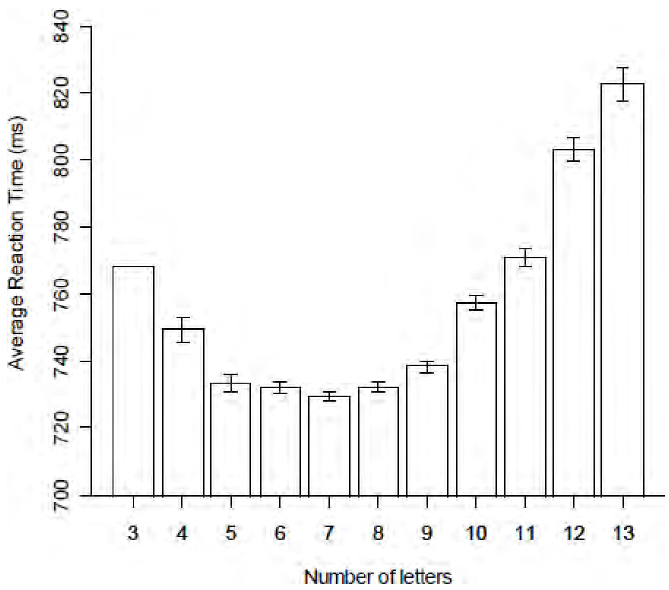


Figure 1: Word length in letters plotted against lexical decision response time from New et al. (2006).

New *et al.* (2006) also noted that when word length was measured in syllables, there was a robust linear inhibitory effect on word reading, that is words with more syllables had slower response times (New *et al.* 2006). And the initial faciliatory effect of word length when measured in letters was not noted when measured in syllables. This disparity may be owed to the sensitivity of the metric in explaining word length effects. As such the current study includes both measures of word length (letters and syllables) to investigate whether there are metric specific effects on word reading.

### 2.5.2 Strategies for word reading

The end goal for fluent word reading is to read words automatically, with little cognitive effort (Ehri, 2005). To achieve this goal, readers must utilize different strategies (Ehri, 2005). For young beginner readers, the challenge comes in that their repertoire of word knowledge is limited. Not only in terms of orthographic word knowledge but also vocabulary. This repertoire grows as readers spend more time with the words on the page and as their oral language skills naturally develop. The beginning stages of learning to read words demand that the reader utilize lower-level literacy skills in order to decode written symbols (Ehri, 2005). These skills include phonological awareness, that is, one's ability to distinguish different sound units such as phonemes, syllables, and whole words from a stream of speech, as well as knowledge of letter-sound relationships in the language (for alphabetic languages). Readers move from awareness of sounds in oral language, to forming connections between these sounds and the symbols on the page (Ehri, 2005). Equipped with this knowledge, a reader should in theory be able to decode any written word in the language, albeit not necessarily with automaticity.

As the reader progresses, these sound-symbol connections are reinforced and become stored in memory (Ehri, 2005). Further, frequently occurring words and orthographic patterns are also stored, and become available to the reader to access during the decoding process. This strategy is known as orthographic analogizing, whereby the reader uses knowledge of orthographically similar words or 'chunks' of letters to decode an unfamiliar word (Goswami, 1998; Ehri, 2005). Essentially this process describes the use of orthographic neighbours (similarly spelt words) as an aid in decoding unknown words. For example, a reader can use their orthographic knowledge of the word *cat* to decode words such as *bat, mat,* or *rat.* This strategy is of particular interest to the current study as it aims to quantify the effect of orthographic similarity in reading in isiXhosa. In addition to analogizing, a reader may also use a strategy known as prediction, whereby the word is guessed by using its shape, or any contextual clues to aid in recognition (Goodman, 1967; Ehri, 2005). A more advanced strategy used when reading familiar words is sight reading. In this strategy the reader makes use of word knowledge stored in their memory to read the word 'by sight', thus retrieving the word from their lexicon (Ehri, 2005; Nation, 2012). Sight word reading is characteristic of the end goal of reading as described earlier. That is, when readers sight read, they are able to access word specific knowledge (lexical retrieval) in order to read with efficiency and automaticity (Nation, 2012).

These are all generalized strategies, and the reader may make varying uses of each of these according to the demands of the language being read in as well as the demands of the specific text. These strategies are framed more specifically within various word reading models, an example of which is the Dual Route Cascaded Model (DRC) (Coltheart *et al.* 2001), a frequently sited model in psycholinguistic literature.

### 2.5.3 The Dual Route Cascaded Model of word reading

The Dual Route Cascaded Model (DRC) (Coltheart *et al.* 2001) is a cognitive approach to reading which attempts to explain how we approach word reading by suggesting that there are "two distinct processing routes for word recognition- a lexical (direct) and a sublexical (indirect) route" (Probert & De Vos, 2016). The lexical or orthographic route refers to the processing of words as whole units which means that the reader decodes the word in its entirety rather than breaking it down into individual graphemes (Probert & De Vos, 2016). Strategies such as analogizing, prediction, and sight word reading would fall under the lexical route of the DRC. That is, in the case of analogizing, readers may use knowledge of other similar orthographic forms to access a word in their lexicon (Goswami, 1998; Ehri, 2005). In the case of prediction, readers may utilize the context of the text surrounding the word, as well as word features such as shape, in order to access the orthographic representation of the word (Goodman, 1967; Ehri, 2005). Sight word reading, as an advanced strategy, would involve the reader automatically accessing the orthographic representation based on their familiarity with the word (Nation, 2012).

The sublexical or phonological route in comparison, refers to the processing of segmented units, or the linear mapping of graphemes to phonemes when reading a word (Probert & De Vos, 2016; Probert, 2019). This involves a strategy of decoding individual letter-sound relationships within the word and then mapping these onto the phonological representation of the word in one's lexicon. Both routes may be utilized by readers for various reasons. For example pseudowords (which are discussed in more detail in Section 2.5.4), cannot be read using the orthographic route, as the orthographic representation does not exist as a real word in the reader's lexicon (Castles, 2006). Whereas, irregular real words, such as those mentioned in Section 2.5.1.2, cannot be decoded using the phonological route, as by definition they violate the grapheme to phoneme conversion rules of the language (Castles, 2006).

Further evidence for the use of distinct processing routes in reading can be found with reference to the Orthographic Depth Hypothesis (ODH) (Frost, Katz & Bentin, 1987). The ODH, as mentioned in Section 2.3 on a discussion of orthography and literacy, is a hypothesis put forward to explain how readers make varied use of the two processing routes "depending on the demands of the orthography" (Ziegler and Goswami, 2005: 22). The main premise is that readers of orthographically transparent languages, will make more productive use of the phonological route, whereas readers of orthographically opaque languages will make use of the orthographical route (Ziegler and Goswami, 2005). The ODH, in conjunction with the DRC model, has been criticized for its overly binary approach to word reading (Probert, 2019). However a discussion on these approaches is necessary to establish a base understanding of psycholinguistic models of word reading before other models can be explored (see Section 2.11).

### 2.5.4 Assessing word reading and the role of pseudowords

As a variable of interest to psycholinguists and other cognitive researchers, various tools or tasks have been developed to measure word reading ability, as well as to experiment with various conditions and factors which influence word reading. The majority of these tasks include the use of pseudowords. Pseudowords are strings of letters that are 'word-like' in structure, in that they follow the orthographic rules of the language, however they are not real words in the language. Pseudowords are often also referred to as non-words in the literature, however this study distinguishes between the two. Non-words can be classified as words that, like pseudowords, have no real meaning, however they do not follow the orthographic rules of the language. For example in English the word *flirp* does not violate any orthographic rules of the English language and so can be classified as a pseudoword. However a word such as *plyogj* does not follow rules such as acceptable letter combinations and letter placements, and as such is a non-word. The commonality between the two is that neither have any real meaning in the language.

The benefits of including pseudowords in word reading tasks and experiments, are that they allow for control of semantic influence, as well as the frequency effect (as discussed in Section 2.5.1.1). Because a pseudoword does not have any meaning, it is not possible for the reader to access the word in their lexicon, thus the word must be decoded using strategies other than sight reading. That is, the word cannot be decoded in the same way that familiar words are. This allows the researcher to examine a reader's ability to decode using letter-sound mappings as opposed to whole word decoding. This is important because a reader's individual familiarity of a word will likely influence results, and as such a pure measure of decoding ability cannot be obtained without the use of pseudowords. Further, because a pseudoword does not exist in the language, it cannot have a frequency score. As mentioned in Section 2.5.1.1, higher frequency words have faster reading times. This effect will not be present for pseudowords, and as such the frequency effect can be controlled for. The lack of semantic meaning and frequency of pseudowords is important in assessing or experimenting with word reading, as both meaning and word frequency can be confounding factors which mask the effect of other variables of interest to the researcher.

The two most popular word reading tasks are lexical decision tasks, and naming tasks (Balota *et al.* 2004; Cortese & Balota, 2012). Some other types include the use of eye tracking to measure eye movements when reading (Land, 2015), with the idea that long eye fixations (where the eye focuses on a unit in the text) are indicative of cognitive processing of the fixated word (Land, 2015). Another task is word masking, whereby a target word is flashed on the screen for a few milliseconds, followed by a masked pseudoword which is then also flashed for a few milliseconds. The pseudoword mask could be similar to the target word in the case of an experimental treatment, or dissimilar in the case of a control treatment. Lastly a pattern mask is displayed (Frost & Yogev, 2001). The participant must then write down what they saw. Other tasks include priming tasks, the Stroop task (Scarpina & Tagini, 2017), and the Burt word reading task (Gaffney, Methven & Bagdasarian, 2002) among others. An important consideration in choosing which task to use in the research design process is that each task will have task-specific processes and effects. Thus researchers recommend the use of more than one task for more reliable results (Andrews, 1997; Cortese & Balota, 2012). The current study employs a lexical decision and word naming task which are described in more detail in the following section.

#### *2.5.4.1 The lexical decision task*

A lexical decision task involves the participant being presented with a string of letters, and then deciding whether the letters form a real word or not (Balota & Chumbley, 1984; Balota *et al.* 2004). The task returns an output of response times for each 'word'. Some of these letter strings are pseudowords and others are real words. Stimuli are manipulated in order to examine various effects on response time for words. For example, words with varying frequencies are used, or – in the case of the present study- words with varying orthographic neighbourhood densities and neighbourhood frequencies are used. The main premise is that a variation in the response times for the stimuli can be explained as an effect of the stimuli's manipulation "on the ease of extracting sufficient information from a letter string to recognize it as a word, that is, to access its lexical representation" (Balota & Chumbley, 1984: 340). The idea is that shorter response times mean faster lexical retrieval. That is, the participant is able to read the word automatically and in doing so recognize whether the word is real or not by accessing it in the mental lexicon. Slower response times indicate some form of inhibition to lexical retrieval, either as a result of uncontrolled factors such as poor reading ability, unfamiliarity to the word, or controlled word related factors such as word length, word frequency, or neighbourhood density and/or frequency.

The lexical decision task has been criticised as to whether it is a true reflection of lexical access, or whether the added cognitive demand of decision making – which is unrelated to the lexical access process- makes the task an unreliable measure (Balota & Chumbley, 1984; Carreiras, Perea & Grainger, 1997). In spite of these criticisms, the lexical decision task remains a well-used tool in the literature for measuring neighbourhood effects on word reading (Brysbaert *et al.* 2015; Lim, 2016; Marian, 2017; Ferrand *et al.* 2018; Aguasivivas *et al.* 2020; Parker *et al*. 2021).

#### *2.5.4.2 The word naming task*

Another commonly used word reading task in the literature is a naming task. A naming task involves presenting the participants with words, either on flashcards, in a list, or in a table, and measuring the speed and accuracy with which they read the words (Cortese & Balota, 2012). A words-correct-per-minute score is often calculated as a measure of speed and accuracy, with a higher words-correct-per-minute score indicating a more fluent reader. This task is used widely as part of the Early Grade Reading Assessments (EGRAs) (RTI International, 2016). To examine word-specific factors, studies such as those focused on orthographic neighbourhood effects calculate word naming latencies per individual word rather than a general words-correct-per-minute score. In order to achieve this, the researcher needs to use specific voice recognition technology and apparatus to collect naming latencies such as the Gebrands voice-operated relay (Balota & Paul, 1996; Balota *et al.* 2004) or the E-Prime psychology software tool (Barnhart & Goldinger, 2015). Owing to the inaccessibility of this form of apparatus, and the impracticality of voice recognition software in a loud classroom environment (where the current study's data collection was conducted) the current study uses an untimed naming task to capture word reading accuracy as opposed to word reading speed. In this type of task, participants are presented with words on flashcards, and a binary accuracy score is recorded, that is, an incorrect answer scores 0 and a correct answer scores 1. Previous studies on orthographic neighbourhood effects have employed the use of the naming task as a measure of both processing speed (time taken to read a word), and accuracy (per word) (Carreiras, Perea & Grainger, 1997; Barnhart & Goldinger, 2015; Chang, Welbourne & Lee, 2016). As such the use of the naming task as a measure of accuracy should be sufficient in measuring neighbourhood effects.

## 2.6 Spelling

This section will discuss spelling as a fundamental literacy skill. It will also consider the underlying factors of spelling, as well as explore how spelling works from a psycholinguistic perspective, framed within the dual route model of spelling production (Ellis, 1982). Lastly, the ways in which spelling is studied will be outlined.

In a discussion on word reading and literacy, the focus is on literacy as a receptive skill, that is fluency in text reading, and the ability to take meaning from written text. In comparison, a discussion on spelling and literacy looks at literacy as a productive skill, with a focus on how the writer can use a written code to produce coherent and meaningful written language. Spelling is considered one of the six dimensions of writing ability, alongside text structure, sentence structure (grammar), vocabulary, punctuation, and handwriting (Scull, Mackenzie & Bowles, 2020). Spelling is further categorized as a secretarial or transcription writing skill, along with punctuation and handwriting, in that its focus is on the "specific mechanical skills of writing" (Daffern & Mackenzie, 2015: 2). These mechanical skills are important for the novice writer to master so that working memory can be freed up for higher order writing skills which are involved in producing a well composed text (Sumner, Connelly & Barnett, 2014). This is supported by empirical evidence which highlights the role of spelling in writing production. For example, in Daffern, Mackenzie and Hemmings' (2016) study on English primary school children, the authors found that out of three predictors; spelling, grammar, and punctuation, spelling was the main predictor of written composition achievement. Further, in their analysis of the six dimensions of writing in grade one English children, Scull, Mackenzie and Bowles (2020) demonstrated the extensive interrelationships between secretarial skills like spelling and higher order writing skills such as text structure, sentence structure, and vocabulary. There is currently little to no research on spelling in the Southern Bantu languages, and its relationship with other writing skills. There is also very little research on the underlying factors of spelling in Southern Bantu languages, particularly in isiXhosa. The current study aims to contribute to filling this gap in the literature.

### 2.6.1 Underlying factors of spelling

Spelling, like word reading, is an amalgamation of various skills and is also influenced by word factors. These skills include metalinguistic skills such as, phonological, morphological, and orthographic awareness as well as fine-motor and reading skills (Caravolas, Hulme & Snowling, 2001). Other influential factors are orthographic or word related factors, and are akin to those factors underlying word reading, namely, word frequency, word regularity, word length, and orthographic neighbours (Folk, Rapp & Goldrick, 2002; Caravolas, 2005; Beinborn, Zesch & Gurevych, 2016). The first three phenomena are discussed here in relation to spelling. To avoid unnecessary repetition, the general definitions for these factors as discussed in relation to word reading (see Section 2.5.1), are not repeated here, instead this section focuses on the unique interaction of these factors with spelling.

### 2.6.1.1 Word frequency

The word frequency effect has been noted in spelling as well as in word reading (Treiman & Zukowski, 1988; Nation, 1997; Fernandes *et al.* 2007; Lété, Peereman & Fayol, 2008). This effect is explained in much the same way as it is for reading, in that higher frequency words are more available for the writer to access from their lexicon, and as such are less likely to cause spelling errors or alternatively will facilitate faster writing. For example, in a study on English grade three and four children, Nation (1997) found that children were particularly sensitive to rime unit frequency when spelling. That is, they were able to spell words with a high frequency rime unit more accurately than those with a low frequency rime unit. Similarly, in Le′te′, Peereman and Fayol's (2008) study on French children, word frequency had a significant faciliatory effect for spelling accuracy, with participants scoring higher on high frequency words. Further, this relationship increased in weight across grade levels, with 13% of variance in spelling accuracy ($\beta = 0.13$, $p < .001$), explained by word frequency in grade one, 32% ($\beta = 0.32$, $p < .001$), in grade two, and 36% ($\beta = 0.36$, $p < .001$), across grades three to five. Similar results were also found in Fernandes *et al.*'s (2007) longitudinal study on grade one Portuguese children. The authors found an increase in spelling accuracy over six months for high frequency words compared to low frequency words. Thus, the word frequency effect appears to be relatively stable cross-linguistically. Much like for word reading, word frequency also appears to interact with word regularity when spelling. That is, the word frequency effect is noted to be stronger for languages with deep orthographies than for those with transparent orthographies (Lambert *et al.* 2011). This is discussed in more detail in the following section on word regularity.

### 2.6.1.2 Word regularity

Word regularity, or the degree of regularity between the sound and spelling of a word, has been found to have a significant effect on spelling or writing latencies much like for word reading. Thus, irregular words are slower to produce in writing than regular words (Delattre, Bonin & Pascal, 2006). The regularity effect also interacts with the frequency effect in spelling, with irregular words creating larger inhibitory effects (higher error rates) for low frequency words than high frequency words (Delattre, Bonin & Pascal, 2006; Lambert *et al.* 2011). Interestingly, this interaction appears to be language specific. For example, owing to the asymmetry of orthographic transparency/regularity, in French, the regularity effect does not interact with word frequency for word reading, however it does interact in spelling (Bonin & Méot, 2002; Delattre, Bonin & Pascal, 2006; Lété, Peereman & Fayol, 2008). This is owed to the irregular sound to print mappings of French utilized in spelling, in comparison to its fairly regular print to sound mappings needed for reading (Lambert *et al.* 2011). The current study will investigate the effect of word frequency on spelling in a highly regular language to see if these claims can be extended to account for spelling in isiXhosa.

##### *2.6.1.3 Word length*

Word length is another significant word factor underlying spelling, with research from psycholinguistic studies showing an increase in error probabilities when the number of characters to be written increases (Beinborn, Zesch & Gurevych, 2016). Thus longer words have higher spelling error rates. This effect has been noted cross-linguistically in languages such as English, German, and Italian (Beinborn, Zesch & Gurevych, 2016) as well as French (Caravolas, 2005). Further, the word length effect also interacts with word frequency. For example in English, longer words are generally less frequent (Beinborn, Zesch & Gurevych, 2016). Thus, longer words have a compound inhibitory effect for English spellers (Beinborn, Zesch & Gurevych, 2016). The word length effect will be investigated in this study as a control variable for both word reading and spelling.

#### 2.6.2 Spelling strategies and the Dual Route model of spelling production

Spelling, much like reading, requires familiarity with the visual code of the language as well as extensive knowledge of sound-symbol correlations. Strategies of spelling have been framed within a dual route model of spelling production (Ellis, 1982). This model, much like the Dual Route Cascaded model of word reading, posits that two processing routes are activated during spelling, the sublexical and the lexical route. The sublexical route is activated when the writer makes use of phoneme-to-grapheme (sound to print) conversions in order to spell a word (Delattre, Bonin & Pascal, 2006). This route can be argued to be a mirror image of the DRC's sublexical route, in that the conversion takes place in the reverse order- from spoken sounds to written symbols. Arguably though, this route may be more important for successful spelling ability than it is for reading. This is owed to the production aspect of spelling which demands an extra level of mastery of the written code, in order to reproduce symbols correctly. One can also examine the use of the sublexical versus lexical routes within the Orthographic Depth Hypothesis (see Section 2.3). Owing to the asymmetry of orthographic depth in most alphabetic languages (as discussed in Section 2.2.2), where sound to print conversions tend to be more inconsistent than print to sound conversions, use of the sublexical route in spelling may be less productive than it is for reading. This is because the writer may not be able to rely on sound to print conversions as much as the reader can rely on print to sound conversions (in transparent orthographies).

The second processing route in spelling is a lexical route which works much in the same way as that of the DRC model for reading, in that whole-word orthographic representations are accessed from the lexicon in order to spell a word (Delattre, Bonin & Pascal, 2006). Within this processing route, writers make use of knowledge of known orthographic forms, including word-specific knowledge, to spell unfamiliar words. Thus generalizing word specific knowledge to new forms – a strategy known as analogizing. Many studies have provided empirical evidence for the use of analogizing in spelling (Bosse, Valdois & Tainturier, 2003; Conrad, 2008). It is this strategic use of prior orthographic knowledge in spelling that is of interest to the present study.

The Dual Route model of spelling production has been critiqued in much the same line as the DRC for reading, in that it posits a very rigid view of spelling and fails to account for interaction between phonological and lexical information (Alcock & Ngorosho, 2003). However, a discussion of this model is necessary to establish a foundational understanding of how spelling works before other models of orthographic processing can be presented (see Section 2.11).

### 2.6.3 Spelling assessment

One of the most common ways of assessing spelling is through a dictation task (Martin *et al.* 2020), whereby words are said aloud to a participant, and the participant must then write down the word. Other tasks include written picture naming tasks, whereby a visual input is presented to a participant who must then identify something in the picture and write down their answer. The medium of spelling assessments also varies, with participants asked to either handwrite, type, or spell words aloud. The key assumption in all of these tasks is that they "involve abstract orthographic representations that are not tied to a specific modality of input or output" (Tainturier & Rapp, 2001: 263) and are thus collectively referred to as assessments of spelling. The current study makes use of a dictation task as a measure of spelling accuracy.

In an assessment of spelling ability, pseudowords, as discussed in relation to word reading (see Section 2.5.4) are beneficial to the researcher to control for frequency and semantic effects. Thus they are used frequently in the literature on spelling (Daffern & Ramful, 2018; Van Vreckem & Desoete, 2018; Martin *et al.* 2020). The current study acknowledges the role of pseudowords in both its word reading and spelling assessments.

## 2.7 The relationship between word reading and spelling

Word reading and spelling are two core literacy processes often considered as two sides of the same coin (Ehri, 1987, 2000; Conrad, 2008; Schaars, Segers & Verhoeven, 2017). This is because they have very similar underlying cognitive and linguistic processes. In simple terms, reading involves decoding written text, by mapping symbols onto stored knowledge of sounds in the language, or drawing on stored orthographic patterns and representations of whole words (Ehri, 2000, 2005; Conrad, 2008). The process of spelling involves this process in reverse, the speller must access known sound-symbol mappings as well as orthographic patterns and whole word representations in order to encode a word onto the page (Ehri, 2000, 2005; Schaars, Segers & Verhoeven, 2017). It is clear then why researchers often classify these processes as "the same skills, performed in opposite directions" (Schaars, Segers & Verhoeven, 2017: 128). Evidence for this can be found across multiple fields including psycholinguistics, neuroscience and behavioural science (Moll & Landerl, 2009).

Research from Psycholinguists has highlighted the strong correlation between word reading and spelling, with r coefficients as high as 0.7 to 0.86 (Ehri, 1987, 2000; Moll & Landerl, 2009). Other studies in the field have found that this relationship is reciprocal, with spelling development influencing reading and vice versa. For example, in a longitudinal study on English grade two and three children, Davis and Bryant (2006) found that children's performance in word reading in grade two, had a causal effect on their spelling performance in grade three. However the reverse effect was less significant. Further, in a longitudinal study on Finnish reading and spelling Leppänen *et al.* (2006) found a recursive pattern in the development of these skills. The authors found that preschool reading performance significantly predicted spelling skills at the end of grade one and the same was noted for the reverse effect. In an investigation of the predictors of word reading and spelling in four languages, English, Spanish, Slovak, and Czech, Caravolas *et al.* (2012) found a similar pattern of weightings for the predictor variables for both reading and spelling. With the exception of word memory span, the authors found that phoneme awareness, letter knowledge, and RAN each predicted spelling and reading performance significantly. Similar findings are reported by Wealer *et al.* (2022) who found that phonological awareness, and letter-sound knowledge in preschool were significant predictors of both reading and spelling in grade one. These studies demonstrate empirical evidence for the claim that common linguistic processes underlie spelling and word reading. Further evidence can be found in neuroimaging studies which have shown "that reading, and spelling activate overlapping brain regions" (Pugh *et al.* 2006 as cited by Schaars, Segers & Verhoeven, 2017: 127).

Although the domains of reading and spelling clearly overlap, there are some key differences which underlie these two literacy processes. Most noticeably, researchers have noted that spelling requires a more advanced knowledge of phoneme-grapheme mappings than reading (Conrad, 2008; Schaars, Segers & Verhoeven, 2017). Reasons given for this are due to the production component of spelling, which requires the speller to not only recognize phonemes and graphemes but also apply and reproduce this knowledge. For this reason, spelling is seen as a more advanced literacy skill (Schaars, Segers & Verhoeven, 2017). In a study on Italian grade one and two learners, Cossu, Gugliotta and Marshall (1995) found that learners had lower levels of spelling accuracy than reading accuracy across both grades. They further examined the type of errors made by the learners and found that the error rates for certain phonemes including geminate (long sounds) and consonant clusters (two or more adjacent consonant phonemes), were different for spelling than they were for reading. Cossu, Gugliotta and Marshall (1995) make further suggestions that the difference in reading versus spelling are owed to structural asymmetries. That is, the authors posit that these differences arise as a result of "distinct components of the functional architecture of children's minds" (1995: 20). The notion that the cognitive architecture for these skills differs is supported by neuropsychological studies on patients with brain damage. Studies such as these have shown instances of patients developing a deficit in spelling (alexia) but not in reading (agraphia) and vice versa (Moll & Landerl, 2009).

Another key difference between word reading and spelling which has already been mentioned in Section 2.3 and Section 2.6.2, is that the consistency of phoneme-grapheme mappings that are necessary in spelling is generally lower than the consistency of grapheme-phoneme mappings used in reading. This is true of most languages with alphabetic orthographies (Moll & Landerl, 2009). For example, in English there are around 40 phonemes, and about 70 graphemes which symbolize them (Ehri, 2000). This means that the English speller has to use their knowledge of 40 phonemes to produce 70 symbols, this is almost a 1:2 ratio, making for a challenging task. It is this orthographic asymmetry which contributes to spelling being more difficult than reading (Moll & Landerl, 2009).

Lastly, the psychomotor component of spelling adds an additional level of skill which the novice speller must master in addition to those components shared with reading (Conrad, 2008; Landerl & Wimmer, 2008). In order to spell, one must first know how to perform the act of writing. They must know how to hold and control a pencil, as well as conform to writing conventions, such as staying between the lines, and separating words with spaces. For these reasons, spelling is considered more difficult than reading and this is usually reflected in the literacy development trajectory, with reading skills developing earlier than spelling skills (Caravolas, Hulme & Snowling, 2001; Keuning & Verhoeven, 2008).

In summary, although word reading and spelling are highly correlated skills, with similar underlying foundations, there are differences in the cognitive processes which are involved in these skills. Further, linguistic factors such as feedforward and feedback consistency interact with these skills differently, and the receptive versus productive nature, of reading and spelling respectively, results in unique challenges for the novice reader and writer.

### 2.8 Word reading and spelling in isiXhosa

Although research on literacy in the Southern Bantu languages has developed substantially in the last two decades (Biesman-Simons *et al.* 2020; Ardington *et al.* 2021), there remains significantly less output in comparison to European languages such as English and French. Word reading, as a proxy for fluent text reading, has been included as a measure in a number of studies on Southern Bantu languages (Lekgoko & Winskel, 2008; Wilsenach, 2013, 2019; Land, 2015; Probert & De Vos, 2016; Makaure, 2017; Probert, 2019; Schaefer, Probert & Rees, 2020, among others). By comparison, very little research exists on spelling in the Southern Bantu languages, and even less so in isiXhosa. This section will review previous studies on word reading and spelling in isiXhosa. Other languages from the Southern Bantu language family, including isiZulu, Northern Sotho, Setswana, Herero, and Kiswahili, will also be included in order to broaden the scope of the review.

Studies on word reading in the Southern Bantu languages have primarily focused on cross-linguistic differences usually pertaining to structural properties such as orthographic depth, syllable structure, morphological complexity, and degree of conjunctiveness. These studies report different cognitive processing for reading as a result of these properties. For example, readers of these transparent Southern Bantu languages appear to utilize a smaller linguistic grain size when reading in comparison to readers of English (Land, 2015). That is, readers decode words by breaking them up into smaller orthographic units and then mapping these units onto the phonology or meaning system of the language. For example, Probert and De Vos (2016), in their study on English and isiXhosa word reading strategies, found that first language speakers of isiXhosa used predominantly sublexical decoding strategies when reading both real and pseudowords. Probert (2019) extended this research into isiXhosa and Setswana and zoomed in on sublexical processing to further understand the sublexical units used in decoding in these languages. She found that both languages made use of the syllable as a linguistic grain size, in other words, a decoding unit when reading. In addition, readers of isiXhosa used the morpheme as a secondary linguistic grain size. Probert (2019) described these findings as a result of the highly regular, syllabic nature of both isiXhosa and Setswana. Further, owing to the conjunctive orthography of isiXhosa, readers are more sensitive to the morpheme as a grain size, in comparison to readers of the disjunctive orthography of Setswana. These findings have been influential in our understanding of word reading in the Southern Bantu languages and in expanding beyond the binary nature of the Orthographic Depth Hypothesis.

Other studies have utilized eye tracking as a means of understanding reading in the Southern Bantu languages. A prominent study in this area is that of Land's (2015) research on eye movements in readers of isiZulu- a similarly structured language to isiXhosa. In her study she reports that reading isiZulu texts is characterized by shorter saccades (sweeps of the eye across text), frequent fixations (moments where the eyes fixate on a word), and frequent regressions (movements backwards across the text). These characterizations result in a slower reading speed for isiZulu. Land (2015) explains these results with reference to the agglutinative and conjunctive nature of isiZulu which result in a high number of long, morphologically complex words. She points out that these orthographic properties result in "the need for readers to take cognisance of small but semantically important shifts in affixes in compound word forms" which in turn "could account for the relatively high number of fixations and longer durations of fixations recorded in this study" (Land, 2015). Thus, reading in agglutinative, conjunctive languages results in different reading strategies than those with isolating morphologies and disjunctive orthographies. Further, these orthographic properties contribute to the complexity of reading in Southern Bantu languages, in spite of their orthographic transparency.

Another large focus of the literature on word reading in Southern Bantu languages is on the interrelationships between metalinguistic skills, with a particular focus on phonological skills. For example, Makaure's (2017) study on early grade literacy skills in Northern Sotho emphasizes the role of phonological processing skills for successful reading and writing. These skills include phoneme isolation, phoneme elision, non-word repetition, digit span rapid naming including, rapid digit naming, rapid letter naming, rapid object naming, and rapid colour naming (Makaure, 2017). This is in concordance with Wilsenach's (2013; 2019) work on Northern Sotho, which also demonstrates the importance of phonological skills for reading in this language. Studies on Setswana word reading have found similar results, for example, Lekgoko and Winskel (2008) found a strong positive correlation between phoneme awareness and both real and pseudoword reading in Setswana grade two children. Likewise, Veii and Everatt (2005) report a significant correlation between phoneme identification and word reading in Herero, a Southern Bantu language spoken in Namibia.

The role of phonological awareness for reading has also been acknowledged for isiXhosa, specifically that of syllable awareness (Probert, 2019). Recent work by Schaefer, Probert and Rees (2020) expanded the scope of metalinguistic skills that inform reading in isiXhosa. The authors found that morphological awareness and RAN (rapid automized naming), but not phonological awareness predicted reading in isiXhosa grade three learners. Schaefer, Probert and Rees (2020: 90) explain this finding as evidence of a prior overestimation of the role of phonological awareness for reading in isiXhosa, as "other important predictors of reading have not been controlled." Thus, although some clear conclusions can be made regarding the metalinguistic skills and orthographic factors underlying word reading in the Southern Bantu languages, there are still some contingencies which require further research. Specifically, little to no research has focused on the role of other orthographic factors such as orthographic neighbours for reading and spelling. The current research aims to fill this gap.

With the exception of Daries and Probert (2020) and Daries, Bowles and Schaefer (2022) little to no research exists on spelling in isiXhosa. In their linguistic analysis of spelling errors in isiXhosa grade three learners, Daries and Probert (2020) found that spelling difficulties were mainly owed to the high number of complex graphemes in isiXhosa, such as *ngx, mhl,* and *dl,* which demand an intricate knowledge of the sound-spelling system of the language. The predominance of sub-lexical errors further suggests that spellers of isiXhosa predominantly utilize a sub-lexical level of processing when spelling, much like they do when reading (Daries & Probert, 2020). The findings of Daries and Probert (2020) confirm those of Alcock and Ngorosho (2003) in their study of spelling errors in KiSwahili who also report a high number of errors as a result of complex graphemes. They also report a significant effect of word length – with longer words resulting in more errors- which interestingly was not significant in Daries and Probert's (2020) study. Alcock and Ngorosho (2003) argue that spelling in languages with transparent orthographies is different to reading "in that phonological code-breaking [sub-lexical decoding] is not the only skill needed for successful spelling, while it is a sufficient skill for successful reading" (Cossu, Gugliotta & Marshall, 1995 as cited by Alcock & Ngorosho, 2003: 657). They posit that a multiplicity of skills and language knowledge are necessary in order to master spelling.

Other research on spelling in Southern Bantu languages has investigated the underlying metalinguistic skills required for spelling. For example, Daries, Bowles and Schaefer (2022) in their study on grade three isiXhosa learners, found that both phonological awareness, and reading ability were significant predictors of spelling. This is similar to the findings of De Sousa, Greenop and Fry's (2010) study on English-isiZulu grade two bilinguals' spelling. De Sousa, Greenop and Fry (2010) reported a significant correlation between phonological awareness and isiZulu real word and pseudoword spelling, and that this knowledge transferred to learners' English spelling. This is also confirmed in Diemer's (2015) study on isiXhosa grade three learners, who found that phoneme identification and phoneme segmenting were significant predictors of spelling is isiXhosa. Similarly, in her study on Northern Sotho, Makaure (2017) acknowledges the importance of phonological processing skills for spelling.

The paucity of research on spelling in isiXhosa highlights the importance of including this literacy skill in the current study. Daries and Probert (2020: 8) point out this gap in the literature with their appeal that "there is an urgent need for further research…to investigate the possible causal elements contributing to the gaps in learners' spelling ability in isiXhosa." The current study addresses this appeal by investigating the role of orthographic neighbours in isiXhosa spelling.

### 2.9 An introduction to orthographic neighbours

This section introduces the orthographic phenomenon of interest to this thesis - orthographic neighbours and neighbourhood effects. The interaction of neighbourhood effects with literacy skills are then explored, followed by a cross-linguistic analysis of orthographic neighbours. Finally a review of the various theoretical models within which neighbourhood effects are framed is presented.

Orthographic neighbours are typically defined as words which have similar orthographic representation, that is, they differ by relatively few letters in their spelling (Andrews, 1997; Ziegler and Perry, 1998; Bowers, Davis & Hanley, 2005a, 2005b). However, the rigidity of this definition varies throughout the literature. For example, the most common definition is that put forward by Coltheart *et al.* (1977) who define orthographic neighbours as words which differ by one letter while maintaining letter positions, and word length, such that the words *stove* and *shove,* are orthographic neighbours, as well as *stove* and *stole*, but not *shove* and *stole.*

In comparison, more recent research has moved away from the stringent conditions for defining orthographic neighbours as proposed by Coltheart *et al.* (1977). Evidence for this shift can be seen in the discovery of priming effects in words with letter transpositions (Perea & Lupker, 2003, 2003a, 2004), for example *lore* and *role*, as well as words with letter additions and/or deletions (Bowers, Davis & Hanley, 2005b) such as *heat* and *wheat,* as well as *hat* and *that.* These words would not be considered as neighbours within the restrictions of Coltheart's definition (Coltheart *et al.* 1977). As such researchers have begun to expand their definition of what constitutes an orthographic neighbour to include these conditions as well (Bowers, Davis & Hanley, 2005b; Yarkoni, Balota & Yap, 2008).

This development is important as although orthographic neighbours may be defined with specific constraints in theory, the real question is whether these constraints hold up in practice. That is, does the reading brain consider orthographic neighbours as only those words that differ by one letter? Or is our perception of them more flexible? And if so, how flexible? How many letter differences do there need to be to reach the threshold of neighbourhood effects in reading processes? This issue is raised by Bowers, Davis and Hanley (2005a: B47) who emphasize the necessity of having "a psychologically accurate definition of a 'neighbour'." In other words, there is a need for better alignment of the theoretical definition of a neighbour with what we know about how the brain organizes orthographic patterns. Thus the current study uses a more recent and nuanced definition of orthographic neighbours.

This newer definition was put forward by Yarkoni, Balota and Yap (2008). The authors reconfigured Coltheart's definition of orthographic neighbours to one which considers orthographic neighbours on a graded scale of similarity (Yarkoni, Balota & Yap, 2008). This definition includes words with different word lengths, obtained by letter additions or deletions such as the words *plan* and *planet,* as well as letter transpositions, such as *trial* and *trail* (Yarkoni, Balota & Yap, 2008). As such, it moves beyond the binary constraints of Coltheart's neighbours, by allowing for words which are "more or less neighbourly" (Yarkoni, Balota & Yap, 2008): 971) as opposed to an either-or classification for neighbours.

Yarkoni, Balota and Yap (2008) quantified orthographic similarity using a computer science metric known as Levenshtein Distance (hereafter referred to as LD) the namesake of mathematician Vladimir Levenshtein who developed this metric in 1965. LD is a metric used to compare two strings of characters to obtain a measurement of the difference or distance between the two strings (Levenshtein, 1965; Yarkoni, Balota & Yap, 2008). With reference to orthographic neighbours we can use this metric to compute the degree of similarity between two words. For example, the words *ukuba* and *kukuba* have an LD of 1, because they differ by 1 letter addition, i.e. the addition of *k* in *kukuba*. We can also compute words with an LD of 4, for example *zinokufikelela* and *ziyakujikeleza*, which differ by the second syllable (*/no/* and */ya/)*, the onset of the fourth syllable (*f* and *j*) and the penultimate letter (*{l}* and *{z}*). Thus, there is a negative correlation between the value of LD and the degree of similarity of words, such that words with a low LD are more similar, and those with a high LD are less similar. This metric successfully captures the graded similarity effect of orthographic neighbours that Yarkoni, Balota and Yap (2008) proposed.

### 2.9.1 Types of orthographic neighbourhood effects

Research on orthographic neighbours, from a psycholinguistic viewpoint, is primarily interested in measuring the effect that word similarity has on literacy processes. To achieve this, researchers focus on the neighbourhood characteristics of words called orthographic neighbourhood effects. This study is interested in two orthographic neighbourhood effects namely, neighbourhood density (also called neighbourhood size) and neighbourhood frequency. The way in which these effects are understood has changed over time throughout the literature. As the definition of orthographic neighbours has shifted, so has the definition of neighbourhood effects. With these changes, various metrics have been introduced in an attempt to quantify these effects as accurately as possible. The following sections will discuss these metrics in more detail within an explanation of neighbourhood density and frequency.

#### *2.9.1.1 Orthographic neighbourhood density*

##### *2.9.1.1.1 Coltheart's N*

Orthographic neighbourhood density was traditionally defined using Coltheart *et al.*'s (1977) understanding of an orthographic neighbour. Namely, those words that differ from a target word by one letter (Coltheart *et al.* 1977). From this, Coltheart *et al.* (1977) established orthographic neighbourhood density as the number of neighbours that a word has in the language. They then proposed a metric for the orthographic neighbourhood density of a target word, which they coined Coltheart's N. This metric is a sum of all the words which differ from a target word by one letter. As such the English word *cheat* has an N of 4 since it has four orthographic neighbours, *cheap, chest, cleat and wheat* (Ziegler & Perry, 1998). The conditions for dense neighbourhoods versus sparse neighbourhoods have been very roughly defined in the literature. Laxon, Coltheart and Keating (1988) classified 'friendly' words, that is words with dense neighbourhoods, as those with a mean N of 11, whereas 'unfriendly' words- those with sparse neighbourhoods- had a mean N of 2. Other researchers have distinguished between a dense neighbourhood as one with at least five orthographic neighbours (N=5), and a sparse neighbourhood as one with between one and three orthographic neighbours (N ≤ 3, ≥ 1) (Ziegler & Perry, 1998). 'Hermit' words are those which have no orthographic neighbours (N=0) at all, for example, *banana* (Bowers, Davis & Hanley, 2005a).

*2.9.1.1.2 OLD20*

After the introduction of a new definition for orthographic neighbours, Yarkoni, Balota and Yap (2008) proposed a new metric for orthographic neighbourhood density which they coined Orthographic Levenshtein Distance 20 (OLD20). Recall from Section 2.9, that Levenshtein distance (LD) is the measure of how many letters a neighbour differs from a target word. Using this measure the authors computed the density of a target word's neighbourhood as the average LD between that target word and its 20 closest orthographic neighbours. In other words, the average LD of the 20 neighbours with the lowest LD values. This average is referred to as OLD20 (Yarkoni, Balota & Yap, 2008). Because OLD20 is essentially an average measurement of neighbour 'closeness', the larger the OLD20 value the more distant a word's neighbours are, and thus, the less dense the words neighbourhood is. Thus, there is a negative correlation between the OLD20 value and the orthographic neighbourhood density of a word. This means that words with a high OLD20 have a sparse orthographic neighbourhood, and words with a low OLD20 have a dense orthographic neighbourhood. For example *condition* has an OLD20 value of 2.4 and as such is classified as having a dense neighbourhood, whereas *pistachio* has an OLD20 value of 4.3 and as such has a sparse orthographic neighbourhood (Yarkoni, Balota & Yap, 2008).

The current study makes use of OLD20 as a metric for orthographic neighbourhood density, as it has been found to be a much stronger predictor of lexical decision response time than Coltheart's N (Yarkoni, Balota & Yap, 2008; Tulkens, Sandra & Daelemans, 2018). The developers of OLD20 also emphasize the efficacy of the metric for "longer multisyllabic words, enabling powerful investigations of similarity effects across the full adult lexicon" (Yarkoni, Balota & Yap, 2008: 972). Owing to the long multisyllabic nature of words in isiXhosa, the OLD20 metric is especially fitting for this study. Most importantly, OLD20 has proved a more reliable measurement, capable of capturing a "more fine-grained index of orthographic similarity" (Yarkoni, Balota & Yap, 2008: 975). To demonstrate the difference between these two metrics for neighbourhood density, Table 3 shows the orthographic neighbourhood of the isiXhosa word *kuqala* (first).

From Table 3, both metrics for orthographic neighbourhood density can be calculated. OLD20 can be calculated by taking the mean of the LD values in the first column which returns a value of 1.7. To calculate Coltheart's N for *kuqala* one needs to firstly consider the number of neighbours with an LD of 1, which would include*: kudala, kulala, kuqela, ukuqala, okuqala,* and *uqala*. However, only those neighbours formed by one letter substitution can be considered for this metric, as such only three of these neighbours would be valid: *kudala, kulala*, and *kuqela*. Therefore, *kuqala* would have a Coltheart's N of 3. Thus by Coltheart's standards, *kuqala's* orthographic neighbourhood would be classified as very sparse, whereas by OLD20 standards, *kuqala* would have a very dense neighbourhood. This stark difference has great consequences for the validity of the measurement and will naturally have ramifications for testing the effect of orthographic density for reading and spelling.

Table 3: Orthographic neighbourhood of *kuqala*

| LD from kuqala | Identity of 20 closest neighbours |
|---:|---|
| 1 | kudala |
| 1 | kulala |
| 1 | kuqela |
| 1 | ukuqala |
| 1 | okuqala |
| 1 | uqala |
| 2 | kula |
| 2 | lokuqala |
| 2 | kuhlala |
| 2 | kusasa |
| 2 | yokuqala |
| 2 | kudlala |
| 2 | wokuqala |
| 2 | waqala |
| 2 | qala |
| 2 | kulaa |
| 2 | ukulala |
| 2 | kumama |
| 2 | kukhala |
| 2 | kusela |

The drawback with using the OLD20 metric is that there is no accessible way to calculate this metric without some experience in computer science and familiarity with coding.

Additionally, there is a much larger body of research that uses Coltheart's N as a metric and as such the lack of studies that utilize OLD20 cross linguistically is hindering for researchers to compare results. This may explain why even more recent studies on neighbourhood effects still adopt Coltheart's metric. In spite of these drawbacks the benefits of the OLD20 metric still far outweigh the disadvantages.

#### *2.9.1.2 Orthographic neighbourhood frequency*

Orthographic neighbourhood frequency is defined as the frequency of a word's neighbours (Grainger, 1990; Yarkoni, Balota & Yap, 2008). The methodology employed for measuring neighbourhood frequency is not as constant as for neighbourhood density, with different studies adopting different metrics to measure this phenomenon. Further, the metric for orthographic neighbourhood frequency has not received the same scrutiny as neighbourhood density in the literature, which presents potential issues for validity and reproducibility within the field. Two metrics of neighbourhood frequency are explored in the following sections.

##### *2.9.1.2.1 Neighbourhood Frequency (NF)*

One of the most popular methods of measuring orthographic neighbourhood frequency appears to originate within the work of Grainger and colleagues (Grainger *et al.* 1989, 1992; Grainger & Segui, 1990). Grainger measures neighbourhood frequency (NF) by dividing stimuli into three sets "(1) words with no higher frequency neighbours; (2) words with only one higher frequency neighbour; (3) words with more than one higher frequency neighbour" (Grainger, 1990: 231). Thus a word with a high neighbourhood frequency is equivalent to one with one or more neighbours that have a higher word frequency than the word itself. For example, the French word *nerf* which has one higher frequency neighbour - *neuf* - would be classified as having a high neighbourhood frequency (Grainger, 1990). Whereas a word with a low neighbourhood frequency is one whose neighbours are all lower in frequency than the word itself, for example, the French word *abus* which has no higher frequency neighbours (Grainger, 1990). Thus with this method, neighbourhood frequency is measured as relative to the frequency of the target word.

In an attempt to quantify this variable, researchers have since defined orthographic neighbourhood frequency as the mean word frequency of a target word's orthographic neighbours as defined by Coltheart's N, i.e. one letter substitutions only (Balota et al. 2007; Chee et al. 2021). The NF metric presents the same issues as Coltheart's N for orthographic neighbourhood density, in that its conditions for neighbourliness are over defined. As such the current study used a more recently developed metric; OLD20 Frequency or OLDF.

##### *2.9.1.2.2 Orthographic Levenshtein Distance Frequency (OLDF)*

With the development of measures for orthographic neighbourhood density over time, the metric for neighbourhood frequency has also undergone some changes in the literature. Yarkoni *et al.* (2008) define neighbourhood frequency on the basis of their OLD20 density measurement as discussed in Section 2.9.1.1.2. That is, they take the mean frequency of the 20 closest neighbours to the target word. The authors coined this metric OLD20 NF. The current study uses the simplified term OLDF to refer to orthographic neighbourhood frequency in line with the terminology used in the English Lexicon Project (ELP)[1] (Balota *et al.* 2007). The ELP can be used to generate lists of words with various properties, an example of a word with a high neighbourhood frequency in English is *man*, whereas the word *warehouse* is classified as having a low neighbourhood frequency.

The difference between the NF and OLDF metrics can be further illustrated by Table 4 which shows the word frequency[2] of the 20 closest neighbours to the word *kuqala* (first). From Table 4, the two metrics for orthographic neighbourhood frequency; NF and OLDF can be calculated for the target word *kuqala.* As explained above, NF is equal to the mean frequency of those neighbours differing from kuqala by one letter substitution, this includes: *kudala* (49), *kulala* (11), and *kuqela* (1), thus NF(*kuqala)* = 20.3. To calculate OLDF the mean frequency of the 20 closest neighbours to *kuqala* is calculated, thus OLDF(*kuqala*)= 17.7.



1: The ELP was updated in 2019 to include the OLDF and OLD20 metrics. Available at: https://elexicon.wustl.edu/about.html

2: The word frequencies and the identity of *kuqala*'s neighbours were taken from a corpus by Rees and Randera (2017) used in this study. See Section 3.3 for more explanation.

Table 4: Orthographic neighbours of kuqala and their corresponding word frequencies

| LD values | Identity of closest 20 neighbours | word frequency |
|---|---|---|
| 1 | kudala | 49 |
| 1 | kulala | 11 |
| 1 | kuqela | 1 |
| 1 | ukuqala | 11 |
| 1 | okuqala | 1 |
| 1 | uqala | 1 |
| 2 | kula | 40 |
| 2 | lokuqala | 31 |
| 2 | kuhlala | 30 |
| 2 | kusasa | 29 |
| 2 | yokuqala | 25 |
| 2 | kudlala | 23 |
| 2 | wokuqala | 19 |
| 2 | waqala | 16 |
| 2 | qala | 15 |
| 2 | kulaa | 12 |
| 2 | ukulala | 11 |
| 2 | kumama | 11 |
| 2 | kukhala | 9 |
| 2 | kusela | 9 |

Although a more nuanced metric for neighbourhood frequency, OLDF is not without its problems. Although not explicitly mentioned in the literature, the primary issue with OLDF is quite obvious. After accounting for Levenshtein distance, the question remains as to how one chooses which neighbours should make up the 20 neighbours used to calculate OLDF. To illustrate this, if one refers back to Table 4, there are six neighbours with an LD of 1 and 14 neighbours with an LD of 2. However the list of neighbours for kuqala with an LD of 2 extends past these 14 shown here. And each of these LD= 2 neighbours have varying word frequencies. The important question then is how one chooses which LD= 2 neighbours should be used to calculate OLDF. Since the metric in question is a measurement of neighbourhood frequency, the author decided to arrange the OLD20 neighbours first by Levenshtein distance, and second by descending order of frequency. Thus the neighbours that are considered by OLDF are the twenty closest, most frequent neighbours to the target word.

The issue perhaps is then not calculating neighbourhood frequency, but rather whether other orthographic neighbourhood factors should be considered as well. For example, there is the question of whether semantic neighbours cause stronger neighbourhood effects over nonsemantic neighbours. In addition, there is the question of whether words that share an initial word segment such as *kusasa* and *kuhlala* are more available in the lexicon when reading the word *kuqala* than those that share a middle or final word segment such as *waqala*. In essence one must question which features of neighbours make them most likely to be activated in the lexicon during reading and spelling and therefore more likely to exhibit neighbourhood effects. This particular issue is beyond the scope of the current thesis. However it is worth noting for future research.

### 2.9.2 Orthographic neighbourhood effects and literacy

This section discusses the role of orthographic neighbourhood density and frequency for reading and writing by examining the current literature on this topic. Research on orthographic neighbourhood effects has primarily focused on their interaction with word reading. A secondary, and less explored interaction has been that of neighbourhood effects and spelling. It is necessary to point out that the majority of research on neighbourhood effects was conducted in the late 1990s and early 2000s in concordance with the development of Coltheart's neighbourhood metric in 1997. A second wave of research on this topic is evident in concordance with the development of Yarkoni, Balota and Yap's neighbourhood metrics in 2008. Thus a review of the literature on neighbourhood effects will demand the inclusion of this older literature as it forms the foundation of this topic. Where possible, more recent research is included to demonstrate the relevance of this topic today, particularly in reference to less extensively studied languages in this field.

Psycholinguistic research is interested in orthographic neighbourhood effects as there is evidence that orthographic neighbours interact with how words are processed in the brain (Andrews, 1997). The exact way in which this happens is explained by various models of orthographic processing which will be explored in Section 2.11. However, the common underlying assumption of these models is that orthographic neighbours are activated in the lexicon simultaneously when a word is read or written (Siakaluk, Sears & Lupker, 2002). That is, a word is not processed in isolation, rather there is a whole wealth of orthographic information, including orthographic neighbours, that the reader or writer can draw on. The following section examines previous literature on orthographic neighbours and reading and spelling.

#### *2.9.2.1 Orthographic neighbours and reading*

The role of orthographic neighbourhood effects in reading is a well explored topic in languages such as English (Siakaluk, Sears & Lupker, 2002; Bowers, Davis & Hanley, 2005a, 2005b; Barnhart & Goldinger, 2015; Lim, 2016; Newman, German & Jagielko, 2017; Parker *et al.* 2021), Dutch (De Moor & Brysbaert, 2000; Boot & Pecher, 2008; Brysbaert *et al.* 2015), French (Grainger *et al.* 1989; Grainger & Segui, 1990; Grainger & Jacobs, 1996; Ziegler, Perry & Coltheart, 2003; Ferrand *et al.* 2018), and Spanish (Carreiras, Perea & Grainger, 1997; Goswami, Gombert & De Barrera, 1998; Acha & Perea, 2008; Aguasvivas *et al.* 2020). These effects have also been explored in non-alphabetic languages such as Chinese (Tsai *et al.* 2006) and Japanese Kanji (Nakayama *et al.* 2014). Research on neighbourhood effects in reading has presented a complex picture. With some studies finding faciliatory neighbourhood effects for reading (reading speed and/or accuracy is aided), whilst others finding inhibitory (reading speed and/or accuracy is hindered), or null effects (reading remains unaffected) (Andrews, 1997). In her meta-analysis of 43 studies on neighbourhood effects, Andrews (1997) found that 77% of studies reported faciliatory neighbourhood density effects for reading, whist 54% reported inhibitory neighbourhood frequency effects (Martín & Pérez, 2008). A further 20% reported null effects for neighbourhood density, and 22% reported null effects for neighbourhood frequency (Andrews, 1997). The discrepancies in the literature can largely be explained with regards to language-specific influence, and secondly with the variations in methodologies employed by studies. The following discussion will expand on these discrepancies with reference to current literature in order to establish the trends across studies. The discussion is structured by language, and the studies referred to are summarized in Table 5.

The majority of studies on English reading have found faciliatory effects for orthographic neighbourhood density (Andrews, 1997). That is, the denser a word's neighbourhood is, the easier it is to read that word in English. This is evident through reduced latencies (time taken to respond) in lexical decision and naming tasks for words with dense neighbourhoods. These effects have also been noted across a variety of other tasks including, perceptual identification, semantic categorization, and auditory word recognition. For example, in multiple experiments, Siakaluk, Sears and Lupker (2002) found faciliatory neighbourhood density effects and neighbourhood frequency effects for English pseudowords in lexical decision tasks. Pseudowords with dense neighbourhoods, and many higher frequency neighbours were responded to faster than pseudowords with sparse neighbourhoods and lower frequency neighbours. This is contradictory to the findings of Slattery (2009) however, who found an inhibitory effect of neighbourhood frequency in their study on eye movements in English reading. Siakaluk, Sears and Lupker's (2002) finding of a faciliatory effect of neighbourhood density was replicated by Huntsman and Lima (2002) for English real and pseudowords, as well as in a more recent study by Parker *et al.* (2021). Similarly in a perceptual identification task and semantic categorization task, Sears, Lupker and Hino (1999a) found a faciliatory neighbourhood density effect, although there was no evidence of a neighbourhood frequency effect. Therefore, in the case of English, there appears to be a mostly faciliatory effect of neighbourhood density for reading, however the effects of neighbourhood frequency are more contentious.

The findings for languages such as Dutch, French, and Spanish deviate slightly from those of English, particularly for neighbourhood frequency whereby robust inhibitory effects are reported. For example, De Moor and Brysbaert (2000) found that orthographic neighbourhood frequency had an inhibitory effect on response time in Dutch in a masked-prime lexical decision task, for target and neighbour primes of different word lengths. In the case of neighbourhood density, faciliatory effects for Dutch reading have been reported. For example, Boot and Pecher (2008) found faciliatory orthographic neighbourhood density effects in Dutch when words were primed with a semantic neighbour (i.e. an orthographic neighbour that had a similar meaning) in comparison with non-semantic neighbours. These findings suggest that orthographic neighbours interact both at the orthographic and semantic level in the lexicon, and that neighbourhood frequency interactions are distinct from neighbourhood density effects in Dutch. Similarly, Brysbaert *et al.* (2015) reported faciliatory density effects for Dutch in a lexical decision task. In summary, there is a tendency towards inhibitory neighbourhood frequency effects for word reading in Dutch, and a faciliatory orthographic neighbourhood density effect.

Table 5: Summary of studies on orthographic neighbourhood effects in reading across languages

| Language | Author | Methodology | Neighbourhood density | Neighbourhood frequency |
|---|---|---|---|---|
| English | Sears, Lupker, & Hino (1999a) | Perceptual identification task | Faciliatory | Null |
| | | Semantic categorization | Faciliatory | Null |
| | Siakaluk, Sears & Lupker (2002) | Lexical Decision | Faciliatory | Faciliatory |
| | Huntsman & Lima (2002) | Lexical Decision | Faciliatory | Null |
| | Mulatti *et al.* (2006) | Naming | Null | __ |
| | Slattery (2009) | Eye-tracking | __ | Inhibitory |
| | Barnhart & Goldinger (2015) | Naming: typed stimuli | Null | |
| | | Naming: handwritten stimuli | Faciliatory | __ |
| | Lim (2016) | Lexical decision | Faciliatory | |
| | Newman *et al.* (2017) | Naming accuracy | Inhibitory | Inhibitory |
| | Parker *et al.* (2021) | Lateralized Lexical Decision | Faciliatory in left visual field and Inhibitory effects in right visual field | – |
| Dutch | De Moor & Brysbaert (2000) | Masked-prime Lexical Decision | __ | Inhibitory |
| | Boot & Petcher (2008) | Semantic Decision | Faciliatory | __ |
| | Brysbaert *et al.* (2015) | Lexical Decision | Faciliatory | _ |
| French | Grainger & Segui (1990) | Lexical decision | __ | Inhibitory |
| | Grainger & Jacobs (1996) | Experiment 1A: progressive demasking task | Null | Inhibitory |
| | | Experiment 1B: Lexical Decision with difficult non-words | Null | Inhibitory |
| | | Experiment 1C: Lexical decision with easy non-words | Faciliatory | Inhibitory |
| | | Experiment 1D: Speeded Lexical decision with difficult non- words | Faciliatory | Inhibitory |
| | | Experiment 2A: Lexical decision with only non-words | Inhibitory when N frequency is low | Faciliatory |
| | | Experiment 2B: Categorized lexical decision with only non-words | — | Faciliatory- increase as N frequency of stimuli increases |
| | | Experiment 3A: perceptual identification word frequency x N frequency | _ | Inhibitory for low frequency target words |
| | | Experiment 3B: Lexical decision word frequency x N frequency | _ | Inhibitory for low frequency targets, Faciliatory for high-frequency targets |
| | Ziegler, Perry & Coltheart (2003) | Lexical decision | Faciliatory | _ |
| | Ferrand *et al.* (2018) | Lexical decision | Faciliatory | _ |
| Spanish | Carreiras *et al.* (1997) | Progressive demasking | Inhibitory | Inhibitory |
| | | Lexical decision | Null | Inhibitory |
| | | Lexical decision with N density blocked | Faciliatory | Inhibitory |
| | | Naming | Faciliatory for words with higher frequency neighbours | Inhibitory for low N density words |
| | | Semantic categorization | Inhibitory for words with higher frequency neighbours | Inhibitory for high N density words |
| | Acha & Perea (2008) | Eye-tracking | _ | Inhibitory for transposition neighbours |
| | Aguasivivas *et al.* (2020) | Lexical decision accuracy | Inhibitory for low frequency words | – |
| Turkish | Erten *et al.*(2014) | Lexical decision | Inhibitory | _ |
| Malay | Yap *et al.* (2010) | Lexical decision | Inhibitory | _ |
| Greek | Kapnoula *et al.* (2017) | Naming | Null | _ |
| | | Lexical decision | Null | _ |

Research on French has found a similar pattern of neighbourhood frequency and density effects. Grainger and Segui (1990) demonstrated that words with at least one higher frequency neighbour had longer response latencies than words with no high frequency neighbours in French. Further, in an extensive cross-task investigation, six out of eight of Grainger and Jacobs' (1996) experiments showed inhibitory neighbourhood frequency effects in French. This was in a lexical decision, progressive demasking, and perceptual identification task, with varying stimuli conditions. Their findings for neighbourhood density were less clear, out of the five experiments which included density as a measure, two resulted in faciliatory effects, one an inhibitory effect, and two in null effects. From Grainger and Jacobs' (1996) study, density appears to have a faciliatory effect in French lexical decision tasks in two conditions. One, when pseudowords have a low degree of lexicality - that is, the pseudoword stimuli are very clearly not real French words. And two, when speed is favoured over accuracy in the lexical decision task - that is, when participants are instructed to complete the task as quickly as possible without considering the accuracy of their responses. Faciliatory density effects in French were also reported by Ziegler, Perry, and Coltheart (2003) and Ferrand *et al.* (2018). However these studies did not control for neighbourhood frequency. In summary, for French, neighbourhood frequency appears to mostly have an inhibitory effect for reading, whereas neighbourhood density has a faciliatory effect. The deviations from this trend are owed to specific stimuli conditions.

This pattern of neighbourhood effects extends to findings in Spanish as well. For example, Carreiras, Perea and Grainger (1997) found inhibitory neighbourhood frequency effects across five different experiments, a progressive demasking task, two lexical decision tasks, a naming task, and a semantic categorization task. They also reported faciliatory neighbourhood density effects in the one lexical decision task (when neighbourhood density was blocked) and the naming task. However null density effects were found in the other lexical decision task when neighbourhood density was not blocked, and inhibitory density effects were found in the progressive demasking and semantic categorization task. The inhibitory neighbourhood frequency effect in Spanish was replicated by Acha and Perea (2008) in an eye movement study. The authors found that there was a significantly higher number of regressions (when the eye moves back across the text) back to the target word, when the word had a higher frequency transposition neighbour. More recently, Aguasivivas *et al.* (2020) found an inhibitory density effect in a lexical decision accuracy task. This finding is somewhat congruent with Grainger and Jacobs' (1996) results for French who reported a faciliatory density effect only when speed was emphasized in the lexical decision task, and null or inhibitory effects when accuracy was emphasized. This suggests that neighbourhood density may interact differently with accuracy and speed of lexical access in French and Spanish. However the inhibitory neighbourhood frequency effect for Spanish appears to be robust across studies, much like in French and Dutch.

Findings for less commonly studied languages (within this topic) such as Turkish, Malay, and Greek, provide more evidence for the language-specific nature of orthographic neighbourhood effects in reading. For example, Erten, Bozsahin and Zeyrek (2014) found an inhibitory effect of neighbourhood density for Turkish in a lexical decision task. This contrasts the majority of studies on neighbourhood density in languages such as English, Dutch, French, and Spanish. The authors suggest that this finding may be a result of the agglutinative morphology of Turkish, "where unique non-stem combinations (unique suffix groups) can be quite large" (Erten, Bozsahin & Zeyrek , 2014: 4). Unfortunately the authors do not expand on this explanation, but this issue will be unpacked more in Section 2.10. Interestingly, studies on Malay, another language with an agglutinative morphology, report a similar finding. For example, Yap *et al.* (2010) found an inhibitory neighbourhood density effect in a lexical decision task. A study on neighbourhood effects in Greek, a highly inflectional language (language with rich inflectional morphology) found null effects of neighbourhood density for reading (Kapnoula *et al.* 2017). Kapnoula *et al.* (2017) explain this finding as a result of the prevalence of long words in Greek. The authors explain that the longer words result "in much sparser neighbourhoods than English, especially if inflectional variants are excluded, and, therefore, fewer opportunities for neighbourhood effects" (Kapnoula *et al.* 2017: 9). This finding will also be explored in more detail in Section 2.10. These findings demonstrate that more research is needed on languages with agglutinative and inflectional morphologies to be able to draw firm conclusions about the role of neighbours in reading.

In summary the role of orthographic neighbourhood effects in reading is not clear cut, even in a well-studied language such as English. This leads one to believe that the nature of orthographic neighbours is quite sensitive, and subject to influence from methodological choices and language factors. The present study aims to pave the way for research into this phenomenon in isiXhosa and the Southern Bantu languages at large.

*2.9.2.2 Orthographic neighbours and spelling*

Research on the interaction of orthographic neighbourhood effects and spelling has been less explored than that of neighbourhood effects and reading. Specifically there are very few studies which investigate neighbourhood effects using the metrics for neighbourhood density and frequency. Rather, studies have taken a holistic approach to studying the interaction of neighbours with spelling.

The few studies that have used the metrics for neighbourhood effects have found similar results to those on reading. Particularly studies in English, have found faciliatory neighbourhood density effects for spelling accuracy, with denser neighbourhoods resulting in less spelling errors. For example, Laxon, Coltheart and Keating (1988) found that ‘friendly’ words – words with denser neighbourhoods, experienced fewer spelling errors than ‘unfriendly’ words. The authors further compared neighbourhood effects in spelling to these effects in reading and found that neighbourhood effects were stronger for spelling than for reading in English children. The authors explained this result as evidence for children’s reliance on larger orthographic structures in spelling rather than specific grapheme to phoneme knowledge. This result could also provide evidence for a stronger interaction of orthographic neighbours in the cognitive processes underlying spelling, in comparison to those underlying reading. A similar finding for French spelling was found by Roux and Bonin (2009), who report a significant faciliatory density effect for oral spelling latencies (time taken to spell a word out loud) and errors as well as a null neighbourhood frequency effect.

Within the domain of spelling, more research has been conducted on phonological neighbours, that is – words which differ by few phonemes, as well as phonographic neighbours – words which differ by a letter and phoneme (Lété, Peereman & Fayol, 2008; Maggio *et al.* 2012; Tainturier *et al.* 2013; Komesidou, 2018). This is most likely owed to the phonological component of spelling tasks whereby participants are made to listen to words aloud and then write down their answers. For example, Komesidou (2018) found that phonological neighbours and not orthographic neighbours, facilitated the spelling of pseudowords in English children, suggesting that “children rely more on their phonological knowledge than their orthographic knowledge" (Komesidou, 2018: iii). Research on phonographic neighbours can be considered in this discussion here as it reflects an overlap of orthographic and phonological similarity between words, and as such is relevant to an exploration of orthographic neighbourhood effects. Much like the results of orthographic neighbourhoods in spelling, studies on phonographic neighbourhood density in French have reported faciliatory effects, whereas those on phonographic neighbourhood frequency have reported inhibitory effects (Lété, Peereman & Fayol, 2008; Maggio *et al.* 2012). These results are again similar to studies on neighbourhood effects in reading in languages such as English, Dutch, French, and Spanish.

Another substantial portion of the literature has diverted its focus from more traditional studies of neighbourhood effects, i.e. neighbourhood density and frequency – to other interactions of spelling and neighbour properties (Folk, Rapp & Goldrick, 2002; Burt & Blackwell, 2008; Conrad, 2008; Andrews & Hersch, 2010; Chen *et al.* 2019). One of the most common being types of neighbours, such as substitution, transposition, and rime neighbours, and their effect on spelling. These studies mirror the faciliatory findings as reported in studies of neighbourhood density and spelling. For example, Chen *et al.* (2019) found that certain types of orthographic neighbours had a stronger faciliatory effect on spelling than others. They report that when words were primed with orthographic rime neighbours such as *rain, vain, pain*, spelling accuracy scores were higher than when words were primed with non-orthographic rime neighbours. They found no significant effect for substitution or transposition neighbours. A similar result was reported by Conrad (2008), who found that by using repeated reading practice – giving children practice words with similar rime units e.g. -ick in *kick, lick, stick* – there was a generalized effect with new words which had the same rime unit, with learners reading and spelling these new words more accurately.

These studies are different to those examined in the previous section for reading, in that they focus on an aspect of spelling acquisition and development. Thus their findings are tuned towards pedagogical and developmental solutions rather than simply providing a descriptive and theoretical approach to neighbourhood effects. Using this framework one can unpack the results of studies which conducted spelling error analyses. For example in Folk, Rapp and Goldrick's (2002) study, the authors conducted an error analysis of spelling errors and found that 92% of errors shared an initial letter with the target word, and the overall letter overlap for errors and targets was 77%. The authors concluded that these lexical substitution errors are evidence of competition from lexical neighbours. This result could be understood as evidence for an inhibitory neighbourhood effect. However, these errors may in reality represent evidence of facilitation in the form of strategic analogizing whereby participants use knowledge of orthographically similar words in their attempt to spell an unfamiliar word, resulting in a word that shares around 77% of its letters with the target word. Taking these results in the context of other research (Chen *et al.* 2019; Conrad, 2008) this competitive effect could in fact be understood as facilitative. This view is consistent with that of Burt and Blackwell (2008) who report that good spellers make errors that are consistent with rime neighbours more than poor spellers. That is, errors made by good spellers are more likely to draw on orthographic neighbours as a facilitative technique. Thus, not only do these rime neighbour errors indicate facilitation of orthographic similarity, but they are also indicative of an advanced strategy for spelling.

This conclusion is however contradicted by Andrews and Hersch (2010) who found that orthographic neighbours caused inhibitory effects for good spellers, and faciliatory effects for poor spellers. The difference in findings between Andrews and Hersch (2010) and Burt and Blackwell (2008) is likely owed to differences in methodology. Andrews and Hersch (2010) made use of a written, spelling dictation task whereby words are read aloud, and participants must write out their answers. Burt and Blackwell (2008) however made use of a vocal spelling test, whereby words must be spelt out loud by participants. These seemingly contradictory findings may in fact be evidence for a unique interaction of orthographic neighbours with different task modalities; written versus oral. These discrepancies in the literature on neighbourhood effects in spelling point to the need for more extensive research on this topic.

The above review of the literature on neighbourhood effects in reading and spelling is by no means exclusive. However it has indicated the trends in the research which exist amongst the various contentions. These trends will inform the discussion of the present study's results in Chapter 5.

## 2.10 Orthographic neighbours: a cross-linguistic exploration

As demonstrated in the previous section, the interaction between orthographic neighbourhood effects and skills are subject to language-specific influence. These differences are borne out of the variation across languages' orthographies, in particular the variation in word structure, as well as other influential linguistic properties such as orthographic depth, syllable structure, and morphology. These variations are discussed here in relation to what orthographic neighbours look like across languages. Once this has been established it will allow for a basis of comparison for investigating orthographic neighbours in isiXhosa. Since a corpus of orthographic neighbours has not yet been established for isiXhosa, this research is venturing into largely uncharted territory. However there are previously established neighbourhood corpora in other languages, including English, Dutch, French, Spanish, and Czech, among others, which will be used as a guide in the following discussion.

A prominent linguistic property to consider in a discussion of orthographic neighbours is that of orthographic depth (see Section 2.2.2). This is because phonological words in a language may be different to their orthographic counterparts, resulting in a confounding influence when studying orthographic neighbours. For example, a language such as English is considered to have a relatively deep or opaque orthography, as it has many digraphs and trigraphs (two or three letters that correspond to one phoneme), as well as silent letters (Ptáčková & Vitásková, 2020). This is also evident in how phonological words in English are often shorter than their orthographic words (Ptáčková & Vitásková, 2020). For example, the word *thought* has seven graphemes, but only three phonemes [θɔ:t]. As a consequence, when studying orthographic neighbourhoods in opaque languages such as English, phonological neighbourhood properties may confound findings. In comparison, in more transparent languages such as Spanish and Czech, the overlap of phonological and orthographic words means that the phonological neighbourhood of a word will be mostly equal to its orthographic neighbourhood (Marian *et al.* 2012; Ptáčková & Vitásková, 2020). Since isiXhosa is characterized by a transparent orthography, much like Spanish and Czech, it may be hypothesized that this is true for this language as well.

In line with a discussion on the overlap of orthographic and phonological neighbours is the property of syllable structure. Languages such as French and Spanish have a highly regular syllabic structure. Further these languages are syllable timed and as such the syllable is a prominent linguistic processing unit when reading and writing (Mathey *et al.* 2006). In addition to this, these languages are relatively feedforward consistent (compared to English) such that the orthographic representation of syllables regularly corresponds to their phonetic realization (Mathey *et al.* 2006). As a consequence, orthographic neighbours are often also syllable neighbours in these languages – that is words which share a syllable unit with a target word – for example *cosa* (thing) and *codo* (elbow) in Spanish (Carreiras & Perea, 2004). IsiXhosa also has a highly regular syllable structure, and the syllable unit has been found to be a prominent linguistic grain size for reading (Probert, 2019). As such syllable neighbours may also play a role in reading and writing in isiXhosa, for example, words such as *ixoki*, *iveki,* and *ipaki.*

In languages without a regular syllable structure such as English, syllable neighbours are not as prominent. Instead, a large percentage of orthographic neighbours share an orthographic body unit also called the rime. For example, words such as *round, found, hound* and *mound*, all share the orthographic body *-ound* and differ by the onset consonant. The extent of these neighbours in English is very large. In Andrews (1997) analysis of 1895 English words, 46% of four-letter words shared an orthographic body. Researchers have concluded that it is these orthographic body neighbours that are responsible for the faciliatory neighbourhood effects found in English (Treiman, 1992; Andrews, 1997). They link this to the irregularity of spelling in English which means that readers cannot always rely on knowledge of letter-sound mappings when decoding. As such readers rely on the frequency of orthographic bodies as a linguistic processing unit (Andrews, 1997).

Another linguistic property to consider is that of the interaction of morphological properties and orthographic neighbours. In languages with inflectional morphologies such as Spanish, orthographic neighbours are often overlapped with morphological neighbours (Vitevitch & Stamer, 2006). For example, the words *nino* (little boy) and *nina* (little girl) share three letters which form the root morpheme (Marian, 2017). Additionally they differ by one letter, but also by the inflected morpheme for gender with *-o* indicating masculine, and *-a* indicating feminine. As a consequence, a lot of words in Spanish are related not only in spelling but also in meaning (Vitevitch & Stamer, 2006; Marian, 2017). This morphological property is used to explain the inhibitory neighbourhood effects which are often reported in Spanish (Carreiras, Perea & Grainger, 1997; Acha & Perea, 2008; Aguasvivas *et al.* 2020).

Contrastingly in studies on Greek, which has higher degrees of inflection than Spanish (Giannakou & Sitaridou, 2020), researchers explain the absence of neighbourhood effects with reference to the language's inflectional morphology (Protopapas & Kapnoula, 2016; Kapnoula *et al.* 2017). That is, they question whether the notion of a neighbourhood is viable for the Greek language since there is a high prevalence of inflected words and "it is not clear whether members of an inflectional family should count as distinct lexical items and, therefore, as neighbors (i.e., potential competitors) of each other" (Kapnoula *et al.* 2017: 30). Such an argument could also be relevant of the study of orthographic neighbours in isiXhosa. However for the purposes of this study, whose focus is on orthographic words rather than semantic or linguistic words, words which fall under the same inflectional family such as *ufunda* (he/she learns), *ukufunda* (to learn), *umfundi* (learner), are considered as distinct lexical items (in the orthographic sense) and thus as orthographic neighbours.

Kapnoula *et al.* (2017) further suggest that morphological inflection in Greek results in long words which in turn result in sparser orthographic neighbourhoods, since longer words have less neighbours(this is discussed in more detail later in this section). Thus readers of Greek do not often come across orthographically dense words. The influence of morphology on orthographic neighbours and neighbourhood effects is thus another contentious issue which requires further research. On the one hand, an inflectional morphology may contribute to neighbours inhibiting lexical access, as has been demonstrated in Spanish, or it may mitigate the effects of neighbours all together as in Greek.

A discussion on inflectional morphology is included here as there is a high degree of inflection in agglutinative languages such isiXhosa (see Section 2.4). That is, words are marked with information such as number, person, tense, and aspect through affixes which are attached to the root word. Owing to the agglutinative morphology of isiXhosa, it is hypothesized that a large number of words share a root morpheme and differ by morphemes at the beginning and/or end of the word. For example, *umntu, bantu, omntu, lomntu, nomntu* all share the root morph *-ntu-* (person), and as such are all related by meaning in addition to orthography. This overlap was pointed out by De Vos, Van der Merwe and Van der Mescht (2014: 18) who suggested that in Southern Bantu languages like isiXhosa, "agglutination, compounded by conjunctive orthographies, could result in a relatively high number of orthographic neighbours." As mentioned in Section 2.9.2.1, research on other agglutinative languages such as Turkish and Malay, have found inhibitory neighbourhood density effects for reading (Yap *et al.* 2010; Erten, Bozsahin & Zeyrek, 2014). The authors of the Turkish study, Erten, Bozsahin and Zeyrek (2014) explained this finding as a result of the language's agglutinative morphology:

"This may have to do with the language's agglutinating morphology, where unique non-stem combinations (unique suffix groups) can be quite large, as much as 50, 000 according to (Sak *et al.* 2011)" (Erten, Bozsahin & Zeyrek, 2014).

In Turkish, as in isiXhosa, groups of suffixes can be arranged in many unique ways thus a root word may have many word form iterations. In other words, there will be many words in the language which share a root form, and which differ by unique suffix combinations. For example ***araba****lar* (cars), ***araba****m* (my car), ***araba****miz* (our car), and ***araba****da* (in the car) (Oflazer, Göçmen & Bozsahin, 1994). Erten, Bozsahin and Zeyrek (2014) suggest that these neighbours, which are similar in both spelling and meaning, cause inhibitory effects in Turkish. It is hypothesized that a similar result may be present in isiXhosa. The extent of this orthographic-meaning overlap will be explored more extensively in the computational linguistic analysis of this study's neighbourhood database in Chapter 4.

Final neighbourhood features to consider here include word length and word frequency, as well as different types of neighbours such as, substitution, addition, transposition, and deletion neighbours. Research on orthographic neighbourhoods has emphasized the interaction of neighbourhood density with word length and word frequency (Martín & Pérez, 2008; González-Nosti *et al.* 2014; Ptáčková & Vitásková, 2020). This is because shorter words are generally more frequent and also have more dense neighbourhoods than longer words. This has been found to be true cross-linguistically in languages such as English, Spanish, Czech, and Greek (Marian *et al.* 2012; Kapnoula *et al.* 2017; Ptáčková & Vitásková, 2020). Figure 2 by Marian *et al.* (2012) shows the distribution of neighbourhood densities across different word lengths. It is important to note that neighbourhood density here refers to Coltheart's N (see Section 2.9.1.1.1), as such, the y-axis is labelled with neighbourhood size. From this it is clear that shorter words have denser neighbourhoods than longer words. Further this distribution appears to differ across languages, with English demonstrating this pattern most distinctly in comparison to Dutch, French, German, and Spanish. Such an interaction will be explored in isiXhosa in the present study.

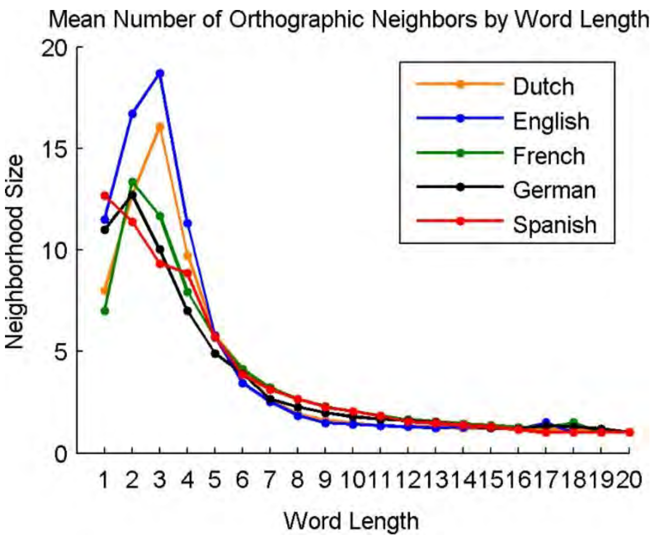


Figure 2: Distribution of mean neighbourhood densities (sizes) across word lengths in five languages (Marian et al. 2012)

Different types of neighbours are another prominent feature of orthographic neighbourhoods. These include substitution neighbours such as *heat* and *feat*, addition neighbours such as *heat* and *cheat*, deletion neighbours such as *heat* and *hat*, and transposition neighbours such as *cheat* and *teach.* The distribution of these neighbour types appears to differ cross-linguistically, which again provides evidence for the language-specific nature of neighbourhood effects. For example, in Marian *et al.*'s (2012) study, they found that English neighbourhoods were made up of a large number of substitution neighbours, whereas French neighbours were mostly addition and deletion neighbours. Figure 3 illustrates this cross-linguistic distribution of neighbour types.

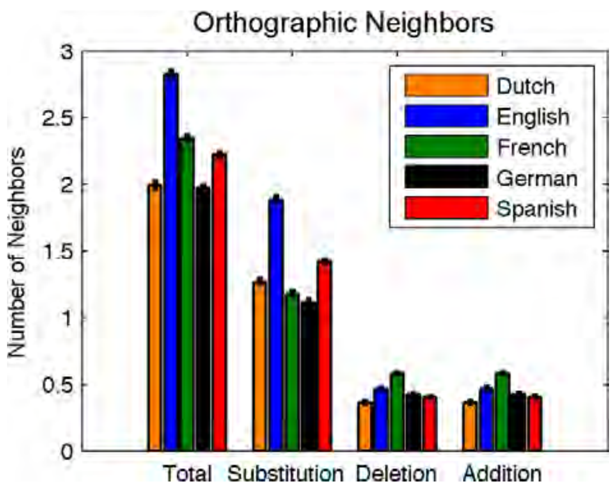


Figure 3: Distribution of types of orthographic neighbours across five languages (Marian et al. 2012)

The above discussion will inform the computational analysis of orthographic neighbours in isiXhosa in order to investigate the linguistic properties of these neighbours.

### 2.11 Models of orthographic processing

Various psycholinguistic models have been put forward in an attempt to explain orthographic neighbourhood effects. These models postulate different systems of organization in the mind for orthographic knowledge. In this way each have varying degrees of explanatory power within the discourse of neighbourhood effects. The following section presents a review of three types of models: search processing models, parallel processing models, and connectionist models.

#### 2.11.1 Search processing models

Search processing models posit that when processing a word, the visual input is checked against a set of possible other words in the lexicon, and this is done in a serial manner (Sears, Hino & Lupker, 1999). Further, words are organized by frequency in the lexicon, such that higher frequency words are checked first (Cortese & Balota, 2012). In a task such as the lexical decision task, where a participant is asked whether a string of letters constitutes a real word or not, this model postulates that when a participant is presented with a pseudoword such as *flirp*, they must search through their lexicon and compare the word against other known lexical items (Coltheart, 2006). Since *flirp* is a pseudoword, the participant will not be able to match it to a real word in their lexicon, and as such they will respond 'no'. Similarly when presented with a real word, the participant will search through their mental lexicon until locating the word and respond 'yes'. Thus search models traditionally emphasize a lexical processing route rather than a sublexical or phonological processing route. However, some models, such as the Dual-route cascaded model (DRC) (see Section 2.5.3) have adopted a search-like structure at the sublexical level. That is, they explain sub-lexical processing as a serial process whereby letters are read sequentially (Kelly,2008).

Search models have been applied to neighbourhood effects, with researchers concluding that the presence of orthographic neighbours in the lexicon creates a larger set of possible candidates to search through which results in longer latencies for lexical access (Andrews, 1992). Further, when a target word has higher frequency neighbours in its neighbourhood, these neighbours are more likely to compete for lexical access with the target word resulting in inhibitory effects (Andrews, 1992). Van Den Boer, De Jong and Haentjens-van Meeteren (2012) found that serial models can be extended to explain word length effects in addition to inhibitory neighbourhood effects. Although word length effects were thought to only interact at the sublexical level of processing, Van Den Boer, De Jong and Haentjens-van Meeteren (2012) argued that the presence of word length effects in a lexical decision task provides evidence for an interaction of word length at the lexical level of processing as well.

### 2.11.2 Parallel processing models

Contrastingly to search models, parallel models of orthographic processing posit that linguistic information is organized in a parallel fashion such that lexical access is achieved through the simultaneous, parallel activation of relevant word information until a threshold is reached (Morton, 1969; Sears, Hino & Lupker, 1999; Lim, 2016). For example, Morton's (1969) Logogen model assumes that each word has a logogen in the mind's lexicon which contains visual, sound, and semantic information about the word. Figure 4 from Warren (2012) illustrates the logogen model with a logogen represented as a 'container' in the lexicon. Input information is collected by the reader which activate a word's logogen until a threshold is reached and an output is produced. Importantly, different words will have different thresholds, and these thresholds are largely determined by frequency such that high frequency words have a lower threshold and as such are recognized more quickly (Cortese & Balota, 2012).

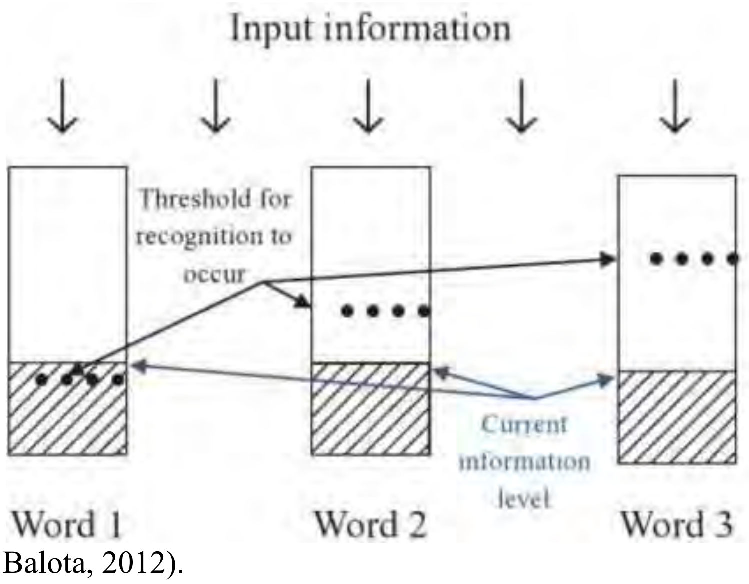


Figure 4: Morton's (1969) Logogen Model, figure by Warren (2012)

In Sears, Hino and Lupker's (1999) computational analysis of Plaut *et al.*'s (1996) and Seidenburg and McClelland's (1989) parallel processing models, they found that the models battled to predict the inhibitory neighbourhood density and neighbourhood frequency effects that Search models explain. Instead, they found that the model could successfully predict faciliatory neighbourhood effects. They explain these findings as higher frequency neighbours providing strengthening of activation for low frequency target words. That is low frequency target words benefit from higher frequency neighbours with faster recognition/ response times.

### 2.11.3 Connectionist models

Connectionist models also sometimes referred to as activation-based models, explain orthographic processing as the interaction between bottom-up sublexical information and top-down lexical information. Importantly – unlike parallel and search models – the two levels feed into one another, such that lexical activation "send[s] excitatory feedback down to their sublexical units" (Sears, Hino, & Lupker, 1999: 221) and vice versa until a threshold is reached and lexical access occurs.

Connectionist models often contain elements from both serial and parallel models. For example, McClelland and Rumelhart's (1981) Interactive Activation (IA) model was initially proposed as a parallel processing model. The original developers posit that the IA model "is spatially parallel (i.e., capable of processing several letters of a word at one time) and involves processes that operate simultaneously at several different levels" (McClelland & Rumelhart, 1981: 377). However, there is a tendency in the literature to label the IA model as a connectionist model (Norris, 2013). This is likely because its structure is reminiscent of the characteristic "neural-network" (Norris, 2013: 518) structure of connectionist models. This structure is illustrated in Figure 5, which shows a conceptual version of the IA model by McClelland and Rumelhart (1981).

Figure 5 illustrates that when a reader is presented with a word on the page both top-down higher level input (such as contextual cues, syntactic structure, and word knowledge), and bottom-up visual input (letters and letter features) interact simultaneously (McClelland & Rumelhart, 1981). Excitatory connections are represented with an arrow, and these increase the activation unit of a particular linguistic unit. Inhibitory connections are represented with a circular end, and these will decrease the activation level of a linguistic unit. These connections are both inter and intralevel, with words activating letters and vice versa, as well as words activating other words (McClelland & Rumelhart, 1981).

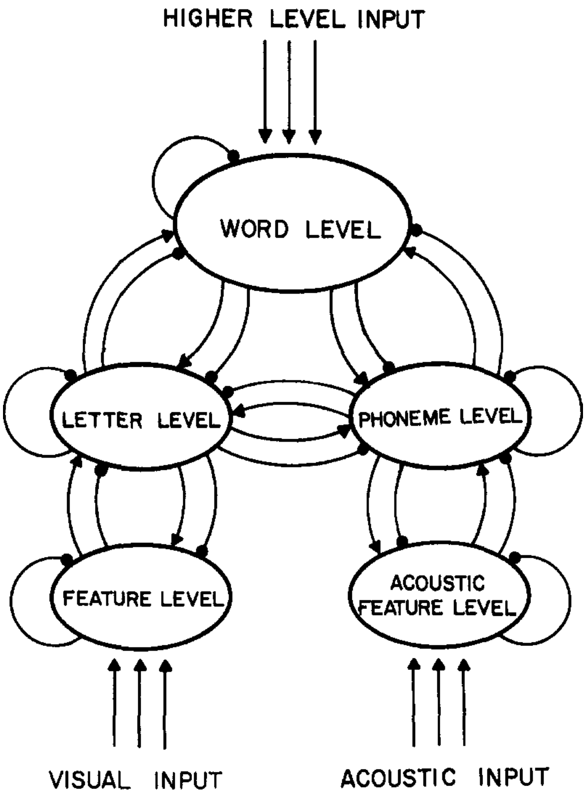


Figure 5: Interactive Activation model by McClelland and Rumelhart (1981: 378)

Connectionist models are unique in that they can accommodate both inhibitory and faciliatory neighbourhood effects (McClelland & Rumelhart, 1981; Grainger *et al.* 1992; Sears, Hino and Lupker, 1995; Grainger & Jacobs, 1996; Sears, Lupker & Hino, 1999). Studies that report faciliatory neighbourhood density effects explain this outcome as a result of the larger number of words available at the lexical level which then provide reciprocal activation of sublexical units (Sears, Hino & Lupker, 1995; Sears, Lupker & Hino, 1999). This surplus of activation at the lexical level, and its subsequent interaction at the sublexical level results in the threshold being reached faster, which means shorter response time latencies.

Further, studies that report inhibitory neighbourhood effects – in particular inhibitory neighbourhood frequency effects – explain this outcome as an "intralevel inhibition between the lexical units of the model [which] delay the activation of a word with higher frequency neighbours" (Sears, Hino & Lupker, 1999: 222). In other words, as a target word is activated, its higher frequency neighbours are activated simultaneously. These neighbour activations will then need to be inhibited before lexical access can occur which results in longer response time latencies (De Moor & Brysbaert, 2000).

These models have predominantly been proposed for word recognition; however models of spelling are exceptionally similar in their framework. For example, Rapp, Epstein and Tainturier (2002) proposed an expansion of the dual route processing model of spelling to a connectionist model which considers spelling as the integration of sub-lexical and lexical processes in spelling. Folk, Rapp and Goldrick (2002) use this model in their investigation of the influence of orthographic and phonological neighbours for spelling. Their rendition of the model is illustrated in Figure 6, beginning with an auditory input, in this case the word “leaf”, the word is broken down into individual phonemes which can then take two processing routes. Either the phonemes are used to identify a phonological lexeme and pass through the semantic level before being converted to an orthographic lexeme, or the individual phonemes are converted directly to their orthographic counterparts which then feedback into possible options for orthographic lexemes. The final two levels at the bottom of the diagram are especially reminiscent of the Interactive Activation model in Figure 5, with feedback from the word (orthographic lexeme) level and the grapheme level cycling through a reiterative process until an output is selected for spelling (Folk, Rapp & Goldrick, 2002).

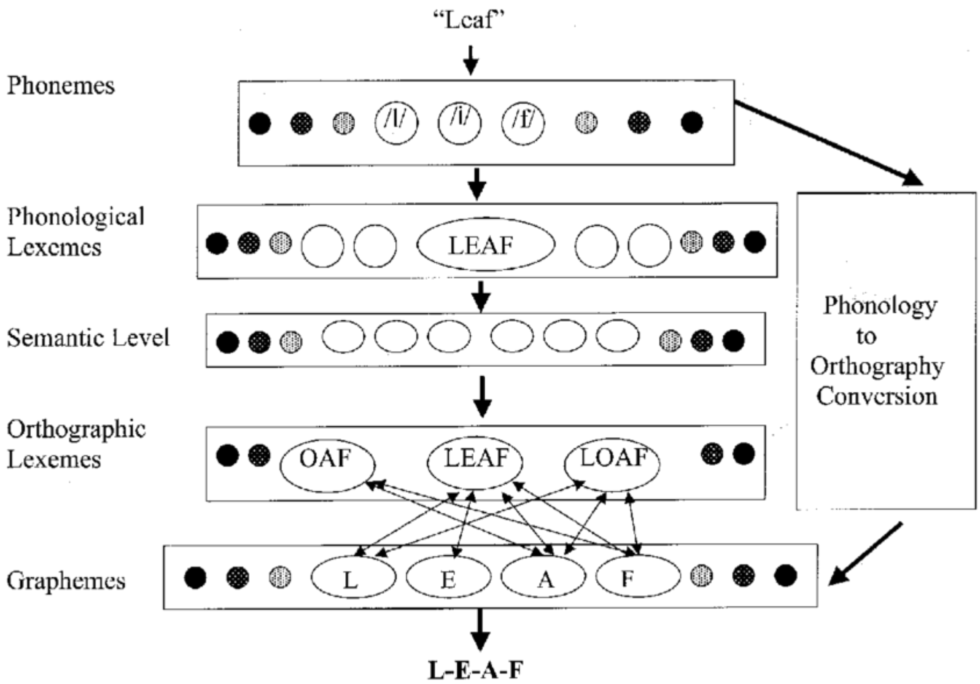


Figure 6: Folk, Rapp & Goldrick's (2002) connectionist model of spelling

Folk, Rapp and Goldrick's (2002) suggest that this model can account for the influence of orthographic, phonological, and orthographic neighbour influences on spelling. They further suggest that the interaction of sublexical with lexical information can strengthen identification of the target word and help to mitigate the effect of neighbours which are competing for access (Folk, Rapp & Goldrick, 2002). Contrastingly, Roux and Bonin (2009) use a connectionist framework to explain their finding of a faciliatory neighbourhood density effect for spelling. Much like for word reading, the connectionist model can explain facilitation from dense neighbourhoods in spelling as the strengthening of interactions between the lexical and sublexical levels, since a larger set of lexical items will create a larger overall reciprocal activation of sublexical units than if a word has less neighbours (Roux & Bonin, 2009).

Owing to the large degree of contention in the literature regarding neighbourhood effects, coupled with the fact that research on these effects in isiXhosa is currently non-existent, the current study predicts that connectionist models of orthographic processing may be best suited to explaining potential neighbourhood effects as these models are capable of predicting both faciliatory and inhibitory neighbourhood effects.

**2.12 Summary**

Chapter 2 has provided an in-depth discussion on the various key components which make up this thesis. In doing so it has also provided an extensive review of relevant literature on each component.

As this research focuses on orthographic neighbours, the chapter first developed a broad discussion on orthography and literacy. It pointed out the intrinsic relationship between orthographic structures such as orthographic depth and conjunctivism, and literacy skills. It further demonstrated the interaction of different linguistic domains such as orthography, phonology, and morphology and how these interactions in turn affect literacy. This discussion is pertinent in illustrating that although the focus of this thesis is on an orthographic phenomenon, other linguistic domains cannot be ignored.

An overview of the structure of isiXhosa was provided in order to equip the reader with the necessary background to later understand how orthographic neighbours may be realised in this language. Linguistic features such as the language's large number of complex graphemes, high degree of orthographic transparency, its conjunctive orthography, and agglutinative morphology were described. The influence of these linguistic features on literacy skills was also hinted at as it is important to first establish the known effects of the language's structure on literacy, before investigating the currently unknown effects of orthographic neighbours. In summary, the transparent nature of isiXhosa's orthography should aid in early acquisition of spelling and reading (Seymour *et al.* 2003; Aro, 2004; Viise, Richards & Pandis, 2011). However the large number of complex graphemes have been shown to negatively impact both reading and spelling performance (Daries & Probert, 2020). Further isiXhosa's agglutinative morphology compounded by its conjunctive orthography results in long, morphologically complex words which are challenging for the novice reader and writer to navigate. It is suggested later in this same chapter that the transparent orthography may result in a substantial overlap of phonological neighbours with orthographic neighbours. Further, the agglutinative morphology is likely to result in a large number of words which share morphemes as well as orthographic units.

Since this thesis is largely interested in the interaction of neighbourhood effects with reading and spelling, the chapter also describes these literacy skills in detail. Word reading is described as a proxy for fluent reading and as such is a significant predictor of comprehension. Similarly, spelling is a key secretarial or mechanical writing skill which is a key predictor of writing composition. These skills are often seen as two sides of the same coin, as they are informed by many of the same underlying linguistic factors, including: word frequency, word regularity, word length, and orthographic neighbours. Both word reading and spelling can be framed within dual-route processing models and a broad overview of these models was provided in order to better understand how reading and spelling work in the brain.

Current literature on word reading in isiXhosa suggests that readers largely make use of sub-lexical processing routes and rely on phonological processing skills when reading. Research has focused on the influence of isiXhosa's orthography on word reading, specifically with regards to its transparent and conjunctive nature. However as of yet, no research has been conducted on the effects of orthographic neighbours for reading in isiXhosa. Similarly, in the case of spelling in isiXhosa, there is very little research on this skill in general for isiXhosa, and no research on neighbourhood effects. This provides a primary motivation for the current study.

Once these key components were unpacked, the chapter could introduce a discussion on the focus of this thesis, which is orthographic neighbours and neighbourhood effects. The main metrics that will be used in this study were introduced: OLD20 for neighbourhood density, and OLDF for neighbourhood frequency. The various contentions in the literature on neighbourhood effects were also pointed out. Mainly, there are often contradicting results found on neighbourhood effects, but these contradictions are owed to methodological issues and the language-specific nature of neighbourhood effects. Some tentative trends in the literature for word reading are faciliatory neighbourhood density effects in English, Dutch, French, and Spanish. But inhibitory density effects in agglutinative languages such as Turkish and Malay. Mostly inhibitory neighbourhood frequency effects are found across languages, however there are exceptions across different experimental conditions. The literature on neighbourhood effects in spelling is less conclusive, however similar findings to reading have been reported.

Owing to the language-specific nature of orthographic neighbourhood effects, the chapter also discussed the linguistic properties of orthographic neighbours cross-linguistically. The interaction of phonology, morphology, and word factors (word frequency and word length) with orthographic neighbours was explored across languages. Finally the chapter concluded with a discussion of three types of psycholinguistic models of orthographic processing which inform this study namely, search models, parallel models, and connectionist models.

Chapter 3 will outline the methodology of the thesis, followed by the results and discussion in Chapters 4 and 5.

# CHAPTER 3: METHODOLOGY

## 3.1 Introduction

The overarching methodology for this study was quantitative. This study consisted of two data analysis components, each drawing on different methodologies. The first component addresses one of the primary aims of the study which is to provide a linguistic analysis of orthographic neighbours in isiXhosa. To achieve this the study used computational linguistic tools in Python and MS Excel. This analysis is conducted in Chapter 4 and largely informs the second component of this thesis. The second component aims to address the effects of orthographic neighbours on reading and spelling in isiXhosa.To achieve this, the study used a cross-sectional correlational design to examine the role of orthographic neighbourhood effects (neighbourhood density and neighbourhood frequency) in three linguistic literacy measures: lexical decision, word reading and spelling. This analysis is presented in Chapter 5. These aims were guided by the study's research questions which were initially presented in Chapter 1. These are presented here again for ease of reading. The specific alternative hypotheses for each question are also provided here. These are informed by the literature presented in Chapter 2.

## 3.2 Research questions and Hypotheses

This study aimed to answer the following research questions. The alternative hypotheses for each question are included. The null hypotheses H(0) are that no orthographic neighbourhood effects will be observed.

**Research Question 1:** What are the linguistic properties of orthographic neighbours in isiXhosa?

**Hypothesis H(1):** Orthographic neighbours in isiXhosa will be characterized by a high degree of overlap between semantic and orthographic similarity, as well as between phonological and orthographic similarity. Since isiXhosa words do not follow an onset-rime pattern, rime neighbours will not be salient in isiXhosa, however syllable neighbours - words that differ by one or more syllables - may be present, owing to the highly syllabic and transparent nature of isiXhosa.

**Research Question 2a:** What role do orthographic neighbourhood effects play in word reading in isiXhosa grade three learners?

**Research Question 2b:** What role do orthographic neighbourhood effects play in lexical decision response time in isiXhosa grade three learners?
**Hypothesis H(2):** Orthographic neighbourhood effects in word reading (lexical decision and word naming) will be similar to those reported for languages other than English. That is, orthographic neighbourhood density will have a faciliatory effect in word reading, and orthographic neighbourhood frequency will have an inhibitory effect.

**Research Question 3:** What role do orthographic neighbourhood effects play in spelling in isiXhosa grade three learners?
**Hypothesis H(3):** Orthographic neighbourhood effects for spelling will be similar to those of word reading with inhibitory neighbourhood density effects and inhibitory neighbourhood frequency effects.

**Research Question 4:** Which models of orthographic processing best capture the patterns of orthographic neighbourhood effects in isiXhosa?
**Hypothesis H(4):** Connectionist models of orthographic processing will best explain the results of the study, as these models can account for both faciliatory and inhibitory neighbourhood effects as hypothesized above.

### 3.3 Developing a neighbourhood database

In order to test the aforementioned hypotheses, it was necessary to first develop a database of orthographic neighbours in isiXhosa. This database needed to serve a dual purpose, first it needed to serve as linguistic data for multiple linguistic analyses to be performed, and second, it needed to be a source for task items which could be used to conduct literacy assessments. Therefore it had to have the following criteria: first, it had to include a list of appropriate words and pseudowords to use as task items in the literacy assessments, to be called the 'target words'. Second, it had to include information about each target word including word length, in letters and syllables, and word frequency, to be used as control variables in the study. Third, it had to include a list of the closest 20 orthographic neighbours to those target words. And lastly, it needed to have information about the neighbourhood of each target word, that is, its neighbourhood density and neighbourhood frequency.

The database was developed from an existing isiXhosa corpus by Rees and Randera (2017).

The corpus consisted of over 100 000 isiXhosa tokens from multiple foundation phase reading sources including, African Story Book, Nal'ibali, DBE readers, DoE readers, Bible stories and Story Weaver. These sources are aimed at children who are in the learning to read phase and as such the resulting corpus is well suited for the present study. From this corpus, Rees and Randera (2017) generated a list of 27 323 unique isiXhosa words. To create a database that was manageable to work with for the purposes of this study, 30 words were chosen from this list of words. These words would form the real word task items used in the literacy assessments and are called the target words in the database. The pseudoword task items and their neighbourhoods are explained in Section 3.3.3.

### 3.3.1 Selecting the target words

In order to narrow down the scope of words to choose the target words from, specific selection criteria were adhered to. First, word frequency was controlled for, to achieve this; the top 300 most frequent words in the corpus were selected. Word frequency has been shown to have a significant effect on reading performance and as such is a necessary variable to control for (Andrews, 1989; Grainger, 1990). The most frequent word in the corpora, ukuba, was not selected as it has a significantly high frequency of 1314. Owing to its high frequency it is likely that the word frequency effect would override any orthographic neighbourhood effect that might be observed.

Secondly, the list was checked for irregular and irrelevant words such as character names e.g. *umax, usara* and English words, as well as words that did not fit the standardized isiXhosa orthography, for example words missing the initial or final vowel and words which were bound morphemes e.g. prefixes such as u-.

Third, the target words had to be matched in syllable length. The pilot study included only trisyllabic words. However, this was later revised to include four syllable words as well (Section 3.8). Although research on orthographic neighbourhood effects in English has largely looked at monosyllabic words, this would not be plausible in isiXhosa since monosyllabic words are rare in the language. Further, the majority of words in the corpus were three syllables or more, thus only three and four syllable words were selected as target words. A post hoc decision was made to also include word length as a measure of letters. This was done for multiple reasons. Firstly, syllable length in isiXhosa can range dramatically owing to the language's complex consonant clusters. For example, a syllable can consist of one letter e.g. {u} in u.mngxu.ma, however it can also consist of five letters such as {mngxu} in u.mngxu.ma. Therefore the number of letters in a word rather than syllables, would be a more accurate measurement of word length. The use of graphemes to measure word length was also considered, however a similar issue to syllables was encountered, as grapheme length can differ dramatically in isiXhosa as well. Further rationale for using letters as opposed to graphemes or syllables was that the unit of measurement for neighbourhood density (OLD20) considers word differences in terms of letters. That is, Levenshtein distance measures the difference between words in letters. Thus, for the sake of consistency across variables in the study, the use of letters as a measure of word length is a more valid option.

Another condition that had to be met was ensuring that the target words were not themselves close orthographic neighbours of each other. Therefore, if *ukuze* was selected as a target word then *ukuya* could not be selected. This was to avoid priming effects in the literacy assessments. Words with a Levenshtein distance of 4 or more were considered distant enough neighbours to warrant selection. A final condition for selection was ensuring a range of orthographic neighbourhood density and orthographic neighbourhood frequency across the target words. This required computations to identify the orthographic neighbours of the target words which existed in the Rees and Randera (2017) corpus. These computations are detailed in the following section.

### 3.3.2 Calculating the neighbourhood metrics

To calculate the neighbourhood density and neighbourhood frequency of the target words, the VBA module developer in Excel was used to code for the Levenshtein distance (LD) function[3]. From this, the selected target words could be compared to each item in the Rees and Randera (2017) corpus using the LD function. The lowest 20 LD values were averaged to calculate the orthographic neighbourhood density (OLD20) for the task item. Further, the corresponding word frequencies of those 20 closest neighbours were also averaged to calculate orthographic neighbourhood frequency (OLDF). Table 6 shows an example of the orthographic neighbourhoods of three isiXhosa words generated from the corpus.

3: The code for Levenshtein distance was sourced from an open-source statistics forum Stack Overflow. Available at: https://stackoverflow.com/questions/4243036/levenshtein-distance-in-vba/4243652#4243652

Table 6: Orthographic neighbourhoods of *ingonyama, ezantsi* and *umngxuma*

| Targetword | Word frequency | Word length (letters) | Word length (syllables) | OLD20 | OLDF | Identity of closest 20 neighbours |
|---|---|---|---|---|---|---|
| ingonyama | 83 | 9 | 4 | 1.75 | 4.4 | [ungonyama; ngonyama; iingonyama; yingonyama; ingonyana; inkonyana; ngonyaka; kwingonyama; kungonyama; lengonyama; ngenyama; ngonyana; wengonyama; yengonyama; eengonyama; iingonyana; kangonyama; nengonyama; sengonyama; zengonyama] |
| ezantsi | 65 | 7 | 3 | 2.4 | 22.8 | [emzantsi; mzantsi; phantsi; ngezantsi; emazantsi; nantsi; esezantsi; ephantsi; umzantsi; asezantsi; izandi; kanti; nantso; ezintle; zathi; wasezantsi; uzandi; ezintsha; aphantsi; ekati] |
| umngxuma | 5 | 8 | 3 | 3,05 | 46,35 | [mngxuma; imingxuma; mingxuma; umnxeba; umgama; umnyama; umgqumo; wangxama; bangxama; inomngxuma; nemingxuma; ugquma; umgquba; umntwama; ungcuka; umama; umntu; amagama; magama; umfama] |

For each target word the word frequency, word length (in letters and syllables), orthographic neighbourhood density, and neighbourhood frequency are provided, as well as the identity of the 20 closest neighbours to the target word. In Table 6, the three target words demonstrate a range of neighbourhood densities and neighbourhood frequencies. First, *ingonyama* has a dense orthographic neighbourhood with OLD20= 1.75, it also has a low orthographic neighbourhood frequency with OLDF= 4.4. *Ezantsi* also has a relatively dense orthographic neighbourhood with OLD20= 2.4 and a medium orthographic neighbourhood frequency with OLDF= 22.8. In comparison *umngxuma* has a sparser orthographic neighbourhood with a higher OLD20 value of 3.05. The neighbourhood frequency of *umngxuma* is the highest of the three with OLDF= 46.35.

The full database of orthographic neighbourhoods for the realword task stimuli can be found in Appendix 2. This consists of 30 target words with a total of 600 neighbours (20 neighbours per target word). In addition to its use in the quantitative analysis of this study, the database is also used in a computational analysis in Chapter 4 in order to determine the morphological characteristics of these orthographic neighbours.

### 3.3.3 The Pseudoword neighbourhood database

Pseudowords were created to be used in the literacy assessments in order to minimize the influence of prior semantic word knowledge on the results. Additionally, in the case of the lexical decision task, pseudowords are necessary for the participant to choose whether a word is real or not. The pseudowords were made up 'nonsense' words that fit the orthographic and phonological constraints of isiXhosa. The orthographic neighbourhood for these pseudowords were calculated in much the same way as for the real isiXhosa words. The Levenshtein distance was calculated from each real word in the corpus to the pseudoword, thereafter the words with the smallest 20 LD values were considered as the pseudoword's neighbourhood. Orthographic neighbourhood density was calculated by averaging the smallest 20 LD values to get OLD20. Orthographic neighbourhood frequency was calculated by averaging the word frequencies of the 20 closest real word neighbours to get OLDF. Thus each pseudoword used in the study has a corresponding orthographic neighbourhood, made up of real isiXhosa words taken from the corpus. Table 7 shows the orthographic neighbourhood of three pseudowords used in the study; *tarhoze, upoya,* and *ucukela*. The full database of orthographic neighbourhoods for the pseudoword stimuli can be found in Appendix 3.

Table 7: Orthographic neighbourhoods of three pseudowords; *tarhoze, upoya* and *ucukela*

| **Target pseudoword** | **Word length (letters)** | **Word length (syllables)** | **OLD20** | **OLDF** | **Identity of closest 20 real-word neighbours** |
|---|---|---|---|---|---|
| tarhoze | 7 | 3 | 3.7 | 115.9 | [torho; asoze; achobe; amhoye; aphole; warhona; wakhe; yakhe; apho; wakho; waze; yakho; zakhe; lakho; bakhe; lakhe; sakhe; aze;yaze; zakho] |
| upoya | 5 | 3 | 1,9 | 20,95 | [umoya; uboya; ukuya; uya; unowa; ujoja; moya; ubona; upapa; usiya; utota; oya; ulona; ubuya; umota; boya; uhola; ukoma; uphola; ujiya] |
| ucukela | 7 | 4 | 2.1 | 6 | [uculela; usukela; ukuwela; ukufela; kusukela; ucula; kubukela;ubukeka; eculela; ukusela; bukela; esukela; ubuyela; ukucela; ukuvela;usukele; ukucula; ubudala; fakela; ukubeka] |

## 3.4 Participants

To investigate the effect of orthographic neighbours on reading and spelling, participant data needed to be collected. Originally, 190 grade three children participated in this study, however after exclusions this was reduced to 97 (see Section 3.8 for exclusion procedures).

Of the 97 participants, 44 were female and 46 were male with three missing gender values. The sample was drawn from five primary schools in KwaNobuhle township bordering the town of Kariega (Uitenhage) in the Eastern Cape of South Africa. All five schools were Quintile 3 schools, meaning that they are no-fee schools and rely on government funding. The schools also have a feeding scheme which provides children with a meal at school. The schools were part of the Legacy Literacy programme, a literacy intervention project run by Volkswagen and the Rhodes University Centre for Social Development, with the aim of improving home language literacy in the foundation phase. The Legacy Literacy programme conducted their year three, round one base line assessment at the time of this study's main data collection in February 2022. This meant that additional literacy assessment data was available for these participants and could be included in the descriptive analysis of the sample. These assessments included two subtasks of the Early Grade Reading Assessments (EGRA) namely, letter-sound knowledge and oral reading fluency. This data is used in the present study to provide additional contextual information regarding the participants' general literacy proficiency.

All learners who participated in the study were home language speakers of isiXhosa and were in the beginning of their grade three year at the time of the study. The schools' language of teaching and learning from grades one to three was isiXhosa. The primary motivation for choosing to study learners in their grade three year was that these learners are still learning in their mothertongue whereas once in grade 4 they start reading and learning in English. Further, by studying the effects of orthographic neighbours in learners who are still in the learning to read phase, there is potential for remedial recommendations based on the findings of the study. That is, by establishing how this linguistic phenomenon interacts with reading and spelling in learners who are still learning to read and spell, there is the opportunity to then provide relevant and reading-level-appropriate recommendations for pedagogical intervention.

**3.5 Ethics**

This study received ethical clearance through Rhodes University in conjunction with the Volkswagen Legacy Literacy programme. The ethics code was 2020-1195-3307 and the ethics certificate can be found in Appendix 1. The tasks administered in this study were first approved by the head researcher of the programme as an amendment to the list of Early

Grade Reading Assessment (EGRA) tasks that were already being administered to track the efficacy of the literacy intervention. In this process, informed consent forms were obtained from the parents/guardians of the learners. In addition, permission was obtained from the principals and teachers at the schools involved. Verbal assent was obtained from each participant before administering the task. All participants were made aware of the process for each task and were given the opportunity to withdraw from the study at any time. The guardian informed consent form, the letter of approval from the Department of Basic Education, and a sample of the participant verbal assent form are included in Appendix 1 along with the ethics certificate.

## 3.6 Literacy Measures

This Chapter has already examined some of the key measures of interest to this study pertaining to the word or item level information in Section 3.3: Developing a neighbourhood database; namely, orthographic neighbourhood density, orthographic neighbourhood frequency, word length, and word frequency. In addition to these item level measures, the study was interested in three literacy measures: lexical decision response time, word reading accuracy, and spelling accuracy. It also conducted a brief secondary analysis of two EGRA subtasks; letter-sound knowledge, and oral reading fluency. These measures are discussed below.

### 3.6.1 EGRA subtasks: letter-sound knowledge and oral reading fluency

The data for the two EGRA subtasks were collected as part of the year three, round one baseline assessment for the Volkswagen Legacy Literacy programme at the KwaNobuhle schools. This collection took place at the same time as the data collection for the lexical decision, word reading, and spelling tasks in February 2022. A secondary analysis of this data was included in the present study so as to provide a basis from which to draw conclusions about the overall reading ability of the sample.

These specific subtasks were chosen for the following reasons: letter-sound knowledge performance is indicative of the participants' proficiency in sound to symbol relations. It also provides an indication of the participants' grasp of the alphabetic principle. Further, it is a crucial underlying skill for both word reading and spelling (Caravolas, Hulme & Snowling, 2001; Schaefer & Kotzé, 2019; Spaull, Pretorius & Mohohlwane, 2020). Secondly, the results of the oral reading fluency task will provide a basis for the average text reading fluency of the sample, which literature has shown is closely linked to reading words in isolation (Verhoeven, 2000; Eason *et al.* 2013). Further, oral reading fluency is also generally used as a measure of learners' reading ability (Spaull, Pretorius & Mohohlwane, 2020).

Letter-sound knowledge was assessed by presenting learners with two grids of letters. One grid contained simple letters such as {s, c, u, o} and the other grid contained more complex letters including {nd, lw, sh, ntsh}. The learners were asked to say the sound of the letters aloud and they were given 60 seconds for each grid of letters. An average letters-correct-per-minute score was calculated for each learner by subtracting the number of errors from the total number of letters sounded out in a minute for each grid of letters and then averaging these two scores.

Oral reading fluency was assessed by presenting learners with a passage of text titled *"Kutheni Imvubu zingenazo inwele" (*How hippo lost his fur). The passage consisted of 132 orthographic words. The learners were asked to read the text aloud and the task was timed for 60 seconds. A words-correct-per-minute score was calculated for each learner by subtracting the number of errors made from the total number of words read in a minute.

### 3.6.2 Lexical decision response time

The first dependent variable of interest to this study in the investigation of orthographic neighbourhood effects, is lexical decision response time. This variable was measured using a lexical decision task, which is the most commonly used task when investigating orthographic neighbourhood effects (Grainger, 1990; Sears, Hino & Lupker, 1995; Andrews, 1997). The task is ultimately a measure of lexical access or word recognition, which has been shown to interact significantly with neighbourhood effects (Andrews, 1997).

#### *3.6.2.1. Lexical decision task design and administration*

The lexical decision task was designed for this study using Psychopy builder (Pierce *et al.* 2019), an open-source experimental design software. It was run online using Pavlovia.org and administered on touchscreen tablets by research assistants who were mothertongue isiXhosa speakers. The basic premise of a lexical decision task is to present a participant with a string of characters on a screen, the participant must then decide whether the string is a real isiXhosa word or if it is a pseudoword and press the relevant button. Psychopy then captures the response time in seconds for each word from when the word is shown on the screen to when the relevant button is pressed. A total of 20 words were shown on the screen for each participant session, of which ten were real isiXhosa words and ten were pseudowords.

The full list of words and pseudowords used in the lexical decision task can be found in Appendices 2A and 3A respectively. A summary of these words' linguistic features is presented in Table 8. This includes the mean word length, word frequency, orthographic neighbourhood density, and neighbourhood frequency. These variables are factored by word frequency, such that low frequency words are those with a frequency of 10 or less, and high frequency words are those with a frequency of 40 or more. Further, the mean values are factored by number of syllables into two categories: 3 and 4 syllable words. Note that although there were no 4-syllable long pseudowords in this task, this is remedied by using word length measured in letters in the statistical data analysis. Lastly, Table 8 presents the data in two groups, real words and pseudowords. Note that the word frequency for pseudowords was coded as zero (since pseudowords cannot have a frequency score as they do not exist in the language), as such pseudowords are only factored by word length.

Table 8: Mean word length, word frequency and orthographic neighbourhood properties for the task items used in the Lexical Decision task

| | Low frequency words (F < 10) | | High frequency words (F > 40) | |
|---|---|---|---|---|
| Target word characteristic | 3 syllables | 4 syllables | 3 syllables | 4 syllables |
| | | **Real words** | | |
| word length (letters) | 6.33 | 9.00 | 6.67 | 8.50 |
| word frequency | 4.00 | 7.00 | 314 | 94.5 |
| OLD20 | 2.03 | 3.67 | 2.13 | 2.52 |
| OLDF | 16.1 | 16.4 | 42.0 | 8.78 |
| | | **Pseudowords** | | |
| word length (letters) | 7.10 | NA | - | - |
| OLD20 | 2.80 | NA | - | - |
| OLDF | 33.1 | NA | - | - |

Note: OLD20= orthographic neighbourhood density, OLDF= orthographic neighbourhood frequency

In the task's administration, the words were presented in a random order. The participant was first given four trial words to practice pressing the buttons on the screen of the tablet. These trial words were also used by the research assistant to demonstrate how the task worked to ensure the participant understood what was required of them. A reliability test was run post-hoc after the main data collection which showed that the lexical decision task was strongly reliable with a Cronbach's Alpha score of 0.95 for the 20 task items.

### 3.6.3 Word reading accuracy

Another dependent variable of interest to this study was word reading accuracy. Although a lexical decision task shares some components with a word reading task, in that it measures a learner's ability to first read a word and then make a decision, a word reading task would provide a more accessible measuring instrument to be used by teachers and other literacy professionals to track learner performance, and - potentially- the effects of neighbourhood variables in the case of this study. Owing to the potential pedagogical implications of this study, the author acknowledges that a lexical decision task alone, although very telling for linguistic theory, is impractical for everyday classroom assessment. As such, the untimed word reading task is included for exploratory purposes.

#### *3.6.3.1 Word reading task design and administration*

Word reading accuracy was measured using an untimed isiXhosa word reading task. Ten real isiXhosa words and ten pseudowords were presented to the participants on individual printed flashcards in a randomized order. A full list of the real and pseudoword stimuli for the word reading task can be found in Appendices 2B and 3B respectively. A summary of these words' features is presented in Table 9. The research assistant held up the flashcards facing the learner who then read the word aloud. Data capture was done using Tangerine[4]. An accuracy score was recorded for each word per participant, with incorrectly read words coded as 0 and correct words coded as 1.

Table 9 presents the mean values for word length in letters, word frequency, OLD20 and OLDF for those target words used in the word reading task. These are factored by low and high frequency words, and 3 and 4 syllable words. The frequency categories were determined in the same way as for the lexical decision task. Further, the data is presented in two groups, real words and pseudowords. Note that pseudowords have a frequency of zero and as such are only presented as low frequency words.

4: Tangerine is an open-source data collection software available at: https://www.tangerinecentral.org/

Table 9: Mean word length, word frequency and orthographic neighbourhood properties for the target words used in the word reading task

| | Low frequency words (F < 10) | | High frequency words (F > 40) | |
|---|---|---|---|---|
| target word characteristic | 3 syllables | 4 syllables | 3 syllables | 4 syllables |
| | | **Real words** | | |
| word length (letters) | 6.00 | 8.50 | 7.00 | 9.00 |
| word frequency | 5.00 | 5.00 | 43.0 | 56.7 |
| OLD20 | 1.88 | 3.05 | 2.25 | 2.65 |
| OLDF | 14.5 | 14.2 | 13.8 | 7.52 |
| | | **Pseudowords** | | |
| word length (letters) | 6.38 | 8.00 | - | - |
| OLD20 | 2.74 | 2.92 | - | - |
| OLDF | 37.6 | 6.72 | - | - |

Note: OLD20= orthographic neighbourhood density, OLDF= orthographic neighbourhood frequency

It is necessary to disclose at this point that one of the real word task items used in the word reading task was the name of a person, *uKoketso.* This was unfortunately only noticed after the data collection had been conducted. The data for this word was not excluded however because it was presented in the task without the capital {k} as *ukoketso*, and therefore it could possibly pass as a pseudoword. The problem with this, however, is that the frequency of the word is unknown, as participants may have been exposed to the word before, whereas a true pseudoword should have a null frequency. A reliability test was run post-hoc after the main data collection which showed that the word reading task was strongly reliable with a Cronbach's Alpha score of 0.97 for the 20 task items. The statistic remained the same when *ukoketso* was dropped from the test which indicates this item's scores were still reliable.

### 3.6.4 Spelling accuracy

The final dependent variable of interest to this study was spelling accuracy. By investigating the neighbourhood effects on spelling, it offers insight into how these effects may interact with both decoding skills such as word reading and encoding skills such as spelling.

#### *3.6.4.1 Spelling task design and administration*

Spelling accuracy was measured using a standard isiXhosa spelling task. Each learner was given a worksheet with 20 spaces to write 20 words. There were 10 real isiXhosa words and 10 pseudowords in a randomized order on the research assistant's assessment sheet. A full list of the real word and pseudoword stimuli used in the spelling task can be found in Appendices 2C and 3C respectively.

Unlike the lexical decision and word reading task which were administered individually, the learners were seated together in the classroom during the spelling task. The research assistant read each word aloud twice, using a normal speech rate. The learner worksheets were checked for spelling errors, and an accuracy score was recorded for each word per participant with incorrectly spelt words coded as 0 and correct words coded as 1.

Table 10 presents the mean values for the word characteristics of the target words used in the spelling task. These include word length in letters, word frequency, OLD20 and OLDF. The data is factored in the same way as for the lexical decision and word reading tasks. Note that the word frequency for pseudowords was coded as zero, as such these words are only factored by word length and not frequency. Further, although there were no 4-syllable high-frequency real words in this task, this is remedied by using word length measured in letters in the statistical data analysis. A reliability test was run post-hoc after the main data collection which showed that the spelling task was strongly reliable with a Cronbach's Alpha score of 0.94 for the 20 task items.

Table 10: Mean word length, word frequency and orthographic neighbourhood properties for the target words used in the spelling task

| | Low frequency words (F < 10) | | High frequency words (F > 40) | |
|---|---|---|---|---|
| target word characteristic | 3 syllables | 4 syllables | 3 syllables | 4 syllables |
| | | **Real words** | | |
| word length (letters) | 8.00 | 7.33 | 7.80 | NA |
| word frequency | 3.00 | 5.00 | 89.6 | NA |
| OLD20 | 2.65 | 2.17 | 2.29 | NA |
| OLDF | 30.4 | 11.1 | 15.7 | NA |
| | | **Pseudowords** | | |
| word length (letters) | 6.67 | 8.00 | - | - |
| OLD20 | 2.71 | 3.50 | - | - |
| OLDF | 17.0 | 9.25 | - | - |

Note: OLD20= orthographic neighbourhood density, OLDF= orthographic neighbourhood frequency

## 3.7 Pilot study

The study was piloted prior to the main data collection in order to evaluate the test instruments and assessment procedures. The pilot data collection was done at one of the five schools which were used in the main study. Two sample sets were considered in the pilot, 17 grade three learners, and 10 grade two learners took part in the pilot study. The pilot study was run towards the end of the school year (November 2021). As such both samples had had a full year of teaching and learning in their respective grades at the time of administration.

### 3.7.1 Procedures

#### *3.7.1.1 Administration*

All three literacy tasks were administered to the learners by trained research assistants who were mother tongue speakers of isiXhosa. The lexical decision and word reading task were administered individually, and the spelling task was administered to each sample group as a whole.

#### *3.7.1.2 Data coding*

Each learner received a unique ID code in order to maintain anonymity. These codes corresponded to the ones administered to the learners by the Volkswagen Legacy Literacy intervention programme for continuity's sake. This also allowed for a collation of the data collected in the pilot study with the data collected by Volkswagen using the Early Grade Reading Assessments (EGRA). The EGRA subtasks of interest to this study were letter-sound knowledge, and oral reading fluency. The EGRA results aided in contextualizing the overall general literacy performance of the samples in question.

The data captured from all three tasks (lexical decision, word reading and spelling) were collated and cleaned in preparation for statistical analysis. The independent variables, orthographic neighbourhood density and orthographic neighbourhood frequency were coded as OLD20 and OLDF respectively. For the pilot analysis, for each dependent variable (lexical decision response time, word reading, and spelling) the average score for each target word in the tasks was calculated for both samples. Lexical decision response time was measured in seconds and this was a recording of the time taken from when the word appeared on the screen to when the learner pressed the button, this was averaged for each word for the whole sample. Word reading accuracy was first captured per participant, correct answers were coded as 1 and incorrect as 0. Thereafter the average reading accuracy per word was calculated across the samples. Spelling accuracy was coded in the same way as word reading. Lastly, any missing data was excluded from the sample using listwise deletion, these were as a result of a learner completing some tasks but not others.

#### *3.7.1.3 Pilot data analysis*

Owing to the small sample size of the pilot study, it was not possible to run inferential statistics on the collected data. The following section reports the descriptive statistics of the pilot samples as well as the EGRA data from the Volkswagen Legacy Literacy programme for these same samples. The EGRA data was from the 2021 end-line assessments for the Legacy Literacy programme and was collected close to the time at which the pilot study data was collected. The primary aim of this analysis was to gain insight into the appropriateness of the test instruments for the main data collection.

### 3.7.2 Pilot results

Table 11 reports the descriptive statistics of the pilot study and EGRA data by grade. Note that lexical decision response time is not reported on in Table 11 as this measure is only relevant when averaged for each word rather than across each sample. The EGRA letter-sound knowledge and oral reading fluency data is included to contextualize the overall general literacy performance for each grade.

Table 11: Descriptive statistics split by grade showing the mean, SD, median, min & max and a Shapiro Wilk's normality score

| | **Grade two (N=10)** | | | | **Grade three (N=17 )** | | | |
|---|---|---|---|---|---|---|---|---|
| | **Word reading** | **Spelling accuracy** | **EGRA LSK** | **EGRA ORF** | **Word reading** | **Spelling accuracy** | **EGRA LSK** | **EGRA ORF** |
| **Mean** | 17.9 | 15.1 | 66.0 | 27.3 | 18.5 | 18.8 | 83.1 | 49.4 |
| **SD** | 2.51 | 3.11 | 15.7 | 14.8 | 1.28 | 1.44 | 14.4 | 12.2 |
| **Median** | 19.0 | 15.5 | 65.0 | 29.5 | 19 | 19 | 86 | 44 |
| **Min** | 12 | 10 | 48 | 6 | 16 | 15 | 55 | 33 |
| **Max** | 20 | 19 | 89 | 60 | 20 | 20 | 107 | 71 |
| **Shapiro-Wilk W** | 0.81 | 0.95 | 0.90 | 0.87 | 0.90 | 0.79 | 0.94 | 0.92 |
| **Shapiro-Wilk p** | 0.02 | 0.61 | 0.22 | 0.10 | 0.06 | 0.002 | 0.27 | 0.15 |

Note: SD= standard deviation, EGRA= Early Grade Reading Assessment, LSK= Letter-sound knowledge,ORF= Oral reading fluency

Both grades performed very well on the word reading and spelling tasks. The mean word reading score for grade two was 17.9 out of 20, this is a percentage of 90% accuracy. The meanspelling score for grade two was 15.1 out of 20, a percentage of 75%. The grade threes had a mean word reading score 18.5 out of 20 or 92,5% and a mean spelling score of 18.8 out of 20 or 94%.

According to the EGRAs, at the end of grade two, this sample of learners are able to read an average of 27.3 words-correct-per-minute (wcpm) in joined text reading. The National reading benchmark for Nguni languages at the end of grade two is 20 wcpm for joined text reading (Ardington *et al.* 2020). Thus the grade two pilot sample has reached the national reading benchmark for their grade level.

At the end of grade three, this sample of learners are able to read 49.4 wcpm in joined text reading. The National reading benchmark for Nguni languages at the end of grade three is 35 wcpm for joined text reading (Ardington *et al.* 2020). Therefore the grade three pilot sample has reached the national benchmark for their grade level. Ardington *et al.* (2020) also provide a letter-sound knowledge benchmark of 40 lcpm which must be reached by the end of grade one. Both the grade two and grade three samples have surpassed this benchmark successfully, with grade twos scoring on average 66 letters correct per minute (lcpm), and grade threes, 83.1 lcpm.

#### *3.7.2.1 Lexical Decision task: pilot results*

Table 12 presents the mean response times for the lexical decision task for both the grade two and three pilot samples. Standard deviations are presented in parentheses.

There is an apparent difference in the mean response time across neighbourhood frequency categories. This difference is more noticeable in the grade two sample; words with a high neighbourhood (N) density and high neighbourhood (N) frequency have a longer mean response time (6.05 seconds) than words with a high N density and low N frequency (5.11 seconds).

Table 12: Mean and standard deviations for response time in the lexical decision pilot task

| | High N density words | Low N density words |
|---|---|---|
| | **High neighbourhood frequency** | |
| grade two | 6.05 (0.332) | NA |
| grade three | 3.94 (0.989) | NA |
| | **Medium neighbourhood frequency** | |
| grade two | 5.14 (0.865) | 5.45 (1.44) |
| grade three | 3.55 (1.15) | 4.58 (0.359) |
| | **Low neighbourhood frequency** | |
| grade two | 5.11 (1.58) | 5.72 (2.54) |
| grade three | 3.24 (0,877) | 3.58 (1.36) |

Note: standard deviations presented in parentheses, N= neighbourhood

For the grade three sample, the differences in mean response time across neighbourhood frequency categories are more prominent for low N density words than high N density words. Low N density words with a medium N frequency have a slower mean response time (4.58 seconds) than words with a low N frequency (3.58 seconds). Unfortunately owing to the small sample sizes of the pilot study, an ANOVA could not berun to test whether these apparent differences were statistically significant, as the statistical power would be questionable. Thus these results should be interpreted with caution.

#### *3.7.2.2 Word reading task: pilot results*

Table 13 presents the mean word reading accuracy of the grade two and three pilot samples. Standard deviations are presented in parentheses[5]. There are apparent differences between the mean accuracy scores for high N density and low N density words. For example, high N density words have slightly higher accuracy scores (grd.2 = 100%; grd.3 = 100%) than low N density words (grd.2 = 70%; grd.3 = 79%). The same trend is present for words with a low N frequency and, in the grade two sample, for words with a medium N frequency. Again, these mean differences could not be tested for statistical significance owing to the small sample sizes.

5: Where there are missing standard deviations these are because there was only one word in this category- i.e. one high neighbourhood density and high neighbourhood frequency word in this dataset

Table 13: Mean and standard deviations for word reading accuracy in the pilot task for grade two and grade three

| | High N density words | Low N density words |
|---|---|---|
| | **High neighbourhood frequency** | |
| grade two | 1.00 | 0.700 (0.00) |
| grade three | 1.00 | 0.794 (0.125) |
| | **Medium neighbourhood frequency** | |
| grade two | 0.945 (0.093) | 0.700 |
| grade three | 0.968 (0.048) | 1.00 |
| | **Low neighbourhood frequency** | |
| grade two | 0.967 (0.058) | 0.750 (0.212) |
| grade three | 0.922 (0.09) | 0.765 (0.083) |

Note: standard deviations are presented in parentheses, N = neighbourhood

#### *3.7.2.3 Spelling task: pilot results*

Table 14 presents the mean spelling accuracy of the grade two and three samples for the pilot study. Standard deviations are presented in parentheses.

Table 14: Mean and standard deviations for spelling accuracy in the pilot task for grade two and grade three

| | High N density words | Low N density words |
|---|---|---|
| | **High neighbourhood frequency** | |
| grade two | 1.00 | 0.500 |
| grade three | 1.00 | 1.00 |
| | **Medium neighbourhood frequency** | |
| grade two | 0.833 (0.192) | 0.700 |
| grade three | 0.966 (0.042) | 0.824 |
| | **Low neighbourhood frequency** | |
| grade two | 0.800 (0.265) | 0.750 (0.212) |
| grade three | 0.843 (0.223) | 0.912 (0.042) |

Note: standard deviations presented in parentheses; N= neighbourhood

There are apparent differences for both samples in the mean spelling scores across neighbourhood frequency categories for high N density words. Words with a high N density and high N frequency have higher accuracy scores (grd.2 = 100%; grd.3 = 100%) than words with a high N density and low N frequency (grd.2 = 80%; grd.3 = 48.3%). There does not appear to be any trend across neighbourhood frequency categories for words with a low N density, nor across neighbourhood density categories.

### 3.7.3 Limitations of the pilot study

A limitation of the pilot study, in addition to the small sample size, was the ceiling effects experienced from the samples, which limits any valid inferential statistical analyses from the pilot data collection. From Section 3.5.2, it can be seen that both the grade two and grade three samples performed very well on all tasks. This high performance was analysed in order to determine whether the test instruments were too easy for these grade levels. However, further analysis revealed that the school at which the pilot study was conducted had a significantly higher performance across the EGRA tasks than the other four schools where the main data collection took place. Table 15 reports the performance of all five schools in the two EGRA tasks, letter-sound knowledge, and oral reading fluency, at the end of grade two and three respectively. The school used in the pilot study is coded as School D.

Table 15: Descriptive statistics showing letter-sound knowledge and ORF performance for all five schools

| **School** | | **A** | | **B** | | **C** | | **D** | | **E** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Grade** | | **2** | **3** | **2** | **3** | **2** | **3** | **2** | **3** | **2** | **3** |
| **N** | letter-sound | 62 | 66 | 110 | 106 | 104 | 112 | 27 | 17 | 30 | 21 |
| | oral reading | 59 | 66 | 106 | 105 | 102 | 112 | 26 | 17 | 30 | 21 |
| **Mean** | letter-sound | 57.8 | 69.2 | 42.7 | 52.7 | 34.9 | 55.9 | 55.7 | 83.1 | 32.0 | 71.0 |
| | oral reading | 20.7 | 30.5 | 13.4 | 24.4 | 9.85 | 24.0 | 20.3 | 49.4 | 7.87 | 28.0 |
| **SD** | letter-sound | 27.7 | 25.2 | 24.0 | 23.6 | 19.7 | 24.3 | 21.9 | 14.4 | 21.8 | 17.2 |
| | oral reading | 19.0 | 19.7 | 13.6 | 18.9 | 11.3 | 16.4 | 16.1 | 12.2 | 14.1 | 15.0 |
| **Median** | letter-sound | 61.0 | 72.0 | 43.5 | 53.0 | 36.0 | 57.5 | 57 | 86 | 30.5 | 73 |
| | oral reading | 21 | 32.5 | 9.00 | 23 | 7.00 | 23.0 | 16.5 | 44 | 0.00 | 31 |

Table 15 shows that learners at School D read on average substantially more letters and words-correct-per-minute than the other four schools in both grades. With the exception of the grade two learners in School A who performed slightly higher than School D in both EGRA tasks. All learners, barring grade twos in School C and School E, reached the letter-sound knowledge benchmark of 40 lcpm by the end of grade one. Only School A and School D's grade two learners are reading at the national benchmark level of 20 wcpm for oral reading fluency, M= 20.7 and M=20.3 respectively. Only School D's grade three learners reached the national benchmark of 35 wcpm for oral reading fluency, M= 49.4.

School D's high performance in the EGRA subtasks is a reflection of their performance in the pilot study's tasks. As such the researcher assumes that the other four schools will follow this same trend, whereby their performance in Table 15 may be indicative of their performance in the final data collection. Thus it is not necessarily that the piloted tasks were too easy, rather the sample school appears to be an outlier in terms of learners' overall reading performance. With this in mind, the following section summarizes the modifications made to the tasks and administrative procedures for the main data collection.

### 3.8 Modification of tasks

Following the pilot study, few modifications were made to the study's tasks for the main data collection. Some changes that were made included removing those task items that were already used in the EGRA word reading and spelling tasks in order to minimize priming effects. Those items were replaced with 4 syllable words which had a lower neighbourhood density, in order to provide a broader range of densities. A final modification was made to the lexical decision task, whereby the 'start' button was modified to make it clearer for the learner that pressing it ended the trial session and began the actual task. This modification was included as it was noticed that some learners thought the start button was part of the trial session. The tasks were not piloted again after modifications were made due to time constraints and access to participants.

### 3.9 Modification of procedures

No modifications were made to the administration of the lexical decision task. For the spelling task, research assistants were encouraged to practice reading the task items aloud prior to administration. This was to avoid any mispronunciations during the administration, in particular the pseudoword pronunciations.

Two administration formats were trialed during the pilot study for the word reading task. One format was similar to the standard EGRA word reading task whereby all word flashcards were placed on the table together at the same time for the learner to read. However the researcher noted that this encouraged 'speed reading' of the words. Although not an issue for

EGRA word reading tasks which are timed for a words-correct-per-minute score, the current study was not interested in word reading speed as a variable. Thus the second format was adopted for the main data collection, whereby words were held up on individual flashcards and presented to the learner one by one. This second format removed the emphasis on speed and focused solely on accurate isolated word reading, which is more aligned to what the study aimed to measure. Further, it allowed the research assistant more control over the task administration and afforded them more time to capture any errors that the learner made.

## 3.10 Data analysis

Following the main data collection, the data was analysed in order to answer the study's research questions. These analyses are reported on in Chapters 4 and 5, an outline of the analyses is presented below.

### 3.10.1 Computational analysis of orthographic neighbours in isiXhosa

First, a computational linguistic analysis of the database of isiXhosa orthographic neighbours was conducted. This analysis allowed for an investigation into the linguistic properties of orthographic neighbours in isiXhosa. This involved identifying trends in the linguistic structure of orthographic neighbours and considered morphological, phonological, and orthographic properties.

For the morphological analysis, the study made use of string comparison, a computational technique used to compare the differences between strings of characters (in this case words made up of strings of letters). Using the orthographic neighbourhood database of 30 real isiXhosa words and 600 neighbours - developed for this study – the initial prefix, root morpheme, and final vowel suffix of each target word was identified, and string comparison was used to determine the percentage of orthographic neighbours which shared each morpheme with their respective target word.

To test for the overlap of phonological and orthographic similarity the study made use of a case-study approach. The word *indlebe* and its orthographic neighbours were phonetically transcribed, thereafter the phonological Levenshtein distance (the number of phoneme differences) was calculated for each neighbour. These phonological Levenshtein distances were compared to the orthographic Levenshtein distances (the number of letter differences) of the neighbourhood of *indlebe* in order to determine the extent of similarity between the phonological and orthographic neighbours of *indlebe.* The use of a case-study approach was necessary owing to the complex and time-consuming nature of phonetic transcription and the lack of open sources for quality transcription of isiXhosa words. Further justification for this method is provided in Chapter 4.

The investigation of syllabic neighbours was conducted in a similar way to the phonological neighbours, once again using a case-study approach. The word *ixoki* and its neighbours were phonetically transcribed and broken up into syllables. Thereafter the syllabic Levenshtein distance (the number of syllable differences) was calculated for each neighbour. The percentage of neighbours which shared word initial, word final, and mid-word syllables was calculated to investigate the saliency of syllabic neighbours in the neighbourhood of *ixoki*.

The interplay of neighbourhood characteristics with word factors such as word frequency, and word length were also considered in this analysis. The findings were compared to research on orthographic neighbours in other languages. This analysis is reported on in Chapter 4 and it informs the literacy aspect of this study.

### 3.10.2 Quantitative analysis of the interaction between neighbourhood effects and literacy skills

The literacy data was analysed in order to examine the effects of orthographic neighbours on word reading, lexical decision response time, and spelling. This analysis is reported on in Chapter 5.

First, descriptive statistics were run which showed a general overview of the data from the word reading, and spelling tasks. As was done in the pilot study analysis, descriptive statistics for the lexical decision task were not run as these results can only be interpreted meaningfully when factored by word properties, rather than when considered across the sample. In addition to this, data from two EGRA subtasks were included in the descriptive data analysis; letter-sound knowledge and oral reading fluency (ORF).

Following the descriptive statistics, inferential statistics were conducted using multilevel regression analyses in order to test whether orthographic neighbourhood density and neighbourhood frequency significantly explained variance in the outcome variables, namely, lexical decision response time, word reading accuracy, and spelling accuracy. The following section provides justification for this method of data analysis.

### *3.10.2.1 Justification for multilevel analysis*

The quantitative data analysis of the literacy data makes use of multilevel modelling (also called mixed effects modelling) in order to examine the relationship between orthographic neighbourhood effects and word reading, lexical decision response time, and spelling. The main benefit of a multilevel analysis for this study is that it allows for the use of the raw scores for the dependent variables (namely lexical decision response time and accuracy, word reading accuracy, and spelling accuracy) as opposed to first averaging response times/accuracy scores across participants for each target word. By running models on aggregated data, one ignores the influence of across item and across participant variation, thus researchers in psycholinguistics recommend the use of multilevel modelling as an alternative (Hoffman & Rovine, 2007; Locker, Hoffman & Bovaird, 2007; Baayen, Davidson & Bates, 2008; Janssen, 2012; Hoffman, 2015; Lo & Andrews, 2015).

A further benefit to multilevel modelling is that it is robust to effects of missing data or unequal group sizes (Locker, Hoffman & Bovaird, 2007; Janssen, 2012). Tables 23 and 29 in Sections 5.3.1 and 5.3.3 respectively, show unbalanced group sizes across item conditions. That is, some subsets of words were not taken into consideration when designing the target item lists. For example, in the word reading and spelling data there are no high-density words with a high neighbourhood frequency. In a traditional ANOVA, unbalanced group sizes would be problematic (Locker, Hoffman & Bovaird, 2007; Hoffman, 2015). However a multilevel analysis is robust to unbalanced group sizes and missing data (Locker, Hoffman & Bovaird, 2007; Hoffman, 2015).

Further, this form of analysis was chosen as it best fit the structure of the study's data. For psycholinguistic data, much like the present study, there are often two levels within the data structure. On the one level is participant data, this includes variables that pertain to the participants in the study, including age, gender, grade, class etc. On the other level is the experimental stimulus data. This refers to the target words (also called items) used in the various literacy tasks, as well as all the variables which pertain to those words. In this study, this includes word length, word frequency, and the main independent variables of interest, orthographic neighbourhood density, and orthographic neighbourhood frequency. When each participant is exposed to all items, as in the present study's design, it is called a crossed random effects design, that is, participants are crossed with items (Hoffman, 2015), such that we can consider variation across participants, variation across items, as well as variation in their interaction. An illustration of a crossed random effects design is presented in Figure 7.

Figure 7 shows the subject data, such as age and gender, in the blue circles, and the word data, such as word frequency, word length, and orthographic neighbourhood variables, in the three circles at the bottom of the diagram. The rectangles on level 1 represent the individual trials which correspond to one subject's response time – or reading, or spelling accuracy – for one word. The arrows indicate the crossed effects design with each subject exposed to each word.

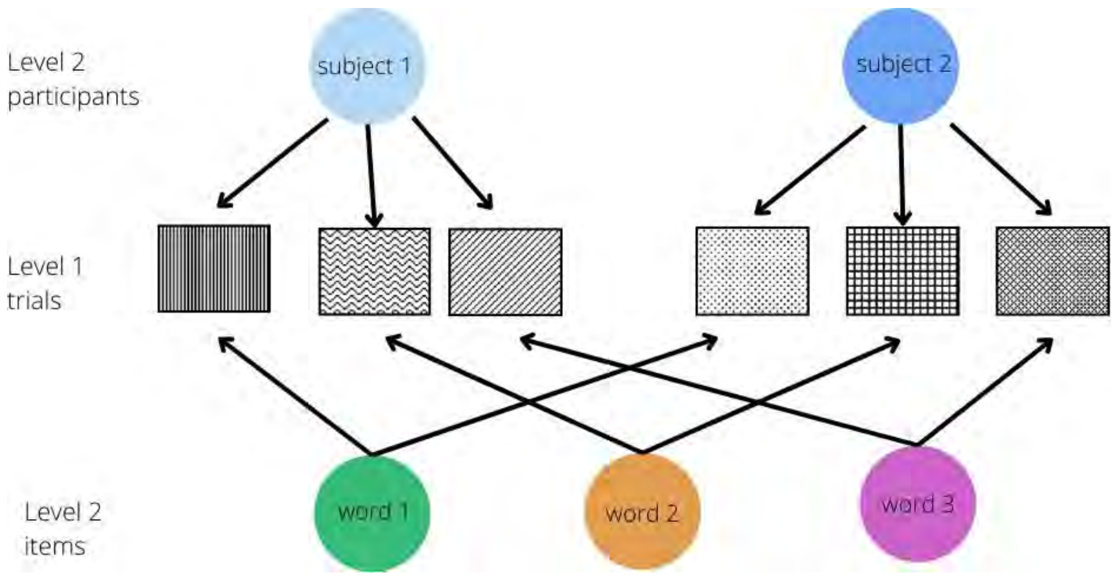


Figure 7: Crossed random effects data structure (Source: author's own work)

Multilevel modelling was used to conduct regression analyses for the literacy data, in order to determine the nature of the relationship between orthographic neighbourhood effects (density and frequency) with word reading accuracy, lexical decision response time, and spelling accuracy. Chapter 5 reports on this analysis and is concluded by interpreting the results of the statistical data analysis within psycholinguistic models of orthographic processing.

### 3.11 Limitations of the Methodology

There were certain limitations of the methodology which need to be acknowledged. First, this thesis acknowledges the interplay of orthography with other linguistic domains, and it is not unaware that these other domains will naturally influence the results. However, the focus of this study falls specifically within the orthographic domain. That is, although there is a broader niche in the literature which includes the study of phonological, phonographic, and semantic neighbours, the focus of this thesis is on orthographic neighbours and neighbourhoods.

This means that for the purposes of this thesis, there were certain methodological trade-offs which needed to be made whereby the linguistic properties of orthographic neighbours, such as phonology and morphology, whilst still acknowledged, were not explored to their full capacity. For example, a morphological analysis of the entire corpus of isiXhosa words, was not feasible for this study, owing to time constraints. However, to demonstrate the overlap of morphology with orthography, a smaller database of neighbours was developed. Further, Chapter 4 uses a case study approach to investigate the phonological properties of orthographic neighbours in isiXhosa, as opposed to using a full phonetically transcribed corpus. Future research may want to develop a phonetically transcribed corpus of isiXhosa words in order for the overlap of orthographic and phonological neighbours to be explored more fully in the language. Although the findings from a case-study approach are limited in their scope, the results provide motivation for this avenue to be explored to a fuller extent in future research.

A second limitation of the methodology was that the study of orthographic neighbours and neighbourhood effects relies largely on computational linguistic skills and, where these are lacking, on the accessibility of previously developed code and/or software. There is a lack of open access resources available for the specific computations necessary for this type of study. The tools that do exist do not perform to the full extent that they are needed. I am yet to find a resource that will provide the following in one output: the OLD20 (neighbourhood density) scores, the OLDF (neighbourhood frequency) scores, and the identity of the 20 closest neighbours to the target word. For example, even software such as LexiCAL (Chee et al. 2021), an open-source tool designed by some of the developers of the OLD20 and OLDF metrics, still does not provide a calculation for OLDF – at least not the OLDF that is described by Yarkoni, Balota and Yap (2008). This is why in Chapter 4, I present an analysis of the distribution of OLD20 scores in the corpus, however I am unable to present an analysis of OLDF scores at such a large scale.

A final limitation of the methodology is the large percentage of missing participant data for the literacy assessments. The investigation of neighbourhood effects on reading and writing, required conducting literacy assessments to collect participant data. Originally the study sample was 190 grade three learners, however there was a large percentage of missing data which reduced the sample size to 97 learners. Missing data was handled using a listwise deletion approach, which was done task by task. First, those participants who didn't complete the spelling task were excluded. Followed by those who, in addition to this, didn't complete the word reading task, and lastly, those who didn't complete the lexical decision task. These exclusions are summarised in Table 16.

Table 16: Exclusion procedure via list wise deletion of missing data

| | **Exclusion criterion** | **Explanation** | **Number of participants excluded** | **Remaining Sample Size** |
|---|---|---|---|---|
| **Step 1** | missing spellingdata | learner absent from class | 25 | 165 |
| **Step 2** | missing wordreading data | task not administered/ learner absent | 49 | 116 |
| **Step 3** | missing lexicaldecision data | task not administered/ learner absent | 19 | 97 |

The missing data most likely occurred due to factors outside of the researcher's control. These could be that research assistants were attempting to save time by having group of learners complete one task, while another group completed another task. In this case the data would be missing at random, that is, the reason for the missingness can be assigned to some other variable in the study i.e. learners were busy being administered the word reading task and as such weren't administered the lexical decision task. Another possible reason behind the missing data is that the tasks were administered during the time that the Volkswagen legacy literacy baseline data was also being collected. This could have created confusion with regards to which students completed which tasks. The time pressure to complete both the Volkswagen baseline tasks and the three additional tasks may have also played a role in tasks failing to be administered. Finally, since the data collection took place over multiple days, learner absenteeism may have also played a role in the high percentage of missing data.

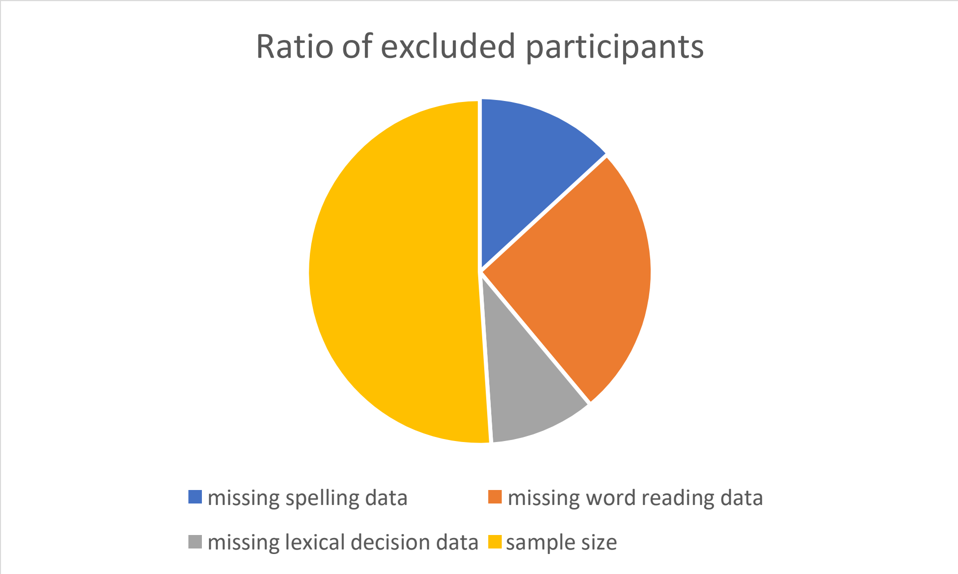


Figure 8: Pie chart showing ratio of excluded participants from the sample

The final sample size was reduced from 190 to 97 participants. This is around 51% of the original sample size. Although this is a large reduction, the remaining sample size is still satisfactory for the statistical analyses which needed to be run for the study.

### 3.12 Summary

Chapter 3 has presented the methodology which this thesis adopted. It has reintroduced the research questions of the thesis and stated the hypotheses which guided this study. It described the process of developing a database of orthographic neighbourhoods for isiXhosa which included 30 real target words used in the literacy assessments, each with 20 neighbours selected as the closest neighbours in the Rees and Randera (2017) isiXhosa corpus. In addition to its use in the literacy assessments, this database was also used to conduct a morphological analysis of the orthographic neighbours. A second database of orthographic neighbours for 30 pseudowords was also developed to be used in the literacy assessments.

Following this, the chapter introduced the participants who partook in the literacy assessments as well as the ethical clearance procedures that were adhered to. The sample of 97 grade 3 isiXhosa learners was drawn from five schools in KwaNobuhle township in the Eastern Cape. These learners were additionally partaking in another study run by Volkswagen Legacy Literacy program, where they were administered various EGRA subtasks. The data from two of these subtasks; letter-sound-knowledge and oral reading fluency were included in the present study's analysis to provide an overview of the learners' literacy abilities. The present study also designed and administered three literacy tasks: a lexical decision task, word reading, and spelling task. The task items were drawn from the orthographic neighbourhood database of real and pseudowords developed for the study.

The chapter then outlined the process of piloting the test instruments. Although the pilot sample size restricted the analysis of the data, the process provided the researcher with the opportunity to adjust the task design and administration procedure where necessary. Following the conclusion of the pilot study, the chapter detailed the data analysis procedures of the study. The study conducted two main analyses each reported in a separate chapter to follow. First, a computational analysis of orthographic neighbours in isiXhosa was conducted, this made use of various methodological tools including string comparison, morphological analysis, phonetic and syllabic transcription, and Levenshtein distance. It also made use of various design concepts such as a corpus-based approach as well as a case-study approach to accommodate certain constraints such as technical and time constraints. Next, the quantitative data analysis was explained whereby the literacy data was analysed to examine the effects of orthographic neighbours on word reading, lexical decision response time, and spelling. Justification for the chosen statistical method is also included.

Finally the chapter has highlighted the methodological limitations which incurred. These included the necessity to use a case-study approach to analyse the overlap of phonological similarity with orthographic similarity, as well as in establishing the saliency of syllabic neighbours in orthographic neighbourhoods in isiXhosa. An additional limitation was the technical nature of the study and the lack of open-source tools for calculating the neighbourhood metrics for the study. Finally an explanation for the excluded participant data is provided.

The following two chapters form the primary data analysis components of the thesis. Chapter 4 provides a linguistic analysis of orthographic neighbours in isiXhosa, and Chapter 5 presents the quantitative analysis of the effects of orthographic neighbours on word reading accuracy, lexical decision response time, and spelling accuracy.

# CHAPTER 4: ORTHOGRAPHIC NEIGHBOURS IN ISIXHOSA

## 4.1 Introduction

The purpose of this chapter is to report on the investigation of linguistic properties of orthographic neighbours in isiXhosa. This chapter addresses research question one:

A. What are the linguistic properties of orthographic neighbours in isiXhosa?

Using computational linguistic tools, the database of neighbours was analysed for various linguistic properties and patterns. These included the overlap of morphological neighbours with orthographic neighbours by quantifying the percentage of neighbours that share different morphemes including word initial prefixes, root morphemes, and final vowel suffixes. In addition, the overlap of phonological and syllabic neighbours with orthographic neighbours was also investigated. Further analysis looked at the distribution of neighbour types such as addition, deletion, substitution, and transposition neighbours, as well as the interaction of other word characteristics such as word length and word frequency with neighbourhood density and neighbourhood frequency. As mentioned in Chapter 3, each of the subsections in this chapter draw on a different data source for computational purposes in order to identify the properties and patterns within the orthographic neighbourhoods. Table 17 provides a summary of what is presented in this chapter and the data source each section uses.

Table 17: Summary of sections in Chapter 4 and the data each refers to

| Section | Data | Description |
|---|---|---|
| 4.2: Orthographic neighbours in isiXhosa and their morphological characteristics | Neighbourhooddatabase | 30 target words and 600 neighbours |
| 4.3: Orthographic neighbours in isiXhosa and their phonological characteristics | Case study approach | Orthographic neighbourhood of *indlebe* and *ixoki* |
| 4.4: The interplay of word characteristics with neighbourhood characteristics | Full isiXhosa corpus | Full corpus of 27 323 isiXhosa words by Rees and Randera (2017) |

The neighbourhood database includes the orthographic neighbourhoods of the 30 real isiXhosa target words used in the literacy tasks in Chapter 5. This includes the 20 closest neighbours for each of the 30 words, resulting in a database of 600 neighbours and 30 target words. The full database can be found in Appendix 2. This database is used in Section 4.2 in order to analyse the morphological properties of the neighbours. In Section 4.3 a case study approach is adopted in order to analyse the overlap of phonological and syllabic neighbours with orthographic neighbours. Following this, Section 4.4 uses the larger corpus of 27 323 isiXhosa words in order to establish trends in the data.

### 4.2 Orthographic neighbours in isiXhosa and their morphological characteristics

The first linguistic domain that will be explored in the analysis of the neighbourhood database is morphology. More specifically the overlap of orthographic units with morphological units in the orthographic neighbourhoods in an attempt to quantify the conjunction of orthographic similarity with meaning similarity. This aspect is of particular interest in the case of isiXhosa, owing to the language's agglutinative morphology (see Section 2.4). Thus it is likely that a lot of neighbours in isiXhosa will potentially share a root morpheme and differ by the affixes that surround the root.

To test this, the initial prefix, root morpheme, and final vowel suffix were first identified for each of the 30 target words. The full gloss for each target word can be found in Appendix 4. The choice for these specific morphemes was motivated by the following reasons; firstly, the root morpheme encodes the core meaning of the word and as such, words which share a root morpheme will be related in meaning. For example, the root for *iimpahla* (clothes), namely -*mpahla,* is shared by many of its neighbours including *impahla* (clothes (singular)), *neempahla* (and clothes), and *yeempahla* (of the clothes). Secondly, the initial prefix was chosen as it also encodes important semantic information about the word. This is usually the noun class if the word in question is a noun, for example in *iimpahla*, the prefix *ii*- encodes noun class 10 which is the plural form of noun class 9. Noun class 9 includes "inanimate objects not included in Class 3, most loan words, some nouns referring to humans, certain nouns derived from verbs" (Eiselen & Bukula, 2022: 6). The initial prefix can also be the subject agreement in the case of a verb. For example, in the sentence *abantwana bayabaleka* (the children are running), the verb *bayabaleka* has the initial prefix *ba* which shows subject agreement with the noun *abantwana.* It may also indicate the locative form as in ***e****khaya* (at home), adjectival form as in ***e****ntle* (beautiful) or the copulative form, ***u****banzi* (it is wide) of the word in some cases. In addition to this, because the target words in the database were only three and four syllables, none of the target words had more than one prefix. All words consisted of some word initial prefix, followed by a root morpheme, and a final vowel.

The final vowel suffix was included as it can in some cases appear in a marked form and indicate additional inflectional or derivational information. The final vowel suffix of the 30 target words appeared mostly in the unmarked form, that is, there were little to no words with a suffix that encoded additional meaning information. Some exceptions are *ixoki* (liar), the final vowel of which *-i* is a derivational marker indicating the nominal form of the verb *-xoka* (to lie), and the same for *umlobi* (fisherman) from *-loba* (to fish).

After performing a morphological analysis of the 30 target words to identify the three morphemes of interest: the initial prefix, root morpheme, and final vowel, each neighbour was checked against their respective target word using string comparison. String comparison takes a specified sequence of characters (for example a root morpheme) and compares these against all the neighbours which may share that sequence. This returns a binary outcome of True or False. This computation was done to determine the percentage of neighbours which shared these morphemes with the target words, and consequently shared some aspect of meaning with the target words.

The task of analysing the database for morphological and orthographic overlap was challenging owing to the rich morphology of the language, and the frequency of morphophonological changes which are also reflected in the orthography. For example, the words *ezintlanu* and *ezihlanu* are close orthographic neighbours, and they also share an underlying root morpheme *-hlanu* (five). However, because of the morphophonological change in *ezintlanu* from /ɬ/ to /tɬ/ the orthographic representation of the root morph has changed. Thus making for difficulties in computing string comparisons, as *ezintlanu* will not show up as sharing a root morph with *ezihlanu,* even though morphologically this is the case. In the case of these words, unfortunately a trade-off had to be made. Seeing as though the study's focus is on orthography, computations were performed which favoured those neighbours whose root morpheme had the same orthographic form, thus prioritizing orthography above morphology. Further studies will need to consider this trade-off in order to conceptualize a solution to this computational challenge.

A further challenge was that some noun class prefixes share the same orthographic representation. For example, the prefix for noun class 9 is {i(n)} as in the word *i-ngonyama,* and the prefix for noun class 5 is {i(li)} as in the word *i-nkonyaka*. Thus in a string comparison, these words will be classified as sharing an initial prefix, when in reality each prefix encodes different morphological information about the noun class of the word. This limitation should also be considered by future studies on this topic in order for a solution to be found, for example, researchers may want to conduct string comparison on the glossed form of the words rather than their orthographic form.

Figure 9 illustrates the number of neighbours which share a morphological unit with their respective target word.

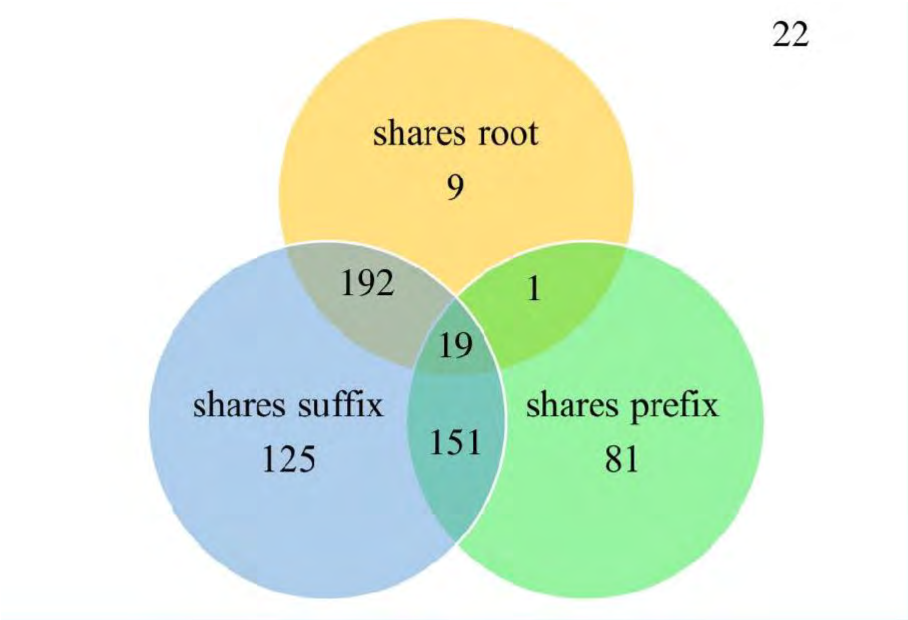


Figure 9: Venn diagram showing the distribution of orthographic neighbours in isiXhosa which share morphological units

Of the 600 neighbours in the database, 221 share a root morpheme with the target word. That is, 37% of neighbours in the database are related in terms of meaning to their respective target word. Further, 252 of the 600 neighbours share a word initial prefix which translates to 42% of neighbours. An additional 81% of neighbours share a final vowel suffix. However, it is important to note that the final vowel suffix can only ever be one of five vowels {a,e,i,o,u} and so a neighbour has a one in five chance of sharing a suffix with its target word regardless of whether the final vowel encodes additional morphological information or not. Thus this specific percentage may not give much substantial information about meaning similarity between target words and neighbours.

Interestingly, only 19 neighbours shared all three morphemes, one neighbour shared both a root morpheme and an initial prefix, and 192 or 32% shared a root morpheme and a final vowel suffix. This indicates that root morphemes and initial prefixes are for the most part mutually exclusive, in that it is unlikely that a neighbour will share both a root morpheme and initial prefix with a word in isiXhosa. There is however a greater chance of neighbours sharing both a root morpheme and a final vowel with their target word. Further, only 22 or 4% of neighbours do not share any of their three morphemes, which again emphasizes the preference for morphological similarity in isiXhosa orthographic neighbours.

The substantial overlap of orthographic and meaning similarity in isiXhosa neighbours could potentially explain how neighbours interact with processes of reading and writing. These 'meaning' neighbours could be used by the reader or writer as a facilitative tool to process words. However it may also result in an inhibitory effect owing to the density of meaning similarity in isiXhosa neighbours. For example, research on languages such as Turkish and Malay, has found inhibitory orthographic neighbourhood density effects for reading, and the agglutinative morphology of these languages has been pointed out as a potential source of these inhibitory effects (Yap *et al.* 2010; Erten, Bozsahin & Zeyrek, 2014). These hypotheses will be revisited in Chapter 5.

### 4.3 Orthographic neighbours in isiXhosa and their phonological characteristics

In addition to isiXhosa's overlap of orthographic and morphological neighbours, the phonological characteristics of the language suggest that this overlap extends to phonology as well. As discussed in Section 2.4, isiXhosa has a relatively transparent orthography which means that the mapping between sound and print units is mostly very regular. Consequently, orthographic neighbours may be considered nearly identical to their phonological neighbour counterparts. For example, the words *okanye* and *abanye*, differ by two letters but also by two phonemes. In an orthographically opaque language such as English, however, this is not the case. For example, the words *though* [ðœʊ] and *thought* [θoːt] differ by only one letter, however phonologically, they differ by three phonemes. As such, the English words *though* and *thought* are closer orthographic neighbours than they are phonological neighbours. It is this distinction that does not appear to exist (at least to the same extent) in isiXhosa. This aspect of isiXhosa's orthographic neighbourhood has been noted in other languages with regular spelling to sound systems as well.

For example, in French and Spanish "the orthographic neighbors of a given target word are generally also phonological neighbors" (Carreiras, Perea& Grainger, 1997: 868).

Although a full investigation of this aspect is beyond the scope of this thesis, owing to the complex and time-consuming nature of phonetic transcription, it is still an important aspect to consider here. As a case study example, Table 18 shows the phonetic transcriptions of the 20 closest orthographic neighbours to *indlebe* (ear), phonetically transcribed as [inɮeɓe]. Table 18 also includes the Levenshtein distance of the neighbours in letters in the case of orthographic LD, and in phonemes in the case of phonological LD. A reminder that LD refers to the number of character differences between two words.

Table 18: Orthographic and Phonological Neighbourhood of *indlebe*

| **neighbours** | **phonetic transcription** | **Orthographic LD** | **Phonological LD** |
|---|---|---|---|
| iindlebe | i:nɮeɓe | 1 | 1 |
| ndlebe | nɮeɓe | 1 | 1 |
| indebe | indeɓe | 1 | 1 |
| indlela | inɮela | 2 | 2 |
| imilebe | imileɓe | 2 | 3 |
| ndebe | ndeɓe | 2 | 2 |
| wendlebe | wenɮeɓe | 2 | 2 |
| indlu | inɮu | 3 | 3 |
| indlovu | inɮovu | 3 | 3 |
| ndlela | ndɮela | 3 | 4 |
| intle | intɮe | 3 | 3 |
| inde | inde | 3 | 3 |
| ndibe | ndiɓe | 3 | 3 |
| ingulube | iŋguluɓe | 3 | 5 |
| yindlela | jinɮela | 3 | 3 |
| iindlela | i:nɮela | 3 | 3 |
| inxeba | iŋǁeɓa | 3 | 3 |
| inene | inene | 3 | 2 |
| ingene | iŋgene | 3 | 3 |
| endlebeni | enɮeɓeni | 3 | 3 |

Table 18 illustrates the overlap of phonological similarity and orthographic similarity for the neighbours of *indlebe*. Of the 20 neighbours, only four disparities are noted, that is four of the neighbours differed in their degree of phonological similarity relative to their orthographic similarity. For example, *ingulube* [iŋguluɓe] has a Levenshtein distance of three letters, but five phonemes from the target *indlebe* [inɮeɓe]. The source of these disparities appears to be the complex grapheme {dl} which is represented by two letters in isiXhosa but constitutes one phoneme /ɮ/. Aside from these, it would appear that the majority of *indlebe's* neighbours overlap in their orthographic and phonological neighbourliness. This finding is similar to neighbourhoods in Spanish, and German which "demonstrate a high degree of similarity in the distributions of their orthographic and phonological neighborhoods" (Marian *et al.* 2012: 8), as well as in French (Carreiras, Perea & Grainger, 1997).

The consequences of this are on the one hand beneficial to the study as they minimize the confounding effect of phonological neighbours for the analysis of orthographic neighbourhood effects. However, it does mean that drawing conclusive claims about neighbourhood effects in isiXhosa is ambiguous, in that the source of an effect could be owed to either the phonological neighbourhood or to the orthographic neighbourhood. These contentions are interrogated further in Chapter 5.

Another aspect of phonology which must be considered here is the degree of syllable neighbours in the database. Research on Spanish and French has found a prevalent overlap of orthographic and syllabic neighbours (words which differ by one or more syllables) in these languages (Carreiras & Perea, 2004; Mathey *et al.* 2006). This overlap appears frequently in languages with transparent orthographies, and regular syllabic structures. In isiXhosa, much like French and Spanish, syllables are highly regular and follow an open Consonant Vowel/ Vowel (CV/V) structure. Thus the degree of overlap between orthographic and syllabic neighbours in isiXhosa is worth investigating.

Table 19 shows the syllabic neighbourhood of the word *ixoki* [iǁo.ki] (liar), as well as the Levenshtein distance of each neighbour in letters for orthographic LD, and in syllables for syllabic LD. From this, 16 out of the 20 neighbours of *ixoki* share a word initial syllable. This translates to a substantial 80% of *ixoki's* neighbours. Further, seven out of 20, or 35%, of the neighbours of *ixoki* share a word final syllable, the syllables appearing mid-word appear to be more variable for these neighbours. Research has found that syllabic neighbours, in particular those words which share a word initial syllable, are activated when processing words (Carreiras and Perea, 2004). Research on isiXhosa specifically has also shown that the syllable is a dominant linguistic processing unit when reading (Probert, 2019). Thus the high degree of syllable neighbours in isiXhosa, is likely to play a role in processing words in reading, and possibly by extension in writing. Interestingly, some morphemes in isiXhosa are syllabic, particularly affixes such as the noun class prefix *i-* in *ixoki* and many of its neighbours. Thus the influence of syllabic neighbours could be confounded by morphological neighbours, both of which are layered beneath a potential orthographic neighbourhood effect.

Table 19: Orthographic and syllabic neighbourhood of *ixoki*

| orthographic neighbours | syllable gloss | orthographic LD | syllabic LD |
|---|---|---|---|
| ihoki | i.ɦo.ki | 1 | 1 |
| xoki | ǁo.ki | 1 | 1 |
| idonki | i.do.ŋki | 2 | 2 |
| iveki | i.ve.ki | 2 | 1 |
| ipaki | i.pa.ki | 2 | 1 |
| ilori | i.lo.ri | 2 | 2 |
| iposi | i.po.si | 2 | 2 |
| ixolo | i.ǁo.lo | 2 | 2 |
| exoka | e.ǁo.ka | 2 | 2 |
| idyoki | i.ɟo.ki | 2 | 1 |
| igoli | i.go.li | 2 | 2 |
| ihodi | i.ɦo.di | 2 | 2 |
| ihoko | i.ɦo.ko | 2 | 2 |
| ikomi | i.ko.mi | 2 | 2 |
| imoski | i.mo.ski | 2 | 2 |
| inki | i.ŋki | 2 | 2 |
| isoka | i.so.ka | 2 | 2 |
| itiki | i.ti.ki | 2 | 1 |
| maxoki | ma.ǁo.ki | 2 | 2 |
| ngoku | ŋgo.ku | 3 | 3 |

## 4.4 The interplay of word characteristics with neighbourhood characteristics

This section analyses the interaction of word characteristics, specifically word frequency and word length, with neighbourhood characteristics. Because the 30 target words in the neighbourhood database were chosen specifically for testing orthographic neighbourhood effects, the distribution of neighbourhood frequency and density values across these words, will not be an accurate reflection of their distribution within isiXhosa as a whole. As such the neighbourhood variables had to be calculated for the entire original corpus of 27 323 words (Rees & Randera, 2017). This was done using a repository of code from Tulkens (2020)[6] who based their computation on Yarkoni, Balota and Yap's (2008) OLD20 metric.

6: Github repository found at: https://github.com/stephantul/old20

Unfortunately, there is yet to be an open access resource for calculating neighbourhood frequency at such a large scale[7], specifically Yarkoni, Balota and Yap's (2008) OLDF metric. As such, the following section only discusses neighbourhood density interactions. First, the distribution of neighbourhood density across the corpus is reported on.

Figure 10 illustrates a slightly positively skewed distribution of OLD20 values across the isiXhosa corpus. The percentiles were calculated to further investigate this distribution which showed that 60% of words had an OLD20 value of 3 or less. Because lower OLD20 values indicate a denser neighbourhood, 60% of isiXhosa words in the corpus have a relatively dense neighbourhood.

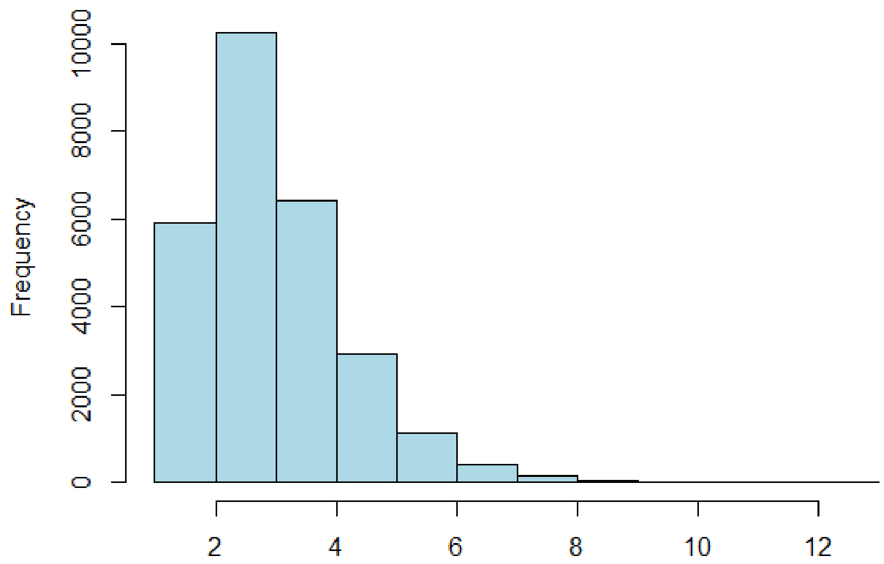

Figure 10: Distribution of neighbourhood density (OLD20) values in the isiXhosa corpus

Comparisons can be made to other languages which have databases of neighbourhood variables available. These include English from the English Lexicon Project (Balota *et al* 2007), French from the MEGALEX database (Ferrand *et al.* 2018), Portuguese from the Brazilian Portuguese Lexicon (Estivalet & Meunier, 2015), and German from the Developmental Lexicon Project (Schröter and Schroeder, 2017). This comparison may help later on to understand how and why orthographic neighbourhood density interacts in isiXhosa reading and spelling and to situate it within findings for other languages.

7: The OLD20 and OLDF metrics for the 30 real and 30 pseudowords used in this study were calculated manually in MS Excel using VBA module developer for levenshtein's distance. This was done particularly to be able to calculate OLDF values for the study.

The descriptive statistics for OLD20 are reported in Table 20 for all five languages. Table 20 shows that isiXhosa has the highest mean OLD20 value ($\bar{x}$ = 3.04) in comparison to English, French, Portuguese, and German. This means that isiXhosa words have a lower average neighbourhood density in comparison to the other four languages.

Table 20: Descriptive statistics for OLD20 in isiXhosa6, English, French, Portuguese, and German

| | n | mean | sd |
|---|---|---|---|
| **isiXhosa** | 27 301 | 3.04 | 1.20 |
| **English** | 40 481 | 2.87 | 1.04 |
| **French** | 25776 | 2.02 | 0.45 |
| **Portuguese** | 215 175 | 2.7 | 1.16 |
| **German** | 1152 | 1.77 | 0.58 |

Note: n= size of corpus, sd= standard deviation

This finding is particularly interesting as it may be a reflection of the agglutinative morphology of isiXhosa and its regular syllable structure. Table 20 shows that words in isiXhosa differ on average by three letters to other words in the language with a standard deviation of one letter. This is reminiscent of the regular (C)V syllable structure of isiXhosa and the frequency of complex consonant graphemes which make up syllable onsets. For example the word *ungonyama,* has the neighbour *kwingonyama*, which differs by the first three letters *kwi-,* which also form the first syllable of the word. It also has the neighbour *kangonyama,* which differs by the first two letters *ka-* which again form the first syllable of the word. In addition to this, morphemes in isiXhosa are often syllabic, as is in the case of *kwi-* in *kwingonyama* and *ka-* in *kangonyama.* Therefore, orthographic neighbours in isiXhosa will differ on average by one syllable, and consequently by one morpheme. This supports the findings in Sections 4.2 and 4.3 regarding the large overlap between orthographic neighbours and morphological and syllabic neighbours.

Correlations between word length, word frequency, and OLD20 values across the corpus were also investigated. Table 21 shows a correlation matrix for these variables. All variables were significantly correlated. OLD20 was strongly positively correlated with word length ($r$= .85, $p$< .001). This indicates a negative correlation between neighbourhood density and word length (as OLD20 and neighbourhood density are negatively correlated: see Section 3.4.1.1). That is, longer words have less dense neighbourhoods. This finding is consistent with other studies in languages such as English, Spanish, Czech, Dutch, German, and French (Martín & Pérez, 2008; Marian *et al.* 2012; Ferrand *et al.* 2018; Ptáčková & Vitásková, 2020).

Table 21: Correlation matrix for OLD20, word length, and word frequency for the isiXhosa corpus

| | 1 | 2 | 3 |
|---|---|---|---|
| **1. OLD20** | --- | 0.85*** | -0.13*** |
| **2. word length** | | --- | -0.14*** |
| **3. word frequency** | | | --- |

Note: *** = p< .001; OLD20= orthographic Levenshtein distance 20

Further, OLD20 had a negative weak correlation with word frequency (r= -0.13, p< .001). This indicates a weak positive correlation between neighbourhood density and word frequency, such that words with a higher frequency have more dense neighbourhoods. This is consistent with other studies as well, for example in Ferrand *et al.*'s (2018) study on French, OLD20 and word frequency also had a weak negative correlation in French (r = -0.26) (Ferrand *et al.* 2018). Thus neighbourhood density is correlated to word frequency in French in much the same way that it is in isiXhosa. The literature has explained this finding as a result of a three-way interaction between neighbourhood density, word frequency, and word length, whereby, shorter words are generally more frequent and also have more dense neighbourhoods than longer words (Martín & Pérez, 2008; Marian *et al.* 2012; Ferrand *et al.* 2018; Ptáčková & Vitásková, 2020).

### 4.5 Summary of findings: answering research question 1

Chapter 4 served to answer research question 1: *What are the linguistic properties of orthographic neighbours in isiXhosa?* The following is a summary of the findings from this chapter:

- Orthographic neighbours in isiXhosa are very similar in their morphological makeup. Around 40% of the 600 neighbours shared a root morpheme with the target words, and an additional 42% shared a word-initial prefix. These results indicate a significant overlap of meaning similarity with orthographic similarity in the isiXhosa database.
- IsiXhosa orthographic neighbours are very similar to their phonological neighbour counterparts. That is, neighbours differ by a similar number of phonemes as they do letters to the target words. This indicates a large degree of overlap with phonological and orthographic neighbourhoods in isiXhosa.
- Orthographic neighbourhoods in isiXhosa have a high degree of syllabic neighbours (words differing by one or more syllables).

- IsiXhosa words have a higher mean OLD20 value in comparison to English, French, Portuguese, and German. This means that on average, words in isiXhosa have less dense neighbourhoods than in these other four languages.
- Words in isiXhosa differ on average by three letters to other words, this is reminiscent of the open (C)V syllable structure of isiXhosa, and the frequency of complex consonant graphemes in the syllable onset position which usually consist of two or more letters. Further, because morphemes in isiXhosa are syllabic, orthographic neighbours in isiXhosa will differ on average by one syllable, and consequently by one morpheme.
- Shorter words in isiXhosa are more frequent and have less dense neighbourhoods than longer words.

The above findings demonstrate that the study of orthographic neighbours in isiXhosa is a complex linguistic puzzle. To limit one's scope to orthography alone is to leave out potential confounding effects from other linguistic domains such as phonology and morphology. Thus, multiple layers of linguistic structure need to be considered simultaneously in order to understand the role that neighbours play in literacy skills such as reading and writing. These findings will serve as a basis from which conclusions can be made regarding the interaction between neighbourhood effects and reading and writing. These interactions are explored in Chapter 5. The hypothesis for research question one is addressed in Chapter 6.

# CHAPTER 5: THE EFFECTS OF ORTHOGRAPHIC NEIGHBOURS ON WORD READING, LEXICAL DECISION RESPONSE TIME AND SPELLING ACCURACY

## 5.1 Introduction

Chapter 5 reports the results of a quantitative data analysis of three literacy tasks, a word reading task, lexical decision task, and spelling task. The chapter begins with a descriptive overview of the sample demographics and overall reading ability of the sample. These results are compared with the national South African reading benchmarks for Nguni languages (Ardington *et al.* 2020). These comparisons are made in order to provide the reader with contextual information regarding the literacy levels of the study sample. Following the descriptive statistics, multilevel regression analyses are run for each task. The results are discussed in Section 5.6 and compared to relevant literature as discussed in Chapter 2. The chapter concludes by framing these results within psycholinguistic models of orthographic processing.

## 5.2 Sample demographics and overall reading ability

The following section reports on the descriptive statistics of the sample demographic. The sample was drawn from five schools in KwaNobuhle Township in the Eastern Cape. The total sample size after accounting for missing data was 97 participants (see Section 3.8 for exclusion procedures). Of this, 44 participants were female and 46 were male with three missing gender values. All participants were in the beginning of grade three at the time of data collection. As mentioned in Section 3.2, the participants were partaking in a literacy intervention programme run by Volkswagen at the time of the study. The results from two EGRA subtasks: letter-sound knowledge and oral reading fluency are reported here as well as the word reading and spelling tasks which were designed and administered as part of the current study.

Table 22 presents the descriptive statistics for the EGRA tasks. The mean letter-sound knowledge score was 44.1 letters correct per minute (lcpm) for the sample as a whole. This score is only slightly above that of the grade one Nguni language benchmark for letter-sound knowledge, which is 40 lcpm (Ardington *et al.* 2020). Their letter-sound knowledge is therefore well below what is expected for their grade level. Unfortunately there is yet to be an established benchmark for grade three letter-sound knowledge, as such only comparisons to the grade one level can be made.

Table 22: Descriptive statistics for letter-sound knowledge, oral reading fluency assessed as part of the Volkswagen Legacy Literacy Year 3, Round 1 baseline assessments

| | | | | | | | | Skewness | | Shapiro-Wilk | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **gender** | **N** | **Missing** | **Mean** | **SD** | **Min** | **Max** | **Skewness** | **Std. error** | **W** | **p** |
| **Letter-sound knowledge (lcpm)** | female | 46 | 0 | 48.7 | 17.3 | 4.00 | 70.5 | -0.910 | 0.350 | 0.903 | 0.001 |
| | male | 47 | 0 | 39.6 | 20.2 | 0.00 | 70.0 | -0.440 | 0.347 | 0.941 | 0.020 |
| | combined | 93 | 4 | 44.1 | 19.2 | 0.00 | 70.5 | -0.668 | 0.250 | 0.929 | < .001 |
| **Oral reading fluency (wcpm)** | female | 45 | 1 | 19.7 | 15.2 | 0.00 | 55.0 | 0.371 | 0.354 | 0.932 | 0.011 |
| | male | 47 | 0 | 12.8 | 11.1 | 0.00 | 43.0 | 0.804 | 0.347 | 0.920 | 0.003 |
| | combined | 92 | 5 | 16.2 | 13.6 | 0.00 | 55.0 | 0.682 | 0.251 | 0.926 | < .001 |

Note: lcpm= letters correct per minute; wcpm= words-correct-per-minute; SD= standard deviation

The mean oral reading fluency (ORF) score for the sample as a whole was 16.2 words-correct-per-minute (wcpm) which is below the grade two National Nguni threshold. According to this threshold all learners should be reading at least 20 wcpm by the end of grade two (Ardington *et al.* 2020). When factored by gender, female participants had a mean ORF score of 19.7 wcpm, which is bordering the threshold, whilst male participants performed well below this grade two threshold with an average of 12.8 wcpm. Comparisons have been made to the attainment of the grade two threshold because as already mentioned, the sample of learners were at the start of their grade three schooling year at the time of data collection. Thus the learners cannot be expected to be reading at the grade three benchmark level, but rather at the grade two threshold level.

Tests for normality were done using a Shapiro wilk's test, which showed the data were not normally distributed for both subtasks ($p < .001$). Letter-sound knowledge for the combined sample was moderately negatively skewed (skewness= -0.668). Thus, although their letter-sound knowledge is below grade level, the majority of learners scored higher than the mean. Oral reading fluency was moderately positively skewed (skewness= 0.682). This is likely owed to the high proportion of learners who scored zero on the ORF task which can be seen in Figure 11. Non-normal distributions are common of psycholinguistic literacy data and is especially prevalent in studies on South African children who continuously underperform in literacy (Howie *et al.* 2017).

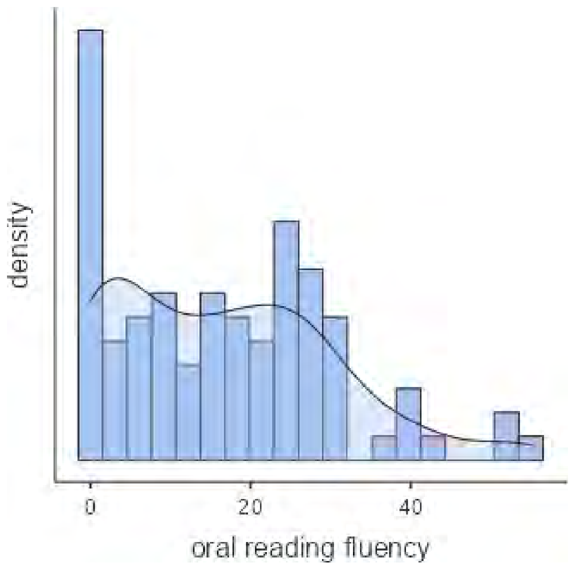


Figure 11: Density plot of ORF scores

The results in Table 22 illustrate the harsh reality of the literacy crisis in South Africa, with learners performing well below their expected grade level. For this sample of learners, letter-sound knowledge, a foundational literacy skill, was just above the level of what is expected of a grade one, this for learners currently in the start of their grade three year. This has a knock-on effect for the learners' oral reading fluency performance, with learners scoring below the grade two threshold for ORF.

The poor performance in these EGRA subtasks is likely to also be reflected in the individual word reading and spelling tasks of the current study. Table 23 presents the descriptive results of the word reading and spelling tasks. The lexical decision response times are not presented in Table 23 as these results can only be interpreted meaningfully when factored by word properties, rather than when considered across the sample. Whereas word reading and spelling can provide meaningful indications of literacy skill both when considered across the sample, and when factored by word properties.

The mean word reading accuracy score out of 20 was 14.2 (71%). Thus on average learners could read 14 words out of 20 correctly. As this task was a measure of word reading accuracy rather than speed, one cannot make direct comparisons to the oral reading fluency scores which was a timed task. However, it is clear that the learners are able to read words in isolation quite successfully, with 50% of learners reading 17 or more words correctly. Thus, there appears to be a disjunct between learners' ability to read words in isolation versus reading words in connected text. This result is also a reflection of the word reading task, in that when learners are granted the opportunity to read all words in the task without time constraints, they perform much better. However in the ORF task where learners are only given a minute to read, their slow reading negatively impacts their ORF score. This suggests that learners in this sample are able to read with relatively high accuracy, but they are slower readers. Ardington *et al.* (2021) explain that readers of transparent orthographies, such as isiXhosa, reach high levels of accuracy quite early, whereas automaticity is developed later.

Table 23: Descriptive statistics for word reading and spelling

| | | | | | | | | | Skewness | | Shapiro-Wilk | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Mean** | **SD** | **Min** | **Max** | **p25** | **p50** | **p75** | **Skewness** | **Std. error** | **W** | **p** |
| **Word reading** | **female** | 14.6 | 7.20 | 0.00 | 20.0 | 13.3 | 18.5 | 20.0 | -1.34 | 0.350 | 0.709 | < .001 |
| | **male** | 13.8 | 7.44 | 0.00 | 20.0 | 11.5 | 17.0 | 19.5 | -1.09 | 0.347 | 0.755 | < .001 |
| | **combined** | 14.2 | 7.15 | 0.00 | 20.0 | 13.0 | 17.0 | 20.0 | -1.21 | 0.245 | 0.740 | < .001 |
| **Spelling** | **female** | 12.5 | 5.84 | 0.00 | 19.0 | 8.25 | 15.0 | 17.0 | -0.824 | 0.350 | 0.874 | < .001 |
| | **male** | 9.89 | 6.54 | 0.00 | 19.0 | 4.00 | 12.0 | 15.0 | -0.370 | 0.347 | 0.888 | < .001 |
| | **combined** | 10.9 | 6.42 | 0.00 | 19.0 | 6.00 | 13.0 | 16.0 | -0.527 | 0.245 | 0.884 | < .001 |

In comparison to word reading learners' performance on spelling was poorer, with learners spelling on average 11 words out of 20 correctly (55%), with 50% of learners spelling 13 or more words correctly (>65%). Learners' poor performance in spelling is likely compounded by their low level of letter-sound knowledge, as spelling is particularly reliant on strong phoneme to grapheme mapping skills (Conrad, 2008; Schaars, Segers & Verhoeven, 2017). Much like in the EGRA subtasks, gender differences are also present in the word reading and spelling results, however these are more prominent in the spelling results than in the word reading. Further, the disparity between word reading and spelling performance for the sample is expected as research has shown that spelling is a more cognitively demanding skill (Schaars, Segers & Verhoeven, 2017).

The results from this section aid in providing a contextual understanding of the sample's overall reading and writing ability. In short, the sample is underperforming in letter-sound knowledge and oral reading fluency in comparison to the National Nguni language reading benchmarks. Although learners are more successful at reading words in isolation than in connected text, their spelling abilities are still quite poor indicating better receptive skills than productive skills. With these general conclusions established, the following section will report the results of the three literacy tasks designed for this thesis: word reading, lexical decision, and spelling, as well as investigate the effects of word factors, particularly orthographic neighbourhood effects, on these literacy skills.

## 5.3 Results by task: word reading, lexical decision, and spelling

The following section reports the results for each task administered: word reading, lexical decision, and spelling. For each task, the mean distribution is reported for the dependent variables (namely, word reading accuracy, lexical decision response time, and spelling accuracy) factored by orthographic neighbourhood density and neighbourhood frequency. Thereafter the inferential statistics are presented and analysed for each task using multilevel regression analyses. As explained in Section 3.9.2.1, multilevel analysis allows for the use of the raw scores for word reading accuracy, lexical decision response time, and spelling accuracy, as opposed to averaging the scores across the sample for each word. This allows for variation across items and across participants to be accounted for in the analysis.

### 5.3.1 Orthographic neighbourhood effects and word reading accuracy

The following section reports the results of the word reading task, in order to answer research question 2a: *What role do orthographic neighbourhood effects play in word reading in isiXhosa grade three learners?*

The mean and standard deviations of the word reading accuracy scores are presented in Table 24 factored by neighbourhood density and neighbourhood frequency. The categories for density and frequency were established as follows, high density words were those with an OLD20 value of less than 3, low density words were those with an OLD20 value of greater than or equal to 3. Words with an OLDF value of less than 10 were categorized as having a low neighbourhood frequency, those with and OLDF value of more than 40 were categorized as having a high neighbourhood frequency. Those in between 10 and 40 were categorized as having a medium neighbourhood frequency[8].

8: As mentioned in Section 3.9.2.1 there were no high density words with a high neighbourhood frequency in this task's stimuli. However, the multilevel analysis uses the continuous variables for OLD20 and OLDF and as such the unbalanced group sizes will not affect the statistical outcomes

Table 24: Mean distribution of word reading accuracy across neighbourhood categories

| High density words (OLD20 < 3) | Low density words (OLD20 ≥ 3) |
|---|---|
| **High neighbourhood frequency (OLDF > 40)** | |
| - | 0.623 (0.030) |
| **Medium neighbourhood frequency (OLDF >10, <40)** | |
| 0.710 (0.084) | 0.667 (0.015) |
| **Low neighbourhood frequency (OLDF <10)** | |
| 0.764 (0.036) | 0.706 (0.092) |

Note: standard deviations are in parentheses

A multilevel regression analysis was conducted to test for a statistically significant relationship between neighbourhood effects and word reading accuracy. First, various diagnostic tests were run on the word reading data to assess whether the data met the assumptions of a multilevel logistic regression. The assumptions of a multilevel logistic regression are similar to those of a traditional logistic regression, with the exception that observations do not need to be independent of one another as multilevel models can account for observation dependence (Maas & Hox, 2004). Firstly, a logistic regression, assumes that the outcome variable is a binary variable with only two options for example, yes or no, true or false, 1 or 0. Secondly, the data must be checked for linearity between the predictor variables and the logit of the outcome variable. Lastly, although not an assumption of the model, multicollinearity, or the degree to which independent variables are correlated, needs to be checked as this could impact the model coefficients (Sonderegger, 2022).

For assumption one, the outcome variable, word reading accuracy, was coded as binary, with an accurate response coded as 1, and an inaccurate response coded as 0. Next, the data were checked for linearity between the predictor and outcome variables. Because the outcome variable, word reading accuracy, is a binary variable, it needed to first be transformed such that linearity could be tested. The logit of word reading accuracy was calculated by taking the inverse of the standard logistic function. This transforms the s-shaped curve of the logistic model, to a linearized distribution that can be interpreted in the much the same way as a linear regression (Kassambara, 2017). Figure 12 shows scatterplots of the predictor variables plotted against the logit of word reading accuracy. From these plots, there is a fairly linear relationship between the predictor variables and the logit of the outcome variable. Thus the assumption of linearity is met satisfactorily.

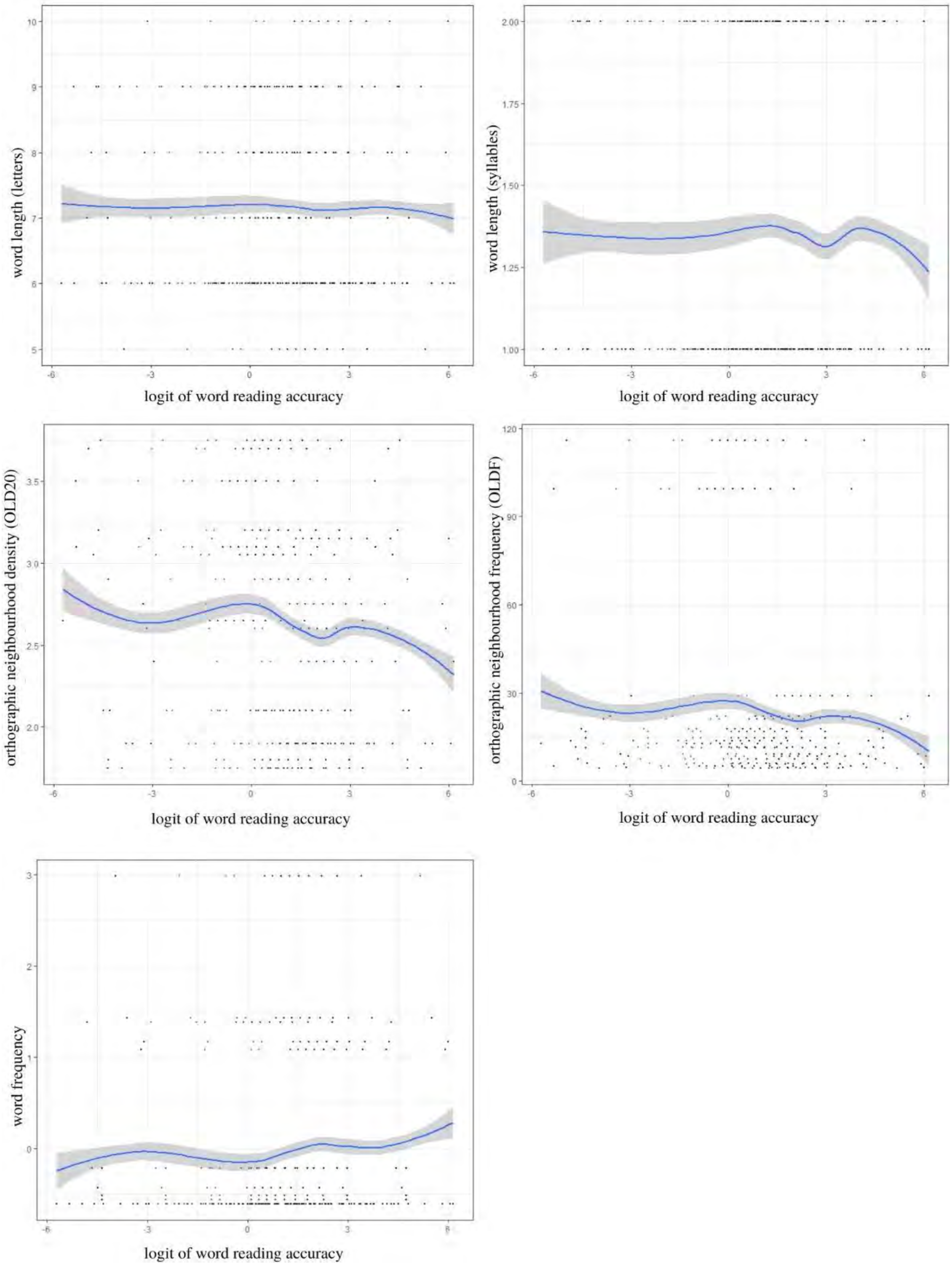


Figure 12: Scatterplots of the predictor variables plotted against the logit of word reading accuracy

Lastly, the degree of multicollinearity between the independent variables was checked. The variance inflation factor (VIF) was calculated for each predictor. Word length in letters had a relatively high VIF (6.55), the other predictor variables all had a low VIF of below 5. Following this, a correlation matrix was run to further test for multicollinearity and to determine which variables were correlated with word length in letters. Table 25 presents the results of the correlation test.

Table 25: Correlation matrix of all predictor variables for word reading accuracy

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| **1.Word length (letters)** | _ | 0.73 *** | 0.44*** | 0.56*** | - 0.27*** | - 0.01 |
| **2. Word length (syllables)** | | _ | 0.37*** | 0.27*** | - 0.31*** | 0.00 |
| **3. Target word frequency** | | | _ | - 0.21*** | - 0.25*** | 0.04 |
| **Neighbourhood density (OLD20)** | | | | _ | 0.35*** | - 0.06* |
| **Neighbourhood frequency (OLDF)** | | | | | _ | - 0.05* |
| **Word reading accuracy** | | | | | | |

Note: *** = p< .001, **= p< .005, *= p< .05

It was found that word length in syllables was strongly correlated with word length in letters ($r = 0.73$, $p < .001$). In addition, word length in letters was also moderately positively correlated with OLD20 ($r = 0.56$, $p < .001$). That is, longer words have a higher OLD20 value and thus have less dense neighbourhoods (because OLD20 is negatively correlated to neighbourhood density: see Section 3.4.1.1). This finding is consistent with the literature on neighbourhood effects which has shown that longer words tend to have less orthographic neighbours and thus sparser neighbourhoods (Martín & Pérez, 2008; Ptáčková & Vitásková, 2020). Other correlations, although significant, were deemed small enough to proceed with the model.

The issue of multicollinearity is a contentious one in the literature on linguistic data, and researchers appear divided on how to deal with it. On the one hand, collinearity between the predictors may result in large changes in the coefficients of the model, as well as unexpected directions of regression lines, and "unexpected nonsignificance" of a predictor (Sonderegger, 2022: 120). However, research also acknowledges that collinearity is simply a "property of the data…and not a violation of model assumptions" (Sonderegger, 2022: 121) and that methods to deal with collinearity, such as residualizing predictors, result in biased results

(Morrissey & Ruxton, 2018). After consultation of the literature and following recommendations from Sondereger (2022) and Morrissey and Ruxton (2018), the collinearity between word length in letters and word length in syllables was deemed unproblematic for the model, in that it makes sense qualitatively (they are a measure of the same characteristic with different metrics). Further, the correlation between word length in letters and OLD20 also makes sense qualitatively. In fact, the developers of the OLD20 metric, Yarkoni, Balota and Yap (2008) point out the strong relationship between OLD20 and word length. They further suggest that previously noted word length effects in the literature may in fact be masked neighbourhood density effects, therefore it is necessary to include both variables in the model. In summary, the collinearity of the predictors in this model is deemed unproblematic for the purposes of this analysis. This does mean that the model may not be as powerful and may report slightly conservative regression coefficients (Sondereger, 2022), however the trade-off for conservativeness is logical in this case owing to the naturally colinear nature of the predictor variables. Table 25 also shows a very weak negative correlation between word reading accuracy and orthographic neighbourhood density ($r = -0.06$, $p < .05$) and neighbourhood frequency ($r = -0.05$, $p < .05$).

Following the diagnostic tests, an empty regression model was fitted to the data which contained only the random effects and no predictors. The model syntax, using the *glme* package in RStudio was as follows: glmer (*word_reading_accuracy* ~ 1 + (1|participants) + (1|items), family= binomial). The model showed an Intraclass Correlation Coefficient (ICC) of 0.79 for participants and 0.04 for items. The ICC indicates "the proportion of the variance explained by the grouping structure in the population" (Hox, 2002: 15). In other words it explains how much of the variance in the outcome is owed to variation between participants and between items. Therefore, 79% of variance in word reading accuracy was due to variation between participants, and 4% was due to variance between items (words used in the task). The high ICC value for participants means that the different levels (different participants) have very similar conditions, that is, they were all exposed to the same words in the task. Further, although the learners were from different schools, they were all enrolled in the Volkswagen Legacy Literacy intervention and were therefore receiving very similar literacy instruction. Thus there is a high degree of homogeneity between participants (Chen, 2018). The remaining unexplained variance in the model is 17%.

A second model was fitted to the data to test whether the predictor variables added any significant variance to word reading accuracy. This model included word length (in letters and in syllables), word frequency, orthographic neighbourhood frequency (OLDF), and orthographic neighbourhood density (OLD20), as well as two random effects: participants and items. The model syntax, again using the *glme* package in RStudio, was as follows: *glmer*(*word_reading_accuracy* ~ 1 + *wordlength_syllables* + *word_frequency* + *OLDF* + OLD20 + (1|*items*) + (1|*participants*), family= binomial (link= logit)). Initially the model did not converge. However through a process of variable elimination it was found that word frequency was on a much larger scale than the other predictor variables, with values ranging from 0 to 668 occurrences per 101 749 tokens. As such the word frequency variable was transformed through scaling and centering, which solved the model convergence issue. The statistics for the word reading model are presented in Table 26.

Table 26: Multilevel logistic regression for word reading accuracy

| | | | | | CI | |
|---|---|---|---|---|---|---|
| **Fixed effects** | ***b*** | **SE** | **z value** | **p** | **5%** | **95%** |
| (Intercept) | 3.53 | 1.67 | 2.10 | 0.04 | 0.24 | 6.81 |
| Word length (letters) | 0.05 | 0.36 | 0.14 | 0.89 | - 0.65 | 0.75 |
| Word length (syllables) | - 0.26 | 0.62 | - 0.41 | 0.68 | -1.48 | 0.97 |
| Target word frequency | 0.14 | 0.30 | 0.48 | 0.63 | - 0.45 | 0.74 |
| Neighbourhood frequency (OLDF) | - 0.01 | 0.01 | - 0.64 | 0.52 | - 0.02 | 0.01 |
| Neighbourhood density (OLD20) | - 0.38 | 0.63 | - 0.61 | 0.54 | - 1.63 | 0.86 |

*No. of observations= 1940, Pseudo $R^2$(fixed effects)= 0.01, Pseudo $R^2$(total)= 0.83, AIC= 1245.04, BIC= 1289.61*

Because the p-values of a multilevel model cannot be interpreted reliably (Sonderegger, 2022), a Likelihood-ratio test was run to test whether the addition of the predictors to the empty model improved the model fit. This showed no significant improvement in model fit ($\chi^2(5)= 3.91$, $p= 0.56$). Therefore none of the predictors explained significant variance in the model. This indicates a null effect of orthographic neighbourhood density and neighbourhood frequency for word reading.

### 5.3.2 Orthographic neighbourhood effects and lexical decision response time

The following section reports the results of the lexical decision task. First, the mean response times are presented, factored by neighbourhood density and neighbourhood frequency categories. Thereafter a multilevel analysis is reported, using a multilevel regression model.

These results are interpreted in line with research question 2b: *What role do orthographic neighbourhood effects play in lexical decision response time in isiXhosa grade three learners?*

The mean response times for the lexical decision task are presented in Table 27, standard deviations are presented in parentheses. Table 27 serves to demonstrate the distribution of lexical decision response times across neighbourhood properties. The neighbourhood frequency and neighbourhood density categories were determined in the same way as for the word reading data (see Section 5.3.1). Response time is measured in seconds.

Table 27: Mean distribution of lexical decision response time across neighbourhood categories

| High density words (OLD20 < 3) | Low density words (OLD20 ≥ 3) |
|---|---|
| **High neighbourhood frequency (OLDF > 40)** | |
| 6.35 (0.97) | 6.35 |
| **Medium neighbourhood frequency (OLDF >10, <40)** | |
| 7.13 (1.46) | 7.13 (0.72) |
| **Low neighbourhood frequency (OLDF < 10)** | |
| 9.33 (0.16) | 9.61 |

A multilevel regression model was fitted to the lexical decision data to test for a significant relationship between lexical decision response time and neighbourhood effects. First, various diagnostic tests were run to test whether the data met the assumptions of a multilevel linear regression. The assumptions for multilevel linear models are similar to those of a simple linear model (Meteyard & Davies, 2020). The only difference being that multilevel models do not assume independence of observations and are therefore robust to correlated observations (Meteyard & Davies, 2020). The data were tested for normal distribution of the model residuals against response time. Figure 13 shows a clear violation of this assumption as the data points are clumped to one side of the distribution.

The positive skewness of response time is typical of data collected for psycholinguistic studies (Balota, Aschenbrenner & Yap, 2013; Lo & Andrews, 2015). This also results in a violation of the assumption of homoscedasticity (Cohen *et al.* 2003). Following Lo and Andrews' (2015) recommendations for non-normally distributed data, this analysis made use of a general linear mixed model (GLMM) or multilevel general linear regression model.

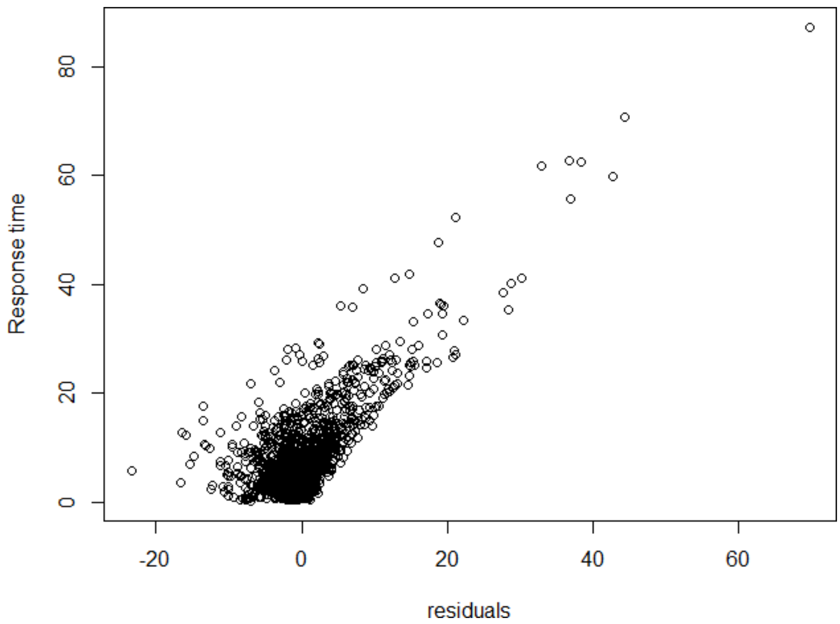


Figure 13: Scatterplot of the model residuals vs lexical decision response time

Before running the regression, the data were checked to see whether the random effects, that is participants and items, were normally distributed. Figure 14 shows a Q-Q plot of the sample quantiles plotted against the theoretical quantiles for the intercept of the random effects. From this graph, there was a fairly normal distribution of the random intercept.

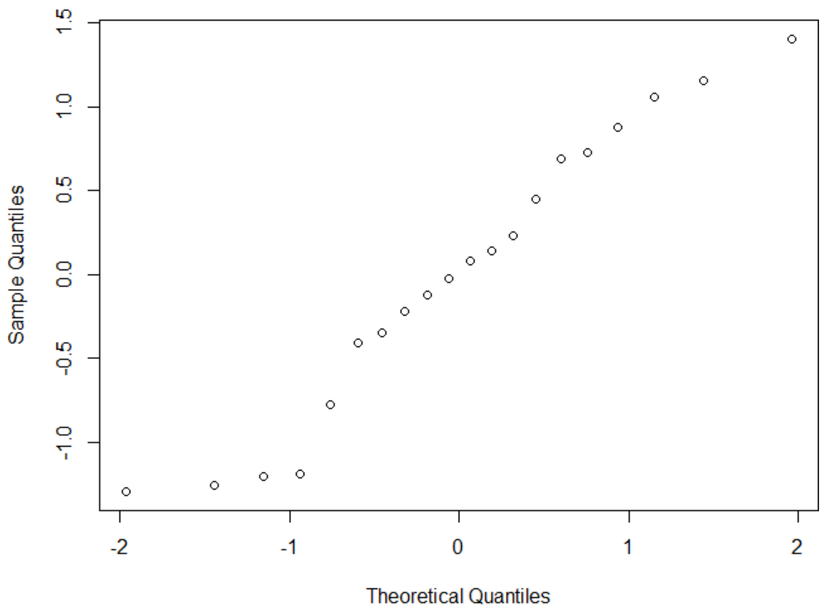


Figure 14: Q-Q plot for the random intercept

Lastly, the data were checked for multicollinearity of the predictor variables. The Variance Inflation Factor (VIF) was low for all variables except word length in letters. A correlation matrix is presented in Table 28 to further investigate multicollinearity. Much like for the word reading data, word length in letters was highly positively correlated with word length in syllables and OLD20. However as with the word reading analysis, the collinearity of the predictors in this model is deemed unproblematic for the purposes of this analysis. Table 28 also shows that all predictors were significantly correlated with response time, of specific interest is the significant weak correlation between response time and neighbourhood density (r = 0.06, $p < .05$) and neighbourhood frequency (r = - 0.08, $p < .001$).

Table 28: Correlation matrix of the predictors for lexical decision response time

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| **1.Word length (letters)** | _ | 0.64*** | - 0.05* | 0.75*** | -0.55*** | 0.11*** |
| **2. Word length (syllables)** | | _ | -0.02 | 0.34*** | -0.27*** | 0.06** |
| **3. Target word frequency** | | | _ | - 0.33*** | 0.02 | - 0.06* |
| **4. Neighbourhood density (OLD20)** | | | | _ | - 0.28*** | 0.06* |
| **5. Neighbourhood frequency (OLDF)** | | | | | _ | - 0.08*** |
| **6. Lexical decision response time** | | | | | | _ |

Note: *** = p< .001, ** = p< .005, * = p< .05

Following the diagnostic tests, an empty model was fitted to the lexical decision data which contained only the random effects and no predictors. The model syntax was as follows: glmer(*LD_response_time* ~ 1 + (1|participants) + (1|items), family= gaussian). The model showed an Intraclass Correlation Coefficient (ICC) of 0.46 for participants and 0.03 for items. Therefore, 46% of variance in word reading accuracy was due to across participant variation, and 3% was due to variance across items (words used in the task).

A second model was then fitted to the data which included all possible predictor variables of response time in order to test whether the predictors contributed significant variance to response time. The model syntax was as follows: glmer(*LD_response_time* ~ 1 + *OLD20* + *OLDF* + *wordlength_letters* + *wordlength_syllables* + *word_frequency* + (1|participants) + (1|items), family= gaussian). The model statistics are presented in Table 29.

Table 29: Multilevel general linear regression for lexical decision response time

| | | | | | | CI | |
|---|---|---|---|---|---|---|---|
| **Fixed effects** | ***b*** | **SE** | **t value** | **df** | **p** | **5%** | **95%** |
| (Intercept) | 3.71 | 2.62 | 1.42 | 15.09 | 0.18 | - 1.42 | 8.85 |
| Word length (letters) | 1.15 | 0.56 | 2.06 | 14 | 0.06 | 0.06 | 2.24 |
| Word length (syllables) | -0.46 | 0.95 | - 0.49 | 14 | 0.63 | -2.32 | 1.40 |
| Target word frequency | - 0.004 | 0.002 | - 1.95 | 14 | 0.07 | - 0.01 | 0.00001 |
| Neighbourhood frequency (OLDF) | - 0.004 | 0.01 | - 0.33 | 14 | 0.75 | - 0.03 | 0.02 |
| Neighbourhood density (OLD20) | - 1.10 | 0.75 | - 1.46 | 14 | 0.17 | - 2.58 | 0.37 |

*No. of observations= 1940, Pseudo $R^2$(fixed effects)= 0.02, Pseudo $R^2$(total)= 0.49, AIC= 12277.07, BIC= 12327.20*

A Likelihood-ratio test was run to test whether the addition of the predictors to the empty model improved the model fit. This returned a significant result ($\chi^2(5)= 12.55$, $p < .05$), indicating that the predictors contributed significant variance to lexical decision response time. To assess which of the variables in the model were significant predictors, additional likelihood ratio tests were conducted. This showed that of the five variables in the predictor model, only word length in letters ($\chi^2(1)= 5.08$, $p < .05$) and word frequency ($\chi^2(1)= 4.63$, $p < .05$) significantly predicted response time. The Beta coefficients (standardized regression coefficients) were calculated to check the effect-size of these significant predictors. It was found that word length predicted 19% (β = 0.19, 95%CI[0.01,0.36]) of lexical decision response time. This means that there is a significant inhibitory effect of word length, with longer words resulting in longer response times. Further, word frequency predicted an additional 8% (β= - 0.08, 95%CI[- 0.17, 0.00]). The negative Beta value indicates that higher frequency words result in shorter response times, thus word frequency has a faciliatory effect on lexical decision response time. There was no significant relationship between neighbourhood effects and response time.

### 5.3.3 Orthographic neighbourhood effects and spelling accuracy

The following section reports the results of the spelling task. The same steps used in the word reading and lexical decision task sections are followed here. First the mean spelling accuracy scores are presented, factored by neighbourhood density and neighbourhood frequency categories. Thereafter the results of a multilevel logistic regression analysis are presented for spelling. These results are interpreted in line with research question 3: *What role do orthographic neighbourhood effects play in spelling in isiXhosa grade three learners?*

The mean accuracy scores for spelling are presented in Table 30, standard deviations are presented in parentheses. Table 30 serves to demonstrate the distribution of spelling accuracy scores across neighbourhood densities and frequencies[9]. Neighbourhood density and frequency were categorized in the same way as for the word reading and lexical decision tasks (see Section 5.3.1 and 5.3.2).

A multilevel logistic regression model was fitted to the spelling data in order to test for a significant relationship between neighbourhood effects and spelling. First, various assumption tests were run to assess the fit of the model to the data. These assumption tests are explained in Section 5.3.1 for word reading.

Table 30: Mean and standard deviation for spelling accuracy split by neighbourhood categories

| High density words (OLD20 < 3) | Low density words (OLD20 ≥ 3) |
|---|---|
| **High neighbourhood frequency (OLDF >40)** | |
| - | 0.394 (0.45) |
| **Medium neighbourhood frequency (OLDF >10, <40)** | |
| 0.55 (0.17) | 0.458 (0.08) |
| **Low neighbourhood frequency (OLDF <10)** | |
| 0.66 (0.17) | 0.713 (0.06) |

The outcome variable, spelling accuracy, was treated as binary with a correct response coded as 1, and an incorrect response coded as 0. Second the data were checked for linearity between the predictor variables and the logit of the response variable (see Section 5.3.1 for an explanation of the logit). Figure 15 shows the scatter plots for each predictor variable plotted against the logit of spelling accuracy. From these plots, there is a fairly linear relationship between the predictors and the logit of the outcome variable.

Lastly, the variance inflation factor (VIF) was calculated to check for collinearity between the predictor variables. All predictor variables had a low VIF score below 2, the low degree of collinearity was further confirmed by a correlation matrix presented in Table 31. Thus the assumptions for a multilevel logistic regression analysis were met satisfactorily.

9: As mentioned in Section 3.9.2.1 there were no high-density words with a high neighbourhood frequency in this task's stimuli. However, the multilevel analysis uses the continuous variables for OLD20 and OLDF and as such the unbalanced group sizes will not affect the statistical outcomes.

From Table 31, all predictors aside from word frequency had a significant weak correlation with spelling accuracy, of particular interest is the significant weak correlations between spelling accuracy and neighbourhood density (r = - 0.10, $p < .001$) and neighbourhood frequency (r = - 0.17, $p$
$< .001$).

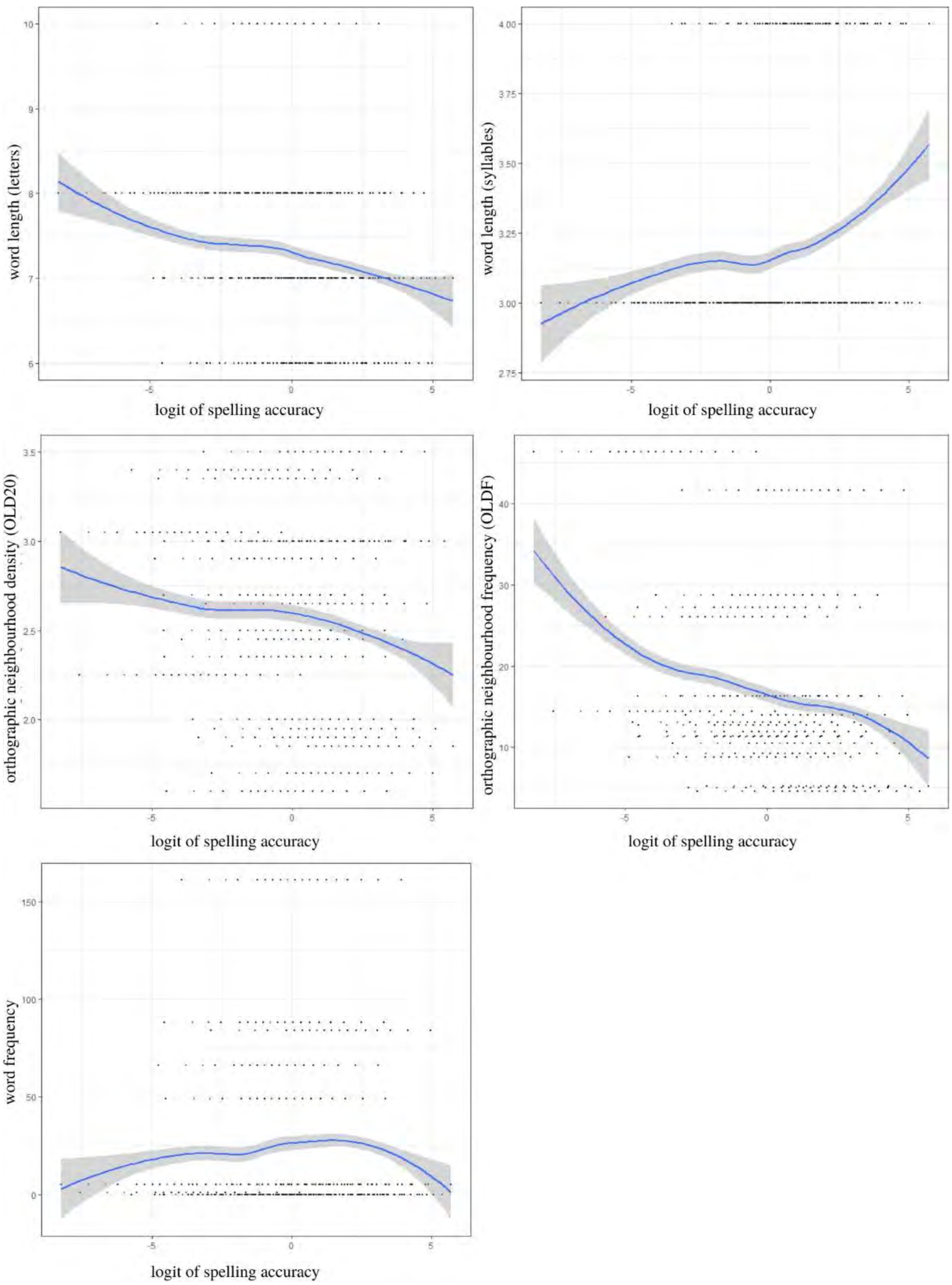


Figure 15: Scatterplots of the predictor variables against the logit of spelling accuracy

Table 31: Correlation matrix of the predictors of spelling accuracy

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| **1. Word length (letters)** | _ | 0.13*** | 0.30*** | 0.39*** | - 0.03 | - 0.14*** |
| **2. Word length (syllables)** | | _ | - 0.23*** | - 0.05* | - 0.27*** | 0.15*** |
| **3. Target word frequency** | | | _ | - 0.21*** | 0.08*** | 0.03 |
| **4. Neighbourhood density (OLD20)** | | | | _ | 0.33*** | - 0.10*** |
| **5. Neighbourhood frequency (OLDF)** | | | | | _ | - 0.17*** |
| **6. Spelling accuracy** | | | | | | _ |

Note: *** = p< .001, **= p< .005, *= p< .05

Following the diagnostic tests, an empty model was run which contained only participants and items as random effects: glmer(*spelling_accuracy* ~ 1 + (1|participants) + (1|items), family= binomial). The model showed an ICC of 0.55 for participants, and 0.21 for items, thus 55% of variance in spelling is explained by between participant variation, and 21% is explained by between item variation, 24% of unexplained variance remains.

A second model was fitted to the data which included all possible predictors of spelling: glmer(*spelling_accuracy* ~ 1+ *wordlength_letters* + *wordlength_syllables* + *word_frequency* + *OLDF* + *OLD20* + (1|participants) + (1|items), family= binomial (link= logit)). The full model statistics are presented in Table 32.

Table 32: Multilevel logistic regression for spelling accuracy

| | | | | | CI | |
|---|---|---|---|---|---|---|
| **Fixed effects** | ***b*** | **SE** | **z value** | **p** | **5%** | **95%** |
| **(Intercept)** | 1.04 | 2.64 | 0.39 | 0.69 | - 4.14 | 6.22 |
| **Word length (letters)** | - 1.20 | 0.31 | - 3.83 | 0.001 | - 1.82 | - 0.59 |
| **Word length (syllables)** | 1.96 | 0.66 | 2.98 | 0.003 | 0.672 | 3.25 |
| **Target word frequency** | 0.02 | 0.01 | 2.77 | 0.01 | 0.01 | 0.03 |
| **Neighbourhood frequency (OLDF)** | - 0.08 | 0.02 | - 3.12 | 0.002 | - 0.12 | - 0.03 |
| **Neighbourhood density (OLD20)** | 0.91 | 0.55 | 1.65 | 0.10 | - 0.17 | 1.99 |

*No. of observations= 1940, Pseudo $R^2$(fixed effects)= 0.13, Pseudo $R^2$(total)= 0.76, AIC= 1624.72, BIC= 1669.29*

A Likelihood-ratios test was run to test whether the addition of the predictors improved the model fit. This returned a significant result ($\chi^2(5)$= 18.78, *p* = .002) which showed the predictors contributed significant variance to spelling accuracy. To assess which of the variables in the model were significant predictors, additional Likelihood-ratio tests were conducted. These showed that four of the five variables in the model significantly predicted spelling accuracy: word length in letters ($\chi^2(1)$= 11.17, *p* < .001), word length in syllables

($\chi^2(1)$= 7.35, $p$ < .05), word frequency ($\chi^2(1)$= 6.5, $p$ < .05), and OLDF ($\chi^2(1)$= 8.03, $p$ < .005).

Because the Beta estimate of the logistic regression cannot be directly interpreted in the same was as for a linear regression, the odds ratios or exponentiated Beta coefficients ($e^\beta$) of the predictor variables were calculated in order to test for effect size. These are presented in Table 33. The odds ratio of a variable indicates the probability of spelling a word correctly relative to spelling it incorrectly when all other variables are held constant. Specifically, an odds ratio of one is interpreted as a null effect, an odds ratio above one indicates a positive or facilitative relationship between the predictor and spelling accuracy, whereas an odds ratio below one indicates a negative or inhibitory relationship between the predictor and spelling accuracy.

Table 33: Odds ratios for the significant predictors of spelling accuracy

| | | CI | |
|---|---|---|---|
| **Parameter** | **Odds Ratio ($e^\beta$)** | **5%** | **95%** |
| **(Intercept)** | 1.11 | 0.54 | 2.28 |
| **Word length (letters)** | 0.30 | 0.16 | 0.56 |
| **Word length (syllables)** | 2.19 | 1.31 | 3.68 |
| **Word frequency** | 2.27 | 1.27 | 4.05 |
| **OLDF** | 0.42 | 0.25 | 0.73 |

From Table 33, word length in letters has an odds ratio of 0.30, this indicates an inhibitory relationship. This means that the odds of spelling a word correctly when word length increases by one standard deviation are 0.3 to 1. In other words, the odds of spelling a long word correctly are less than half times the odds of spelling a short word correctly. To make the effect more tangible, one can calculate the change in odds by using the following formula: $e^\beta$ -1* 100. The change in odds is a calculation of the percentage change experienced in the outcome, that is associated with a one-unit increase (in this case a one standard deviation increase) in the predictor. For word length in letters this results in a change in odds of 70%. Therefore, an increase in the length of a word (in letters) results in a 70% decrease in the odds of spelling that word correctly.

Interestingly, word length in syllables has an odds ratio of 2.19, which indicates a faciliatory effect. In other words the odds of spelling a word with a high number of syllables correctly are twice the odds of spelling a word with a low number of syllables correctly. The change in odds shows that an increase in the length of a word (in syllables) results in a 119% increase in the odds of spelling that word correctly. Thus word length when measured in letters has an inhibitory effect on spelling in this dataset, however when measured in syllables it appears to have a faciliatory effect. This seemingly contradictory finding is unpacked more in Section 5.4.1, but as a summary, when holding the number of letters constant, a word with more syllables should be easier to spell than a word with less syllables. This is because a ten-letter word with three syllables likely has many complex consonant graphemes, whereas a ten-letter word with four syllables will likely have more simple consonant graphemes. This finding is interrogated more thoroughly in Section 5.4.1.

Table 33 shows that word frequency has an odds ratio of 2.27, which indicates a faciliatory effect. This means that the odds of spelling a high frequency word correctly are more than twice the odds of spelling a low frequency word correctly. The change in odds for word frequency showed that an increase in the frequency of a word is associated with a 127% increase in the odds of spelling that word correctly.

Lastly, orthographic neighbourhood frequency had an odds ratio of 0.42, which indicates an inhibitory effect. In other words, the odds of spelling a word with a high neighbourhood frequency correctly are less than half times the odds of spelling a word with a low neighbourhood frequency correctly. Further, the change in odds shows that an increase in the neighbourhood frequency of a word results in a 58% decrease in the odds of spelling that word correctly.

These results indicate an inhibitory effect of both neighbourhood frequency and word length in letters for spelling accuracy in isiXhosa. And a faciliatory effect of word length in syllables and word frequency. These results are discussed in more detail in Section 5.6.

### 5.4 Additional findings: unpacking the role of word length and word frequency

Additional findings which need to be unpacked are the disparity between the two metrics for word length: letters and syllables, as well as the finding of a word length and word frequency effect for response time and spelling, but not for word reading. Although these findings do not form the core focus of this thesis, nor do they fall under a specific research question, it is necessary to interrogate them as both word length and word frequency are important control variables when studying neighbourhood effects.

### 5.4.1 Measuring word length: syllables or letters

Beginning with the word length metrics, two metrics for word length were included in this study: number of syllables, and number of letters. Both were included as research has shown that the different metrics have different effects on literacy skills such as word reading (New *et al.* 2006). In a language such as isiXhosa, which has very little research on the effects of word length on literacy, it is important to cover all bases. The results for the present study indicate that the effect of word length varies by metric for all three literacy measures: word reading accuracy, response time, and spelling accuracy.

This variation is illustrated in Table 34 which shows the Pearson's correlation coefficients for the two word length metrics and the three literacy measures.

Table 34: Correlation matrix showing Pearson's correlation coefficients for word length metrics and literacy outcomes

| | word length letters | word length syllables |
|---|---|---|
| Word reading accuracy | - 0.01 | 0.00 |
| Lexical decision response time | 0.11*** | 0.06** |
| Spelling accuracy | - 0.14*** | 0.15*** |

Because different sets of words were used as stimuli for each literacy assessment, each dataset needs to be analysed in isolation before general claims can be made. The lack of a word length effect for both metrics in word reading accuracy is discussed later in this section, therefore this discussion will mainly focus on the disparity of word length effects across metrics for lexical decision response time and spelling.

Word length in letters and in syllables was weakly positively correlated with response time, however only word length in letters was a significant predictor of response time (see Section 5.3.2). What is interesting is that word length in letters and syllables were moderately positively correlated to each other for the lexical decision data set (r= 0.64, $p < .001$). This means that words with more syllables also had more letters, and yet only word length in letters significantly predicted response time. The lack of a syllable word length effect for response time is somewhat unexpected, however, this may be owed to the type of linguistic processing which is required by the lexical decision task. That is, the lexical decision task is a purely visual task and does not involve any auditory processing. Since syllables are a phonological unit, the number of syllables in a word does not appear to affect the processing time for words in the lexical decision task. Whereas letters are an orthographic unit and as such their effect is more tangible for a visual modality-based task. This finding is supported by Barton *et al.* (2014) who suggest that the syllable unit is more suited for measuring word length in relation to phonological aspects of literacy, whereas the letter unit is suitable for investigation into visual aspects of literacy.

The results of word length for spelling accuracy are more complex. Table 34 shows a weak negative correlation between word length in letters and spelling accuracy, but a positive correlation between word length in syllables and spelling accuracy. Further, Section 5.3.3 reports that word length in letters had a significant inhibitory effect on spelling accuracy, whereas word length in syllables had a significant faciliatory effect. Therefore words with more letters were spelt less accurately, but words with more syllables were spelt more accurately. This result may seem contradictory, however closer inspection reveals a logical explanation. Table 31 in Section 5.3.3 shows a very low correlation between word length in letters and word length in syllables ($r = 0.13$, $p < .001$) for the words used in the spelling task in comparison to the other datasets. Further investigation revealed that this was likely owed to the variance in letter length for three and four syllable words in the spelling task, with some three syllable words consisting of more letters than some of the four syllable words. For example, *ngaphandle* is three syllables but 10 letters, whereas *elusizi* is four syllables but seven letters. Further, if one holds letter length constant, words with more syllables will naturally have less letters per syllable. For example the words *elininzi* and *umngxuma* are both eight letters in length, however *elininzi* has four syllables whereas *umngxuma* has three syllables. The average length of the syllables in *elininzi* is two letters, whereas the average length of the syllables in *umngxuma* is 2.6 letters. Research has shown that complex consonant graphemes such as those in the onset of the second syllable of *umngxuma* often result in spelling errors (Daries and Probert, 2020). Thus, when holding letter length constant, a word such as *elininzi* will be easier to spell than *umngxuma* even though it has more syllables than the former. In this way, an increase in the number of syllables in a word can actually facilitate the spelling of that word, as reported in Section 5.3.3.

Although the findings of this study are based on a very small sample of words, they indicate the need for sensitivity towards the word length metric for isiXhosa. They also suggest the need for further research to establish the specific interactions of word length metrics across task modalities, that is visual versus auditory based tasks.

### 5.4.2 Word length and word frequency effects across tasks

Word length and word frequency effects were found for the lexical decision and spelling tasks; however no such effects were found for the word reading task. This section interrogates this finding further.

Figures 16, 17, and 18 illustrate the disparity of the word length effect across lexical decision response time, spelling accuracy and word reading accuracy respectively. Note that word length in letters is used in this discussion following conclusions from Section 5.4.1 regarding the disparity of the word length metrics. Figure 16 illustrates how words with more letters resulted in longer response times. Figure 17 indicates a similar inhibitory effect of word length for spelling, with longer words resulting in higher error rates. However Figure 18 shows no effect of word length on word reading accuracy.

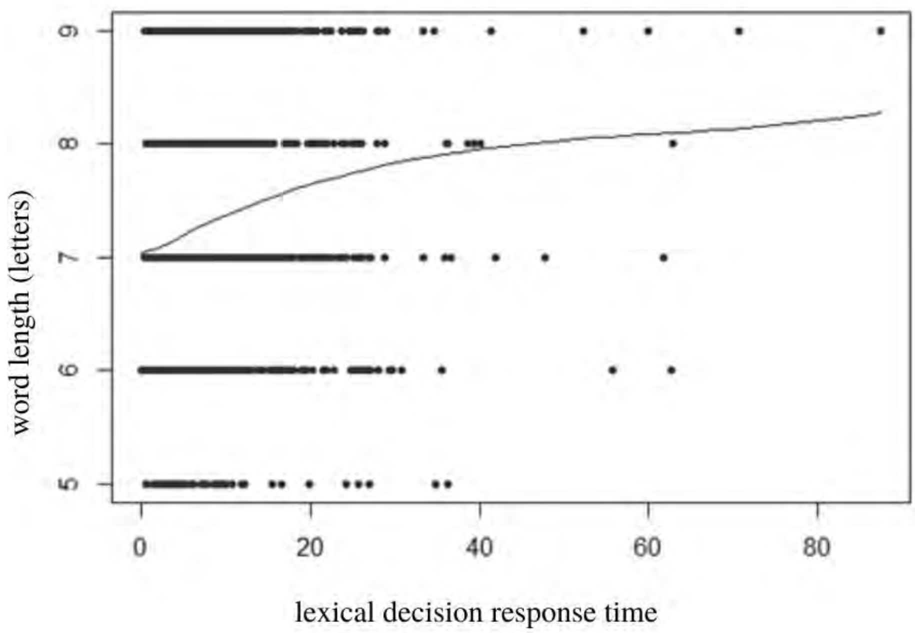


Figure 16: Line graph of lexical decision response time plotted against word length (letters)

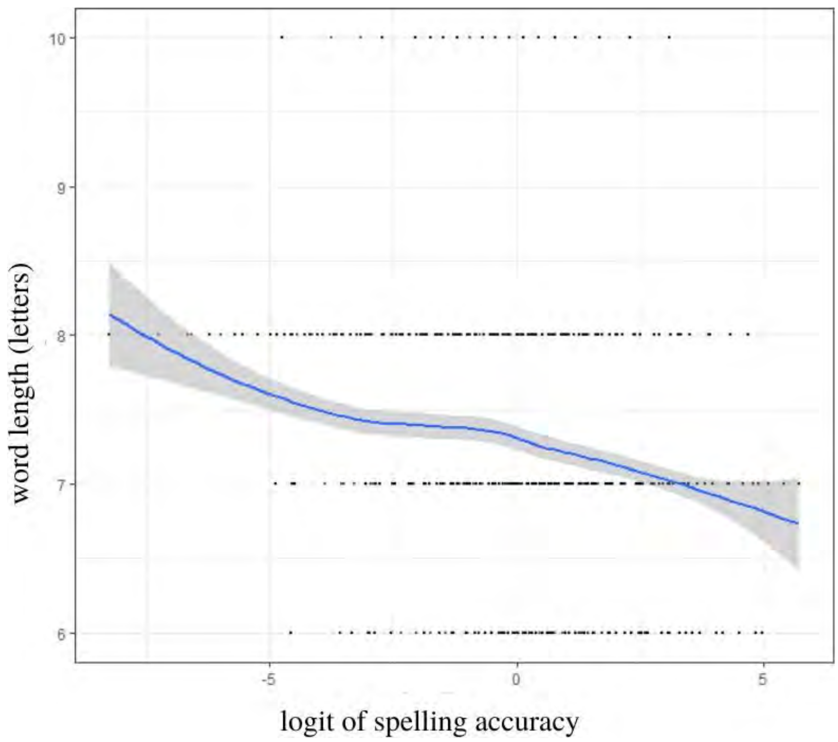


Figure 17: Line graph of the logit of spelling accuracy plotted against word length (letters)

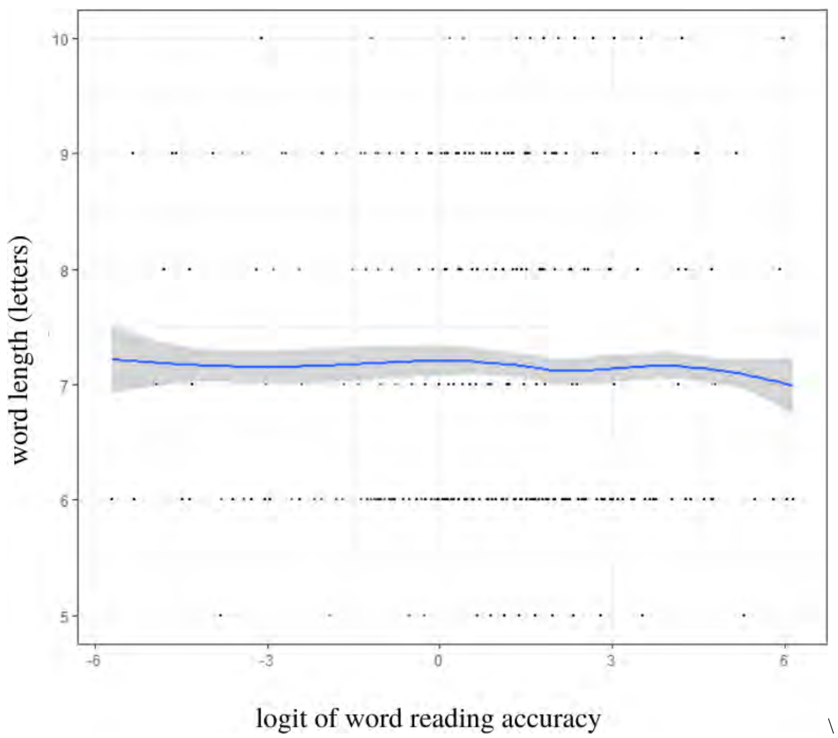


Figure 18: Line graph of the logit of word reading accuracy plotted against word length (letters)

The lack of a word length effect for word reading may be owed to a bias of stimuli selection. To investigate this more, Table 35 reports the descriptive statistics for word length by task, including the mean, standard deviation, variance, range, percentiles, and a Shapiro wilks test.

Table 35: Descriptive statistics for word length (in letters) for task stimuli by task

| | | | | | | | | Shapiro-Wilk | |
|---|---|---|---|---|---|---|---|---|---|
| Task stimuli | Mean | SD | Variance | Range | p25 | p50 | p75 | W | p |
| word reading task | 7.15 | 1.46 | 2.13 | 5 | 6.00 | 6.50 | 8.25 | 0.858 | 0.007 |
| LD task | 7.25 | 1.21 | 1.46 | 4 | 6.00 | 7.00 | 8.00 | 0.911 | 0.066 |
| spelling task | 7.25 | 1.02 | 1.04 | 4 | 6.75 | 7.00 | 8.00 | 0.855 | 0.006 |

Note: SD= standard deviation, p*n*= $n^{th}$ percentile

From Table 35, there is more variation in word length for the stimuli in the word reading task than in the other two tasks. This is evident in the higher variance coefficient (2.13) as well as the higher range (5). The standard deviation is also higher than for the other two tasks' stimuli, which indicates that the word length values are more dispersed around the mean. This could explain why no significant correlation was discovered between word length and word reading accuracy. The current study originally accounted for variation in word length in terms of the number of syllables, and then considered word length in letters post hoc after data collection had been conducted. Future studies may wish to account for equal variance in word length in letters when selecting stimuli across tasks, in addition to ensuring an equal range of syllable length.

Similarly to word length, word frequency (the number of times the target word appeared in the corpus) had a significant faciliatory effect in both the lexical decision and spelling task, but no effect in the word reading task. This finding can once again be explained as an effect of stimuli selection. Table 36 shows the descriptive statistics for word frequency across tasks. These statistics are presented for the full datasets for each task (all words used in each task) as well as for the real words used in each task, since pseudowords do not have a frequency score. From Table 36, it is evident that there is substantially more variance in word frequency for the words in the lexical decision and spelling tasks in comparison with those in the word reading task, and this is true for the real word stimuli subset and for the full data set of stimuli.

Table 36: Descriptive statistics for word frequency of task stimuli across tasks

| | | | | | | | | | Shapiro Wilk | |
|---|---|---|---|---|---|---|---|---|---|---|
| Task stimuli | subset | Mean | SD | Variance | Range | p25 | p50 | p75 | W | p |
| word reading | | | | | | | | | | |
| | real words | 28.1 | 27.3 | 745 | 82 | 5.25 | 24 | 44.8 | 0.86 | 0.08 |
| | full dataset | 14.1 | 23.7 | 561 | 83 | 0.00 | 0.5 | 16.5 | 0.66 | < .001 |
| Lexical decision | real words | 116 | 205 | 42076 | 667 | 6 | 37 | 99.3 | 0.62 | < .001 |
| | full dataset | 57.9 | 153 | 23460 | 668 | 0.00 | 0.5 | 23 | 0.438 | < .001 |
| Spelling | real words | 46.9 | 53.3 | 2843 | 160 | 5 | 27 | 79.5 | 0.83 | 0.03 |
| | full dataset | 23.4 | 43.9 | 1925 | 161 | 0 | 0.5 | 16 | 0.61 | < .001 |

Most noticeable is the higher variance and range in word frequency for the lexical decision and spelling stimuli. Much like for word length, this could explain why there was no significant effect of word frequency for word reading accuracy. Future research may wish to consider the effects of variance and range of independent variables such as word length and word frequency as these appear to be sensitive to the predictive power of variables.

### 5.5 Summary of Chapter 5 results: answering research questions 2a, b, 3 and 4

- The sample's overall reading performance was below their expected grade level. Learners underperformed in letter-sound knowledge and oral reading fluency in comparison to the National Nguni language reading benchmarks (Ardington et al., 2020). Learners appear to be more successful at reading words in isolation than in connected text, however their spelling abilities are still quite poor indicating better receptive skills than productive skills.
- Word reading displayed no significant relationship with neighbourhood density or neighbourhood frequency, nor with word length and word frequency according to a multilevel logistic regression.
- Lexical decision response time showed no significant relationship with neighbourhood effects. However, word length (in letters) explained 19% of variance in lexical decision response time, and word frequency predicted an additional 8%. Thus word length had an inhibitory effect on response time, with longer words resulting in longer latencies, and word frequency had a faciliatory effect with higher frequency words resulting in shorter latencies.
- Orthographic neighbourhood frequency had an inhibitory effect on spelling accuracy. An increase in the neighbourhood frequency of a word was associated with a 58%

decrease in the odds of spelling that word correctly. This was compounded by word length (when measured in letters) which also had an inhibitory effect on spelling. Specifically, an increase in word length was associated with a 70 % decrease in the odds of spelling a word correctly.

- Both word frequency and word length in syllables had a significant faciliatory effect on spelling accuracy. Words with a higher frequency were more likely to be spelt correctly. Specifically, an increase in word frequency was associated with a 127% increase in the odds of spelling a word correctly. Words with more syllables were more likely to be spelt correctly, with an increase in the number of syllables of a word associated with a 119% increase in the odds of spelling that word correctly.
- Orthographic neighbourhood density had no significant effect on spelling accuracy.

These findings are discussed in more detail in the following section and comparisons are drawn to relevant literature.

### 5.6 Discussion of results: orthographic neighbourhood effects in isiXhosa word reading, lexical decision, and spelling

The above findings will be discussed in light of research question 2 to 4, as well as with regards to Hypotheses 2 to 4 as set out in Chapter 3. These alternative hypotheses are repeated here for ease of reference.

Hypothesis H(2): Orthographic neighbourhood effects in word reading (lexical decision and word naming) will be similar to those reported for languages other than English. That is, orthographic neighbourhood density will have a faciliatory effect in word reading, and orthographic neighbourhood frequency will have an inhibitory effect.

Hypothesis H(3): Orthographic neighbourhood effects for spelling will be similar to those of word reading with faciliatory neighbourhood density effects and inhibitory neighbourhood frequency effects.

Hypothesis H(4): Connectionist models of orthographic processing will best explain the results of the study, as these models can account for both inhibitory and faciliatory neighbourhood effects as hypothesized above.

### 5.6.1 Orthographic neighbourhood effects in word reading: answering research question 2a

Orthographic neighbourhood effects did not play a significant role in word reading accuracy in isiXhosa. There was a weak negative correlation between word reading accuracy and orthographic neighbourhood density (r = - 0.06, $p< .05$) and neighbourhood frequency (r = - 0.05, $p< .05$). However, a multilevel logistic regression showed that neither neighbourhood density nor neighbourhood frequency significantly predicted word reading accuracy. Therefore, although there is a slight correlation between neighbourhood effects and word reading, this relationship is not causative.

This finding is inconsistent with the literature on neighbourhood effects which has consistently reported some effect of orthographic neighbours on reading, be it faciliatory or inhibitory. For example, the majority of studies report faciliatory neighbourhood density effects for reading, and inhibitory neighbourhood frequency effects, and this is mostly consistent across languages (see Siakaluk, Sears & Lupker, 2002; Slattery, 2009; Barnhart & Goldinger, 2015; Lim, 2016; and Parker *et al.* 2021 for English, De Moor & Brysbaert, 2000; Boot & Pecher, 2008; and Brysbaert *et al.* 2015 for Dutch, Grainger *et al.* 1989; Grainger & Segui, 1990; Mathey & Zagar, 2000; Ziegler, Perry & Coltheart, 2003; and Ferrand *et al.* 2018 for French, and Carreiras, Perea & Grainger, 1997; Goswami, Gombert & De Barrera, 1998; and Acha & Perea, 2008 for Spanish).

One exception is Kapnoula *et al.*'s (2017) study on neighbourhood effects in Greek who found null density effects for word reading, in both a timed word naming and lexical decision task. The authors suggest that this is owed to the long morphologically complex words in Greek which naturally result in sparser orthographic neighbourhoods. This reasoning could also be applied to isiXhosa, as was shown in Section 4.4, isiXhosa has a low mean neighbourhood density (OLD20= 3.04) compared to English (OLD20= 2.87), French (OLD20= 2.02), Portuguese (OLD20= 2.7), and German (OLD20= 1.77). It was proposed in Section 4.4, that the low density is likely attributable to the agglutinative morphology of isiXhosa, as well as its highly regular syllable structure. These linguistic properties mean that neighbours will differ on average by one morpheme, further because morphemes in the language are usually syllabic, neighbours will also differ by one syllable. This means that orthographic neighbours in isiXhosa are not very close in spelling in comparison to other languages where neighbours differ on average by 1 or 2 letters. Much like in Greek then, a neighbourhood density effect is nullified by the low degree of words with orthographically dense neighbourhoods, such that the closeness of a word's neighbours does not provide any significant facilitation nor hindrance to the reader.

The lack of an effect for neighbourhood frequency in isiXhosa word reading is harder to interpret, as little to no studies which include neighbourhood frequency as a variable have found null effects (see Table 3 in Section 2.9.2.1). The result of the present study may then be owed to a task effect. The present study made use of an untimed word naming task, whereas other studies in the literature have made use of a variety of word reading tasks including timed word naming tasks (Carreiras, Perea & Grainger, 1997; Barnhart & Goldinger, 2015), perceptual identification tasks (Grainger & Jacobs, 1996; Sears, Lupker & Hino, 1999; Grainger *et al.* 2005), and semantic categorization tasks (Carreiras, Perea & Grainger, 1997; Sears, Lupker & Hino, 1999; Bowers, Davis & Hanley, 2005a, 2005b; Boot & Pecher, 2008). With the majority of studies using a lexical decision task to measure neighborhood effects on word reading (Grainger & Jacobs, 1996; Siakaluk, Sears & Lupker, 2002; Grainger *et al.* 2005; Mathey *et al.* 2006; Lim, 2016; Meade, Grainger & Declerck, 2021; Parker *et al.* 2021). These tasks appear more robust to measuring neighbourhood effects than an untimed word naming task, as demonstrated by the present study's findings, which in itself provides valuable information for future studies on neighbourhood effects in isiXhosa.

The word reading task of the current study was primarily included as an exploratory measure to determine whether neighbourhood effects can be measured using a simplified and accessible task such as the untimed word naming task This task is considered accessible because it does not require the use of technology or specialized psycholinguistic software such as Psychopy, or timing apparatus and can be conducted purely with words on printed flashcards. Thus if capable of capturing neighbourhood effects, such a task would be a more feasible tool for teachers and researchers. However, from the results this type of task could potentially be ruled out as an ineffective measure of neighbourhood effects. But since there is no other research on neighbourhood effects in isiXhosa, it could also be that neighbourhood effects simply do not interact with word reading in isiXhosa, a finding which is supported by the results of the lexical decision task.

### 5.6.2 Orthographic neighbourhood effects in lexical decision: answering research question 2b

Orthographic neighbourhood effects did not play a significant role in lexical decision response time. There was a weak positive correlation between response time and neighbourhood density (r = 0.06, $p < .05$) and a weak negative correlation between response time and neighbourhood frequency (r = - 0.08, $p < .001$). However a multilevel regression analysis showed that neither variable significantly predicted lexical decision response time. Thus, although there is a correlation between neighbourhood effects and response time, this relationship is not causative. This finding is consistent with the findings for the word reading data reported above.

Much like the findings for word reading, this result is also inconsistent with the results of other studies which show a robust relationship between lexical decision response time and both neighbourhood density and neighbourhood frequency cross-linguistically (see Lim, 2016 and Parker *et al.* 2021 for English, Brysbaert *et al.* 2015 for Dutch, Ziegler, Perry & Coltheart, 2003 and Ferrand *et al.* 2018 for French, Carreiras, Perea & Grainger, 1997 for Spanish, Yap *et al.* 2010 for Malay, and Erten, Bozsahin & Zeyrek, 2014 for Turkish). Owing to the robust nature of the lexical decision task in predicting neighbourhood effects in other languages, the finding of null effects in the present study cannot be reduced to a task effect. Further, because a lexical decision task is considered a measure of word reading (see Section 2.5.4.1), combined with the null results for the untimed word naming task reported above, this suggests that orthographic neighbourhood effects do not interact with word reading in isiXhosa. The source of this null effect is however less certain. Predictions can be made with reference to the findings for neighbourhood effects in spelling in the following section.

### 5.6.3 Orthographic neighbourhood effects in spelling: answering research question 3

Orthographic neighbourhood frequency had a significant inhibitory effect on spelling accuracy, whereby words with a higher neighbourhood frequency were more likely to be spelt incorrectly. However, orthographic neighbourhood density had no significant effect on spelling accuracy. These findings were obtained through a multilevel logistic regression. Likelihood-ratio tests showed that neighbourhood frequency contributed significant variance to spelling accuracy in the model ($\chi^2(1)= 8.03$, $p < .005$), however neighbourhood density did not ($\chi^2(1)= 2.56$, $p = 0.11$). Further analysis showed that an increase in neighbourhood frequency was associated with a 58% decrease in the odds of spelling a word correctly. Thus words with high neighbourhood frequencies result in large inhibitory effects for spelling accuracy in isiXhosa.

This inhibitory effect of neighbourhood frequency on spelling is consistent with studies on orthographic neighbours in reading in other languages which report a competitive effect of higher frequency neighbours (see Slattery, 2009 and Newman, German & Jagielko, 2017 for English, De Moor & Brysbaert, 2000 for Dutch, Grainger & Jacobs, 1996: Experiments 1 and 3 for French, and Carreiras, Perea & Grainger, 1997 and Acha & Perea, 2008 for Spanish). That is, higher frequency neighbours compete for lexical access when reading. This finding suggests an extension of this competitive effect to spelling as well. Further this finding is also consistent with research on phonographic neighbours in spelling (Lété, Peereman & Fayol, 2008; Maggio *et al.* 2012). Other research on orthographic neighbours in spelling using linguistic error analysis report a prevalence of spelling errors which can be attributed to competition from neighbours (Folk, Rapp & Goldrick, 2002; Burt & Blackwell, 2008; Andrews & Hersch, 2010) much like the results of the present study.

A pressing question remains as to why neighbourhood frequency interacts with spelling but not with word reading in isiXhosa. In their study on English children, Laxon, Coltheart and Keating (1988) reported stronger neighbourhood effects for spelling than for reading. This finding was specifically for neighbourhood density, thus the findings for isiXhosa suggest an extension of the word reading-spelling disparity into neighbourhood frequency as well. This disparity between neighbourhood effects in word reading versus in spelling could be an indication of the different linguistic knowledge that is drawn on when spelling in comparison to that used when reading. It has been acknowledged in the literature that spelling requires more advanced knowledge of phoneme to grapheme mappings (Conrad, 2008; Schaars, Segers & Verhoeven, 2017). It is also true that spelling requires a more sophisticated level of orthographic knowledge as well, for example, Daries (2022) showed that orthographic awareness was a significant predictor for spelling in isiXhosa. Therefore, when spelling in isiXhosa, learners may draw on knowledge of similar orthographic forms to help in the spelling of words, albeit unsuccessfully. Whereas when reading, learners may not need to rely on this knowledge as explicitly and can get by with word-specific orthographic information. What is evident is that orthographic neighbours, specifically higher frequency neighbours, are activated in the lexicon when spelling in isiXhosa.

Another explanation for the discrepancy between word reading and spelling results, may be the presence of a masked phonological neighbourhood effect. As discussed in Section 4.3 the overlap of orthographic neighbours with phonological neighbours is substantial in isiXhosa, with neighbours differing by a similar number of phonemes as letters from a target word. Thus, an orthographic neighbourhood effect may in fact be masking a phonological neighbourhood effect. This potentially confounding issue has been brought up by other researchers who note that "in reality the effect of orthography is not limited to visual word processing but also extends to auditory processing" (Marian, 2017: 9) and vice versa. Thus, the study of orthographic neighbours will always overlap to some degree with phonological neighbours, especially when the language in question has a transparent orthography. Further, because the spelling task includes an auditory component whereby the participant must first listen to the word spoken aloud before writing the word down, phonological neighbours may be more active during an auditory spelling task than they are for a visual word reading task. Thus again, the observed orthographic neighbourhood frequency effect for spelling may be indicative of a masked phonological neighbourhood effect, which could potentially explain why no such effect was observed for word reading.

The lack of a neighbourhood density effect for spelling can be explained in much the same way as for word reading. That is, the agglutinative, syllabic nature of isiXhosa results in sparse orthographic neighbourhoods with words differing on average by three letters to other words. As such, a neighbourhood density effect is mitigated in spelling, as it is in reading since the isiXhosa speller does not come across a high-density word very frequently.

Another possible explanation for the lack of a neighbourhood density effect for spelling, and reading, in isiXhosa may be owed once again to the language's orthographic transparency. Parker *et al.* (2021) suggests that word recognition in transparent languages such as Spanish does not rely on word level orthographic knowledge but instead relies more on grapheme to phoneme mappings. Therefore activation from words with dense neighbourhoods in Spanish will likely be less than in English (Parker *et al.* 2021). Although neighbourhood density effects have been noted in Spanish (Carreiras, Perea & Grainger, 1997; Goswami, Gombert & De Barrera, 1998; Perea, Carreiras & Grainger, 2004; Acha & Perea, 2008), Parker *et al.*'s (2021) argument remains that these effects will be less than for languages with more opaque orthographies such as English. In light of isiXhosa's transparent orthography it is likely that this argument can be applicable here as well. That is, isiXhosa readers and writers may rely more on sublexical grapheme to phoneme mappings than whole word orthographic representations. This is supported by research on linguistic processing units in word reading and spelling in isiXhosa. For example, in Probert and De Vos's (2016) study, they noted that the majority of errors when reading in isiXhosa were sublexical errors, indicating that the learners in their study "overwhelmingly use sublexical decoding strategies for isiXhosa" (Probert & De Vos, 2016: 6). Additionally, in Daries & Probert's (2020) study on spelling in isiXhosa, they found that the majority of errors were at the sublexical level with learners omitting graphemes or substituting incorrect graphemes. In light of these findings from previous research on isiXhosa, and since neighbourhood density effects are argued to be activated only in the lexical processing route, it is fitting that neighbourhood density does not play a significant role in isiXhosa reading and writing.

### 5.6.4 Explaining orthographic neighbourhood effects: models of orthographic processing, answering research question 4

In light of the above findings, a theoretical explanation for neighbourhood effects in isiXhosa needs to be established. Specifically, in answering research question 4: *Which models of orthographic processing best capture the patterns of orthographic neighbourhood effects in isiXhosa?*

In Chapter 2, three types of models were outlined; search comparison models, parallel comparison models and connectionist models (see Section 2.11). A hypothesis was also put forward that connectionist models would be the best fit for explaining the results of the study as these models can account for both inhibitory and faciliatory neighbourhood effects.

From the findings in the previous sections, this hypothesis can be accepted, as a connectionist model would be able to predict the inhibitory neighbourhood frequency effects found in isiXhosa spelling. However, search comparison models may also be fitting for the results as they are also able to account for inhibitory neighbourhood effects. A full computational analysis of these models is beyond the scope of the present thesis; however these two models can be used from the point of view of psycholinguistic theory in order to unpack the quantitative findings.

*5.6.4.1 Connectionist models of orthographic processing*

Connectionist models such as the Interactive Activation (IA) and Multiple Read Out Model (MROM) explain inhibitory neighbourhood effects as a lateral inhibition effect at the word level which occurs when similar orthographic forms compete for lexical access (Sears, Hino & Lupker, 1999; Parker *et al.* 2021). In other words, higher frequency neighbours provide top-down excitatory feedback which inhibit lexical access to the target word which in turn results in spelling errors. This effect is illustrated in an adapted version of Folk, Rapp and Goldrick's (2002) integrative model of spelling in Figure 19. In this model, orthographic neighbours are activated at the lexeme level, for example *imbala* and *imbiza* are activated when the word *imbila* is heard. These neighbourhoods send excitatory feedback to the grapheme level which in turn sends feedback back to the lexeme level until a threshold is reached and a word is accessed for spelling. In the case of *imbila*, which has a low word frequency of 10, higher frequency neighbours such as *imbiza* are likely to be activated more than the target word itself. Thus *imbiza's* activation will inhibit access to the target word when spelling and consequently result in a spelling error.

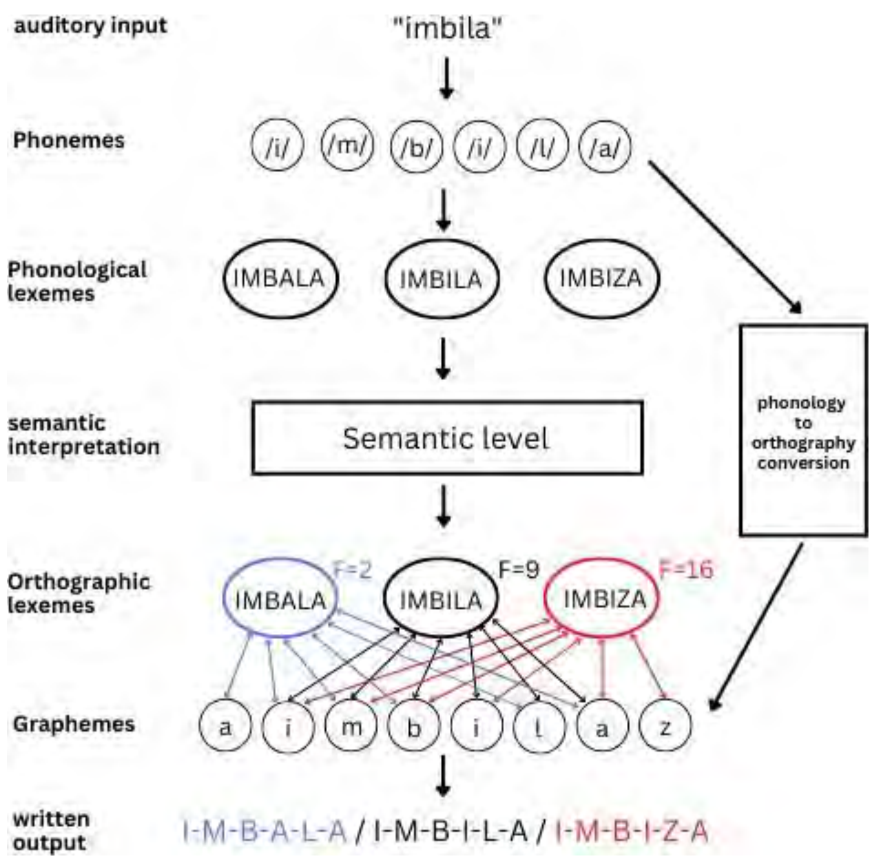


Figure 19: Connectionist model of spelling in isiXhosa to explain inhibitory neighbourhood frequency effects

This model can also be used to explain the discrepancy between neighbourhood effects in word reading versus in spelling. As was alluded to in Section 5.3.3, word reading in isiXhosa relies predominantly on sublexical decoding strategies owing to the consistent grapheme to phoneme mappings (Probert & De Vos, 2016; Probert, 2019). In the proposed model, this would mean a higher degree of bottom-up excitatory feedback, that is from graphemes to lexemes. Consequently, because whole word orthographic representations are not significantly drawn on during reading in isiXhosa, top-down feedback would be weaker when reading, resulting in negligible orthographic neighbourhood effects. In comparison, spelling in isiXhosa appears to rely on both bottom-up and top-down feedback, as evidenced by the presence of neighbourhood effects. A possible explanation for this is the asymmetry of orthographic transparency evident in the language (see Section 2.4). Much like languages such as French and German (Aro, 2004; Moll & Landerl, 2009), we assume that isiXhosa's orthography is more transparent for reading than it is for writing. Thus writers of isiXhosa may not be able to rely on sublexical encoding strategies when spelling as strongly as they do when reading. Consequently, top-down feedback plays a role in conjunction with bottom-up feedback when spelling in isiXhosa, which in turn accounts for the presence of neighbourhood effects in spelling.

In addition to the model's explanatory account for neighbourhood effects, it can also be used to explain the observed word length and word frequency effects. An inhibitory word length effect was observed in both the lexical decision and spelling task (see Section 5.4.2 for suggestions as to why no length effect was observed for word reading). Previous research has indicated that word length interacts with orthographic processing at the sub-lexical level (Barton *et al.* 2014). Whereby a word's letters are processed in a serial manner, with longer words resulting in more letters to be processed. Thus the finding of an inhibitory word length effect can be explained by a large degree of bottom-up activation as longer words require more graphemes to be activated simultaneously. Further, the faciliatory word frequency effect can be explained in much the same way as the inhibitory neighbourhood frequency effect found for spelling, in that if the target word is of a higher frequency, it will have higher degrees of excitatory feedback.

In addition to connectionist models of orthographic processing, search models may also be able to explain the findings for this study.

#### *5.6.4.2 Search comparison models of orthographic processing*

Search comparison models for example, Forster's Search Model (Forster & Bednall, 1976) explain inhibitory neighbourhood frequency effects as a lexical competition effect. Thus these models can be useful in accounting for the inhibitory neighbourhood frequency effect observed for isiXhosa spelling. Search models predict that that orthographic neighbours of a word increase the lexical candidate set which must be searched through for lexical access to occur. Further, they posit that the candidate set is ordered by frequency, such that higher frequency neighbours are more likely to compete for access (Grainger and Segui, 1990). In this way, search models can also account for the inhibitory word frequency effect observed for lexical decision response time and spelling in isiXhosa, in addition to neighbourhood frequency effects. Further they can also explain the inhibitory word length (in letters) effect found for response time and spelling in that search models posit that a word's letters are processed in a serial manner, which results in delayed response times and an increased chance of errors. However the model cannot account for word reading in isiXhosa as word reading does not appear to rely on lexical level decoding, as evidenced by the lack of neighbourhood effects noted for response time and word reading accuracy.

## 5.7 Summary

Chapter 5 has presented the results and discussion of the literacy component of this research. Mainly it has provided empirical evidence of the quantitative effects of orthographic neighbours in literacy skills for isiXhosa grade three learners. In summary, orthographic neighbourhood frequency and density did not have a significant effect on word reading accuracy, nor lexical decision response time, suggesting that neighbours do not interact with word reading in isiXhosa. It was pointed out that this is likely due to readers' reliance on sub-lexical processing when reading, which is motivated by the transparent orthography of the language and the high degree of feed forward consistency.

Contrastingly, a significant inhibitory effect of neighbourhood frequency on spelling accuracy was observed. That is, words with higher frequency neighbours were more likely to be spelt incorrectly. This suggests that when spelling in isiXhosa, learners rely partly on lexical processing strategies. This is likely owed to the higher degree of feedback inconsistency in the language, which is true of most alphabetic languages. Therefore, spelling in isiXhosa requires at least partial use of lexical processing in order to navigate any sound to print inconsistencies in the language. It is at this level of processing where higher frequency neighbours compete for lexical access. It was also suggested that the presence of an orthographic neighbourhood frequency effect in spelling, but none in the word reading tasks, may be due in part to a masked phonological neighbourhood effect. Since the degree of overlap between orthographic and phonological neighbours is very high in isiXhosa and, owing to the auditory component of the spelling task, phonological neighbours may be more active for spelling in isiXhosa than for word reading.

The lack of a neighbourhood density effect for all three literacy tasks can be explained with reference to the sparse orthographic neighbourhoods in isiXhosa in comparison to other languages. The agglutinative and highly syllabic nature of isiXhosa means that neighbours will on average differ by three letters which likely constitute one morpheme and syllable. Thus when reading or writing in isiXhosa, a learner will not come across close orthographic neighbours very frequently, as such the effects of orthographic neighbourhood density are nullified.

These findings can be most conclusively framed within connectionist models of orthographic processing, which posit that higher frequency neighbours provide top-down excitatory feedback which inhibit lexical access to the target word which in turn results in spelling errors. Search processing models may also be able to explain the inhibitory neighbourhood frequency effects in spelling in isiXhosa, however they cannot account for the null effects of neighbourhoods in word reading.

# CHAPTER 6: CONCLUSION

In this thesis, the linguistic properties of orthographic neighbours in isiXhosa and their interaction with word reading accuracy, lexical decision response time, and spelling accuracy were investigated. The findings of this thesis will therefore provide future researchers with a foundational understanding of neighbours and neighbourhood effects in isiXhosa so that these effects can be explored in other Southern Bantu languages. This research also contributes empirical evidence for neighbourhood effects in isiXhosa, which can help inform linguistic theory as well as pedagogical practices, specifically surrounding spelling in isiXhosa. This chapter provides a conclusive summary of the main findings of this thesis and addresses the initial hypotheses of the study. It also outlines the specific contributions of these findings to linguistic theory, as well as recommendations for pedagogy and future research.

The study was guided by four research questions, repeated as follows:

**1:** What are the linguistic properties of orthographic neighbours in isiXhosa?
**2a:** What role do orthographic neighbourhood effects play in word reading in isiXhosa grade three learners?
**2b:** What role do orthographic neighbourhood effects play in lexical decision response time in isiXhosa grade three learners?
**3:** What role do orthographic neighbourhood effects play in spelling in isiXhosa grade three learners?
**4:** Which models of orthographic processing best capture the patterns of orthographic neighbourhood effects in isiXhosa?

The alternative hypothesis for question 1, was threefold. First it was hypothesized that orthographic neighbours would be characterized by a high degree of overlap between semantic and orthographic similarity in the orthographic neighbourhoods of isiXhosa. To investigate this, a database of 600 neighbours and 30 target words was created using an existing corpus by Rees and Randera (2017). These neighbourhoods were for the 30 target words used in the literacy assessments. The target words were morphologically glossed, and string comparison was used to calculate the proportion of neighbours which shared morphemes with their respective target word. Three morphemes were selected for comparison: the word initial prefix, the root morpheme, and the final vowel suffix. It was found that 36% of neighbours in the database shared a root morpheme with their respective target word, a further 42% of neighbours shared a word initial prefix, and 81% shared a final vowel suffix. This suggests a large overlap of semantic similarity with orthographic similarity in isiXhosa. Therefore this component of hypothesis 1 is accepted. Further research is needed to fully investigate the effect of these meaningneighbours on the orthographic processing of words in isiXhosa. A linguistic analysis of the spelling errors produced by learners may be useful in identifying the specific effects of these morphological neighbours on spelling in isiXhosa.

The second component of the alternative hypothesis for question 1 was that there would be a high degree of overlap between phonological and orthographic similarity. This was investigated by using a case study approach. The orthographic neighbourhood of *indlebe* was phonetically transcribed and string comparison was used to calculate the phonological neighbourhood of *indlebe* and the phonological Levenshtein distance (LD) for each neighbour. It was found that 16 of the phonological neighbours of *indlebe* were identical in phonological LD to the orthographic LD of the orthographic neighbours. The four disparities were owed to the complex consonant grapheme {dl} in *indlebe.* Therefore, the hypothesis is accepted. Although a full investigation of this linguistic property was not possible for the constraints of this thesis, this finding suggests that further investigation into the phonological neighbours of isiXhosa is warranted.

Finally, hypothesis one suggested that since isiXhosa words do not follow an onset-rime pattern, rime neighbours will not be salient in isiXhosa, however syllable neighbours – words that differ by one or more syllables – may be present, owing to the highly syllabic and transparent nature of isiXhosa. This was investigated by using a case study approach, in which the syllabic neighbourhood of *ixoki* was calculated. It was found that 80% of *ixoki's* orthographic neighbours shared a word initial syllable, 35% shared a word final syllable, and the mid-word syllables were more variable. Thus confirming the hypothesis that syllable neighbours are salient in isiXhosa.

The alternative Hypothesis H(2) addressed research questions 2a and 2b regarding the effect of orthographic neighbours on word reading accuracy and lexical decision response time. It was hypothesized that orthographic neighbourhood effects in word reading (lexical decision and word naming) would be similar to those reported for languages other than English. Specifically those languages with similar orthographic properties to isiXhosa such as Spanish and French which have transparent orthographies, a high degree of morphological complexity, and regular syllable structures. Therefore, it was hypothesized that orthographic neighbourhood density would have a faciliatory effect on word reading, and orthographic neighbourhood frequency would have an inhibitory effect. This was investigated using a quantitative research design. An untimed word naming task, and a lexical decision task were developed for the study. Both real word and pseudoword stimuli were specifically chosen to investigate the effect of word properties including orthographic neighbourhood density, neighbourhood frequency, word length, and word frequency. Data were collected and analysed in RStudio and MS excel.

The present study found no effect of orthographic neighbourhood density or neighbourhood frequency for either word reading task. Thus this hypothesis is rejected. The lack of neighbourhood effects in word reading accuracy and lexical decision response time is likely owed to learners' reliance on sub-lexical processing when reading. Since orthographic neighbours only interact at the lexical level of orthographic processing, it is understandable that these effects are not present for word reading.

The alternative Hypothesis H(3) addressed research question 3 pertaining to orthographic neighbours in spelling in isiXhosa. It was hypothesized that orthographic neighbourhood effects for spelling would be similar to those of word reading with faciliatory neighbourhood density effects and inhibitory neighbourhood frequency effects. The methodology for this component was the same as for the word reading and lexical decision components. The second part of this hypothesis can be accepted, as neighbourhood frequency had a significant inhibitory effect on spelling accuracy. However, neighbourhood density did not have any effect on spelling, and thus the first part of the hypothesis is rejected. The presence of a neighbourhood frequency effect in spelling, but not in word reading, can be explained as a partial reliance on lexical processing when spelling in isiXhosa. This is likely a response to the feedback inconsistencies which may occur in the language, which make sub-lexical processing unreliable at times for spelling in this language. The lack of a neighbourhood density effect in both spelling and word reading, can be explained with reference to the sparse orthographic neighbourhoods in isiXhosa in comparison to languages such as English, French, Portuguese, and German, which nullifies any potential effects of neighbourhood density.

The final alternative hypothesis H(4) for this thesis addressed research question 4 pertaining to which orthographic models best explained the findings above. Specifically, it was hypothesized that connectionist models of orthographic processing would best explain the results of the study, as these models can account for both inhibitory and faciliatory neighbourhood effects. From the results of the study, this hypothesis can be accepted as connectionist models are able to account for the inhibitory neighbourhood frequency effect observed for spelling in isiXhosa. Additionally, Search processing models may also be able to account for this finding.

This thesis has demonstrated that the study of orthographic neighbours involves a sensitivity to various other linguistic domains in order to fully appreciate and understand this phenomenon. The various contentions in the literature concerning the specific nature of orthographic neighbourhood effects for literacy skills, can be resolved if researchers adopt a more thorough investigation into potentially confounding linguistic structures. The findings of this thesis contribute to a theoretical understanding of reading and spelling in isiXhosa. Of particular significance are the findings for spelling, since very little research on spelling in isiXhosa exists. Research that has addressed this skill in isiXhosa, for example, Daries and Probert (2020), indicates that learners make use of sub-lexical processing when spelling, as evidenced by the prevalence of errors of omission, and the significance of grapheme complexity for spelling accuracy. The findings of this thesis suggest that while sub-lexical strategies are used, as evidenced by the presence of a word length effect, there is also a partial reliance on lexical strategies for spelling. This is captured by the inhibitory effect of neighbourhood frequency, with higher frequency neighbours competing for lexical access when spelling in isiXhosa.

It is necessary to note that this thesis investigated neighbourhood effects in grade three learners, using stimuli taken from an isiXhosa foundation phase corpus. Thus the results are likely to only be applicable to novice readers and writers in the foundation phase, and these findings may not necessarily extend to higher grades. The interaction of neighbourhood effects over different grade levels should be addressed by future research, in order to uncover whether these effects differ over a developmental trajectory of reading and writing.

The relevance of these findings in the context of the South African literacy landscape, is that they contribute to a more thorough understanding of reading and writing in a setting where learners are continuously underperforming in literacy (Howie *et al.* 2017). Further these findings provide empirical evidence which can inform linguistic theory, and importantly, may also contribute to the development of targeted pedagogical practices which can address learners' spelling errors. It is my recommendation that spelling reforms implement lists of orthographic neighbours when teaching novice words, such that the nuances between word spellings are made more explicit. This will of course require a more extensive database of orthographic neighbours in isiXhosa to be made available to educational practitioners, such that linguistically sound teaching resources may be developed. It is these recommendations which form my contribution to the resolve of the literacy crisis in South Africa.

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# APPENDICES

## Appendix 1: Ethical clearance documentation

### A: Ethical clearance certificate

RHODES UNIVERSITY
Where leaders learn

**Rhodes University Human Research Ethics Committee**

PO Box 94, Makhanda, 6140, South Africa

t: +27 (0) 46 603 7727

f: +27 (0) 46 603 8822

e: ethics-committee@ru.ac.za

**NHREC Registration number: RC-241114-045**

**https://www.ru.ac.za/researchgateway/ethics/**

28th January 2022

Ms Tracy Bowles
Department of Linguistics & Applied Language Studies
Rhodes University

Review Reference: 2020-1195-3307

Dear Tracy,

**Re: Extension to the Project: "VWCT Legacy Literacy Project: Investigating literacy skills in KwaNobuhle FoundationPhase learners"**

This letter confirms that the above research proposal is renewed for a further calendar year with the **approval** of the Rhodes University Human Research Ethics Committee (RU-HREC).

The following changes are noted:
The Addition of Paige Cox (g17C3743) as a collaborator - She is a MA student in the Department of Linguistics and Applied Language Studies.

And the Addition of a lexical decision task to the already approved instruments (EGRA), as a proxy for word reading. A lexical decision task involves presenting a reader visually with a string of letters and asking them to decide whether the string is a real or non-word. The assessment procedure for this task will follow those for which ethical clearance was granted. There are no risks involved in adding this one task to the current instruments which are used.

Please ensure that the RU-HREC is notified should any substantive change(s) be made, for whatever reason, during the continued research process. This includes changes in investigators. Please also ensure that a brief report is submitted to the Ethics Committee on completion of the research. The purpose of this report is to indicate whether the research was conducted successfully, if any aspects could not be completed, or if any problems arose that the Ethical Standards Committee should be aware of.

Sincerely,

Prof Arthur Webb

**Chair: Rhodes University Human Research Ethics Committee, RU-HREC**

B: Guardian informed consent form

Mzali obekekileyo

**INCWADI YOKUZAZISA NESIVUMELWANO NOMZALI**

Ndibhala ndicela imvume ukuba umntwana wakho abe nokuthatha inxaxheba kwinkqubo yolwimi lophando (Literacy task research) ephakathi kweCentre for Social Development (CSD) Rhodes University kunye neVolkswagen Community Trust (VWCT) yongenelelo lophando lwangaphambili, yecandelo lemfundo yabaqalayo (foundation phase) ukusukela kuGrade 1 - 3. Le nkqubo yongenelelo lophando lwangaphambili ijongana nohlolo lokufunda eye iqhutywe esikolweni somntwana wakho.

Sincedisa abafundi ngokuthi bazifundele ukuze baqonde, ingakumbi ngolwimi lwabo lweenkobe. Umfundi uvumelekile ukuba kunye nathi ngokunokwakhe kungekho kunyanzeleka. Nangaliphina ithuba engasafuni ukuqhubekeka nathi akusayi kubakho salelo angayeka. Kwimisebenzi eyothi yenziwe kunye naye akukho nto iyakupapashwa enegama lomntwana wakho.

Uvumelekile ukuba ungabuza imibuzo kophetheyo, Nkosazana uNikki Green, nayiphina into nangaliphina ithuba ephathelele nesikhalazo, unga qhakamshelana naye ku n.green@ru.ac.za okanye kule nombolo 046-603 8573.

**…………………………………………………………………………………………………………………………………………….**

**IPHETSHANA EMALIBUYE**

Mna ……………………………………………………… (igama lomzali, nceda ulibhale ngokucacileyo), ndiyifundile lengxelo ingentla. Ndiyavuma ngokukhululekileyo ukuba umntwana wam angathatha inxaxheba CSD/VWC) yongenelelo lophando lwangaphambili. Ndiyathemba ezozinto bakuzenza nani zakugcinwa zingaziwa.

| | |
|---|---|
| ………………………………………… | …………………………………. |
| Umzali asayine | Umhla |

Igama lomntwana ……………………………………………………

Igama lesikolo ……………………………………………………

Igama likatitshala ……………………………………………………

C: Letter of approval from the Department of Basic Education

Province of the
EASTERN CAPE
EDUCATION

**CORPORATE PLANNING MONITORING POLICY AND RESEARCH COORDINATION**
Steve Vukile Tshwete Complex • Zone 6 • Zwelitsha • Eastern Cape
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Enquiries: B Pamla Email: babalwa.pamla@ecdoe.gov.za Date: 14 September 2020

Ms. Tracy Probert

Department of English Language and Linguistics

Rhodes University

P.O Box 94

**Grahamstown**

**6140**

Dear Ms. Tracy Probert

**PERMISSION TO UNDERTAKE AN INDEPENDENT STUDY: A VOLKSWAGEN COMMUNITY TRUST LEAGACY LITEACY PROJECT- INVESTIGATING LITERACY SKILLS IN KWANOBUHLE FOUNDATION PHASE LEARNERS.**

1. Your application to conduct the above mentioned research involving 1177 learners and 33 educators from 5 selected schools under the jurisdiction of Nelson Mandela Bay of the Eastern Cape Department of Education (ECDoE) is hereby approved based on the following conditions:

   a. there will be no financial implications for the Department;

   b. institutions and respondents must not be identifiable in any way from the results of the investigation;

   c. no minors will participate;

   d. it is not going to interrupt educators' time and task;

   e. the research may not be conducted during official contact time;

   f. no physical contact with educators and learners, only virtual means of communication should be used and that should be arranged and agreed upon in writing with the Principal and the affected teacher/s;

D: Sample of participant verbal assent form

**CHILD PARTICIPANT'S ASSENT FORM**

**INFORMED CONSENT DECLARATION**
**(Child participant)**

**Project Title:** VW Literacy Legacy Project: Investigating literacy skills in Kwanobuhle Foundation Phase learners.

**Researcher's name:** Centre for Social Development, Rhodes University

**Name of participant:** ………………………………………………………………………………

1. Has the researcher explained what s/he will be doing and wants you to do?

   YES NO

2. Has the researcher explained why s/he wants you to take part?

   YES NO

3. Do you understand what the research wants to do

   YES NO

4. Do you know if anything good or bad can happen to you during the research?

   YES NO

5. Do you know that your name and what you say will be kept a secret from other people?

   YES NO

6. Did you ask the researcher any questions about the research?

| YES | NO |
|---|---|

7. Has the researcher answered all your questions?

| YES | NO |
|---|---|

8. Do you understand that you can refuse to participate if you do not want to take part and that nothing will happen to you if you refuse?

| YES | NO |
|---|---|

9. Do you understand that you may pull out of the study at any time if you no longer want to continue?

| YES | NO |
|---|---|

10. Do you know who to talk to if you are worried or have any other questions to ask?

| YES | NO |
|---|---|

11. Has anyone forced or put pressure on you to take part in this research?

| YES | NO |
|---|---|

12. Are you willing to take part in the research?

| YES | NO |
|---|---|

____________________________ ______________________

**Signature of Child** **Date**

## Appendix 2: Neighbourhood database for real word task stimuli

A: Lexical decision task real word stimuli

| Target word | Frequency | Word length (letters) | Word length (syllables) | OLD20 | OLDF | Identity of 20 closest neighbours |
|---|---|---|---|---|---|---|
| kakhulu | 668 | 7 | 3 | 1.85 | 18.3 | [makhulu; bakhulu; kahulu; umakhulu; omkhulu; amakhulu; mkhulu; kamakhulu; okukhulu; wakhula; abakhulu; kumakhulu; likhulu; lukhulu; khulu; kukhule; umkhulu; akhula; kakhu; mikhulu] |
| okanye | 210 | 6 | 3 | 2.15 | 84.89 | [kanye; okunye; kunye; omnye; abanye; nganye; amanye; olunye; nanye; yanye; ekunye; nokunye; kane; nakanye; okutye; kwaye; ngenye; naye; enye; ezinye] |
| ixoki | 1 | 5 | 3 | 1,95 | 17,95 | [ihoki; xoki; idonki; iveki; ipaki; ilori; iposi; ixolo; exoka; idyoki; igoli; ihodi;ihoko; ikomi; imoski; inki; isoka; itiki; maxoki; ngoku] |
| encinane | 85 | 8 | 4 | 2.15 | 7.3 | [incinane; mncinane; encincane; kancinane; omncinane; elincinane; ezincinane; esincinane; emincinane;kuncinane; umncinane; encine; esencinane; lincinane; encinci; amancinane; endinalo; okuncinane; abancinane; ndifane] |
| imnandi | 9 | 7 | 3 | 1,65 | 11,9 | [emnandi; mnandi; amnandi; zimnandi; omnandi; limnandi; simnandi; izandi; kamnandi; isandi; elimnandi; kumnandi; ezimnandi; esimnandi; inani; irandi; lumnandi; yamnandi; amnanadi; bumnandi] |
| indlebe | 2 | 7 | 3 | 2,5 | 18,3 | [Iindlebe; ndlebe; indebe; indlela; imilebe; ndebe; wendlebe; indlu; indlovu;ndlela; intle; inde; ndibe; ingulube; yindlela; iindlela; inxeba; inene; ingene; endlebeni] |
| amaphondo | 5 | 9 | 4 | 3,35 | 11,15 | [amaphiko; umkhondo; kwiphondo; iphondo; mkhondo; uphondo; amahindu; amaphini; amaphulo; lephondo; mpondo; ngephondo; ngophondo; amaqanda; amazinyo; amadoda; waphinda; yaphinda; amaphepha; aphinde] |
| umnumzana | 104 | 9 | 4 | 2.9 | 10.25 | [mnumzana; kumnumzana; nomnumzana; kamnumzana; ngumnumzana; umntwana; umpukwana; umzuzwana; kumfumana; kukamnumzana; bukamnumzana; kwamnumzana; lukamnumzana; ufumana; ukumana; wafumana; ukumkani; unyana; usizana; ukufumana] |
| ezantsi | 65 | 7 | 3 | 2.4 | 22.8 | [emzantsi; mzantsi; phantsi; ngezantsi; emazantsi; nantsi; esezantsi; ephantsi; umzantsi; asezantsi; izandi; kanti; nantso; ezintle; zathi; wasezantsi; uzandi;ezintsha; aphantsi; ekati] |
| Intliziyo | 9 | 9 | 4 | 4 | 21,55 | [kwentliziyo; unentliziyo; intlazi; intloko; intlanzi; elizayo; intsini; intsimi; intlalo; angalaziyo; inaliti; intini; intlobo; inziniya; ndiyiyo; nolizo; nozaziyo; into; ilizwi; entloko] |

B: Word reading task real word stimuli

| Target word | Frequency | Word length (letters) | Word length (syllables) | OLD20 | OLDF | Identity of 20 closest neighbours |
|---|---|---|---|---|---|---|
| ingonyama | 83 | 9 | 4 | 1.75 | 4.4 | [ungonyama; ngonyama; iingonyama; yingonyama; ingonyana; inkonyana; ngonyaka; kwingonyama; kungonyama; lengonyama; ngenyama; ngonyana; wengonyama; yengonyama; eengonyama; iingonyana; kangonyama; nengonyama;sengonyama; zengonyama] |
| ngokwenene | 41 | 10 | 4 | 3.15 | 4.6 | [wokwenene; yokwenene; bokwenene; lokwenene; ngokwenzeke; ngenene; ngokwenza;ngolwesine; ngokwenu; ngokwenyani; ngokwenzeka; ngowenye; nkwenkwe; ngokwaneleyo; nokwenza; ngomlenze; okwenzeke; ngokwakhe; usikhwenene; wenene] |
| imbila | 9 | 6 | 3 | 1,8 | 11,3 | [imbiza; imbala; iimbila; mbila; imvula; umsila; imihla; umbala; imbulu; imbi; imibala; ibala; imisila;mbala; imbali; impilo; ambia; embala; imkile; iimbiza] |
| ubanzi | 2 | 6 | 3 | 1,75 | 14,55 | [ubani; banzi; umanzi; lubanzi; ebanzi; amanzi; ubongi; manzi; uyazi; bani; uzandi; umazi; emanzi;uninzi; ebunzi; olubanzi; abazi; ibunzi; umanz; abanizi] |
| ixilongo | 1 | 8 | 4 | 2,9 | 16,8 | [xilongo; imibongo; nexilongo; sexilongo; imilomo; isilonda; imibono; isilingi; amaxilongo; ibhongo; iimengo; iintongo; impongo; injongo; isilinge; izilonda; uxhongo; izinto; ilanga; intloko] |
| iimpahla | 39 | 8 | 3 | 2.6 | 5.65 | [impahla; ziimpahla; mpahla; yempahla; nempahla; wempahla; imihla; iimpawu; neempahla; yeempahla; imbala; isihlahla; weempahla; asimahla; eyiyimpahla; ihlahla; iimbasa; iimbila; iimfihlo; iimpilo] |
| umlobi | 4 | 6 | 3 | 2,1 | 17,65 | [umlozi; umhlobo; umlomo; uhlobo; uhlosi; umgodi; umoloi; umfoti; umlebe; umlimi; lobi; uloba; umaloyi; umhobe; umlibo; umlo; umzobo; umoya; umlilo; umhlaba] |
| ukoketso | 46 | 8 | 4 | 3.05 | 13.55 | [koketso; kukoketso; ukoketsho; kakoketso; nokoketso; uketso; ukakembo; ukhotso; ketso; nguketso; koko; ugoso; ugqatso; unomatse; kweso; uzokutya; ukhethe; ukato; ukubetha; kokutya] |
| ezintlanu | 9 | 9 | 4 | 3,2 | 11,55 | [zintlanu; ezihlanu; zantlanu; ezintathu; ezintle; emihlanu; zintlu; ezindlu; ezinelungu; ezinolu; ezintanthu; zintlanzi; izihlangu; iintlanzi; ezifana; intlanzi; ezinkulu; izindlu; ezincinane; zihlangu] |
| enkosi | 47 | 6 | 3 | 1.9 | 21.95 | [nkosi; inkosi; nenkosi; senkosi; yenkosi; yinkosi; enkosini; unyosi; zinkosi; eenyosi; enkomo; inkhosi; inyosi; kwenkosi; lwenkosi; nenyosi; nyosi; ntoni; enkulu; esi] |

## C: Spelling task real word stimuli

| Target word | Frequency | Word length (letters) | Word length (syllables) | OLD20 | OLDF | Identity of 20 closest neighbours |
|---|---|---|---|---|---|---|
| elusizi | 5 | 7 | 4 | 1,85 | 5,15 | [lusizi; ulusizi; alusizi; ilusizi; nelusizi; olusizi; kalusizi; ebelusizi; ebusini; elilusizi; esilusizi; lulusizi; luzizi; nalusizi; uselusizi; usizi; zilusizi;elalini; eklasini; kusini] |
| elininzi | 5 | 8 | 4 | 2 | 11.95 | [ezininzi; emininzi; lininzi; eninzi; zininzi; elincinci; ininzi; elipinki; isininzi; oluninzi; elimanzi; eminizi; ezinizi; linini; luninzi; mininzi; nezininzi; abaninzi; elalini; amaninzi] |
| umvundla | 88 | 8 | 3 | 2.35 | 11.3 | [mvundla; kumvundla; umandla; imivundla; nomvundla; ngumvundla; ummandla; umvundlana; komvundla; lomvundla; womvundla; imvula; umdla; mandla; amandla; mvula; ngomvundla; ufunda; emvula; umvulo] |
| kwakhona | 161 | 8 | 3 | 2.45 | 28.7 | [kwakho; ngakhona; akhona; kwakhala; kwatshona; kwawona; kwakhiwa; lakhona; wakhonya; warhona; yakhona; wakho; khona; kwakhe; wabona; lwakho; wakhala; kwaphela; wakroba; wakha] |
| umngxuma | 5 | 8 | 3 | 3,05 | 46,35 | [mngxuma; imingxuma; mingxuma; umnxeba; umgama; umnyama; umgqumo; wangxama; bangxama; inomngxuma; nemingxuma; ugquma;umgqubа; umntwama; ungcuka; umama; umntu; amagama; magama; umfama] |
| akukho | 84 | 6 | 3 | 1.7 | 13.95 | [kukho; akakho; awukho; abukho; akekho; ekukho; kwakukho; akho; bekukho; anakho; akusekho; kuko; ukukha; ayikho; akuthi; kukhe; ukukhe; abekho; akakhe; akakhi] |
| ingcinga | 1 | 8 | 3 | 2,25 | 14,45 | [yingcinga; iingcinga; ngcinga; enicinga; icinga; igcina; imicinga; ingqanga; nengcinga; nicinga; nocinga; ungacinga; wacinga; ucinga;ndicinga; inyanga; ingca; incinci; cinga; ingwenya] |
| ngaphandle | 66 | 10 | 3 | 3.35 | 13.1 | [engaphandle; bengaphandle; phandle; ngamandla; ngaphantsi; ephandle; esingaphandle; ezingaphandle; umphandle; uphandle; ngaphaya; ngaphambili; ngamanye; ngaphezulu; ngezandla; ngesandla; ngapha; ngaphambi; aphinde; ungathanda] |
| wahamba | 49 | 7 | 3 | 1.6 | 11.4 | [bahamba; yahamba; ahamba; wabamba; zahamba; lahamba; sahamba; wahlamba; hamba; ehamba; wazama; kuhamba; uhamba; behamba; wayehamba; ahambe; ihamba;sihamba; bahambe; ohamba] |
| amajoni | 5 | 7 | 4 | 2,65 | 16,3 | [lamajoni; namajoni; amabini; amanani; amabani; amanzi; amabali;amaninzi; amadoda; amane; ababini;amazwi; emafini; magona; amavili; amaxolo; amacici; omabini; abanini; akafuni] |

## Appendix 3: Neighbourhood database for pseudoword task stimuli

A: Lexical decision task pseudoword stimuli

| Target pseudoword | Word length (letters) | Word length (syllables) | OLD20OLDF | | Identity of 20 closest neighbours |
|---|---|---|---|---|---|
| ndlashaza | 9 | 3 | 3.854.6 | | [ndakhwaza; ndabhaka; ndakhala; ngaphaya; ndazama; ndilapha; achaza; lakhala; ndledlana; ndaqala; ndisaya; zisasaza; lakhwaza; ndlwana; ngamaza; naphaya; ndahamba; ndakwazi; ndikhaba; ndishiya] |
| tshafiba | 8 | 3 | 3.515.4 | | [tshatisa; tsiba; safika; tshayela; tshisa; otshatisa; thafa; tshila; tshiza; wahamba; hamba; thina; wafika; ehamba; bahamba; kwafika; kuhamba; bafika; yahamba; uhamba] |
| ingxembo | 8 | 3 | 3.424 | | [ingxelo; ingxolo; intambo; inxeba; ingcambu; ingqumba; ingubo; ingxoxo; ingekho; ingemva; ngxelo; ingaba; ingoma; ngomso; ngelo; ngento; inqwelo; inkomo; ngobo; nohambo] |
| nokhube | 7 | 3 | 2,75 | 17.35 | [nokuba; nokrebe; nokubi; nomxube; oqhube; kokuba; ngokuba; lokuba; yokuba; inokuba; kube; lokhwe; ookrebe; ngulube; sokuba;wokuba; ikhuba; kukhule; likhule; nkqubo] |
| werhata | 7 | 3 | 311 | | [ekhaya; wathatha; wakhala; wehla; nekhaya; ekhala; webhasi; wekhari; whahaha; rhaxa; webhola; echasa; ephala; erhuqa; wabhaka; wabhala; wachaza; wakhaba; wakhasa; watshata] |
| ixasha | 6 | 3 | 2.5 | 43.75 | [ixesha; xesha; lixesha; ihashe; intsha; igusha; iqatha; iyatsha; izapha; apha; igama; ilanga; icala; entsha; chapha; iigusha; ibanga; iqanda; omtsha; rhwasha] |
| sukiba | 6 | 3 | 2.35 | 102.65 | [ukuba; suka; kukuba; sokuba; kusiba; usiba; siba; siziba; sikipa; kuyiba; kuziba; soziba; sukube; kuba; ukuya; kukuba; siza; nokuba; lokuba; yokuba] |
| thakathi | 8 | 3 | 2,77,35 | | [phakathi; ephakathi; ophakathi; iphakathi; uphakathi; ihlabathi; ihlathi; qakatha; thatha; ipakethi; hlathi; akuthi;awathi; bakuthi; naphakathi; akakhi; baphakathi; ehlabathi; iqakatha; liphakathi] |
| ulunwa | 6 | 3 | 2.1587.4 | | [ufuna; ukuna; ufunda; kulunga; ulona; uludwe; ukulwa; ulunge; efunwa; elunga; gulunda; ifunwa; kuvunwa; lunga; ulundi; ulungi; umunca; ukuba; ukutya; ukuya] |
| kabali | 6 | 3 | 1,817,5 | | [kabani; kambali; mabali; abali; ibali; amabali; bali; umbali; sebali; nabani; nebali; kwebali; mbali; kabini; webali; imbali; abazi; lebali; libali; yebali] |

B: Word reading task pseudoword stimuli

| Target pseudoword | Word length (letters) | Word length (syllables) | OLD20 | OLDF | Identity of 20 closest neighbours |
|---|---|---|---|---|---|
| nilema | 6 | 3 | 2.4 | 28.85 | [ndlela; ileta; lema; iileta; naleya; ndema; ndileqa; ndiyema; neleta; niceba; ntlama; zilima; igama; indlela; nceda; nomama; ndicela; baleka; biyela; iqela] |
| lokuzinyo | 9 | 4 | 3.75 | 7.45 | [lokucinga; lokulinda; lokuzihoya; lokuzila; okuzayo; lokuzalwa; amazinyo;lokutya; okunye; obuzayo; okuninzi; okwaziyo; izinyo; sokucinga; lokugcina;lwezinto; mazinyo; owaziyo; lokuya; nokunye] |
| gomtweno | 9 | 3 | 3,5 | 5,05 | [ngomnqweno; nomtwana; molweni; emotweni; womyezo; umnqweno; nomntwana; womileyo; bomyezo; emaweni; komjelo; komntwana; ngomnwe; nomkrwelo; nomyeni; omyezo;yomthungo; efotweni; entweni; kokwenu] |
| logeka | 6 | 3 | 2,65 | 12,75 | [lodaka; logama; loyika; labeka; libeka; lopheka; loyena; lonke; baleka; lokuba; lona; ubeka; oyena; wabeka; ehleka; engena; ngena; woyika; lenzeka; ligama] |
| ucukela | 7 | 4 | 2.1 | 6 | [uculela; usukela; ukuwela; ukufela; kusukela; ucula; kubukela; ubukeka; eculela; ukusela; bukela; esukela; ubuyela;ukucela; ukuvela; usukele; ukucula; ubudala; fakela; ukubeka] |
| tuzugo | 6 | 3 | 3,1 | 99,45 | [uzuko; ufudo; ugogo; ubuso; kuzo; luvuyo; ugugu; kufudo; inzuzo; ululo; uzayo; uzuba; kubuso; nguzuko; nozuko;tumato; ubuzo; ukuba; ukuze; uze] |
| upoya | 5 | 3 | 1,9 | 20,95 | [umoya; uboya; ukuya; uya; unowa; ujoja; moya; ubona; upapa; usiya; utota; oya; ulona; ubuya; umota; boya; uhola; ukoma; uphola; ujiya] |
| xefuna | 6 | 3 | 1,9 | 8,45 | [efuna; befuna; ufuna; ifuna; ofuna; efana; sifuna; wafuna; efunda; bafuna; kufuna; lifuna; afuna; funa; zifuna; ebefuna; zafuna; ayefuna; nifuna; efunwa] |
| levisa | 6 | 3 | 2,75 | 9 | [wemisa; wezisa; ewisa; nesisa; yemisa; weva; esiya; efika; liza; esiza; befika; besiya; evela; beva; elila; ncedisa; bonisa; lehla; leli; lika] |
| tarhoze | 7 | 3 | 3.7 | 115.9 | [torho; asoze; achobe; amhoye; aphole; warhona; wakhe; yakhe; apho; wakho; waze; yakho; zakhe; lakho; bakhe; lakhe;sakhe; aze; yaze; zakho] |

## C: Spelling task pseudoword stimuli

| Target pseudoword | Word length (letters) | Word length (syllables) | OLD20 | OLDF | Identity of 20 closest neighbours |
|---|---|---|---|---|---|
| qetaza | 6 | 3 | 3 | 41,6 | [waza; utata; yenza; baza; wenza; intake; yaza; weza; ntaka; egama; tata; aza; benza;notata; chaza; intaba; qala; esiza; eza; kwaza] |
| kolohla | 7 | 3 | 3 | 4.6 | [koloni; kulala; lolona; kulula; lehla; kolo; kuluhlu; lomhla; kodonga; kwahla; nomhla; olona; kondla; kwehla; oluhle; ukulahla; womhla; yomhla; elahla; ihlahla] |
| tyizena | 7 | 3 | 3 | 12,7 | [yena; yiza; thina; usizana; oyena; izitena; tsibela; yizani; tyeba; tyile; tywina; yazenza; ayibona; ebizela; esizenza; isitena;oyibona; thiza; tyabeka; tyini] |
| hlenama | 7 | 3 | 1,95 | 5,05 | [lenyama; egama; engama; ezama; ligama; nama; efama; negama; lama; lema; lentlama; leyaa; lizama; logama; segama; bezama; lengca; lentaba; nenyama; senyama] |
| tsilaba | 7 | 3 | 2.9 | 8.75 | [tsiba; osicaba; umhlaba; usizana; mhlaba; tselane; isifuba; saba; sihamba; tsibela; esifana; etsiba; sihlala; tsala; isilayi; laba; usiba; siba; sidlala; silale] |
| bovenani | 8 | 4 | 3.5 | 9.25 | [ngenani; bonisani; balekani; bonana; buzanani; bekani; boobani; bophani; kunenani; nenani; bona; ncedani; bobabini;bani; belali; oyena; emveni; bongi; orenji; jongani] |
| ibhisu | 6 | 3 | 2,7 | 16,3 | [ibhasi; isisu; ibhaso; ibhafu; ithishu; izisu; ibhola; ihagu; iphi; isiqu; ithi; ubisi; bhaku; ithile; ibhokisi; ibhedi; ibhegi; iliso; iphini; iqhina] |
| ililwi | 6 | 3 | 2,5 | 27,2 | [ilizwi; Ilizwe; ilali; lizwi; ivili; lilizwi; ileli; iliwa; ilila; ibali; imini; imali; imithi; isithi; ilitye; mlilo; lali; iselwa; elithi; liphi] |
| kufotsha | 8 | 3 | 3.4 | 26.05 | [kutsha; kutsho; kufutshane; unotshe; uyatsha; okutsha; kulotywa; kumatshi; kunetha; kuxesha; ukucotha; kufuneka; utsho; kuthi; kutya; kubona; kwatsho;kusasa; kwexesha; kuthe] |
| juqala | 6 | 3 | 1,9 | 10,5 | [kuqala; uqala; kudala; waqala; qala; kulala; ukuqala; ugala; zaqala; baqala; eqala; liqala; uqale; yaqala; ulala; uyala; laqala; aqala;beqala; iqala] |

## Appendix 4: Morphological gloss of real word task stimuli

| | target word | gloss | translation |
|---|---|---|---|
| 1 | kakhulu | ka-khulu<br>ADV-very | very |
| 2 | ixoki | i-xok-i<br>NC5-lie-NOM | liar |
| 3 | encinane | e-ncinane<br>ADJ-small | small/little |
| 4 | imnandi | i-mnandi<br>COP-nice | it is nice |
| 5 | indlebe | i-ndlebe<br>NC9- ear | ear |
| 6 | amaphondo | ama-phondo<br>NC6-province | provinces |
| 7 | umnumzana | um-numzana<br>NC1-mister | mister/sir |
| 8 | ezantsi | e-zantsi<br>LOC-south | at/from/to the south/down |
| 9 | intliziyo | i-ntliziyo<br>NC9-heart | heart |
| 10 | ingonyama | i-ngonyama<br>NC9-lion | lion |
| 11 | ngokwenene | ngokwe-nene<br>INSTR-true | truly/truthfully |
| 12 | imbila | i-mbila<br>NC9-dassie | dassie/ rock hyrax |
| 13 | ubanzi | u-banzi<br>COP-broad | it is broad/wide |
| 14 | ixilongo | i-xilongo<br>NC5-trumpet | trumpet |
| 15 | iimpahla | ii-mpahla<br>NC10-clothes | clothes |
| 16 | umlobi | um-lob-i<br>NC1-fish-NOM | fisherman |
| 17 | ukoketso | u-koketso<br>NC1a-Koketso | Koketso (name of person) |
| 18 | ezintlanu | ezin-tlanu<br>ADJ-five | five |
| 19 | enkosi | enkosi<br>thank you | thank you |
| 20 | elusizi | e-lusizi<br>REL-sad | sad |
| 21 | elininzi | eli-ninzi<br>ADJ-much | much/ a lot of |
| 22 | umvundla | um-vundla<br>NC3-rabbit | rabbit |
| 23 | kwakhona | kwa-khona<br>ADV-again | again |
| 24 | umngxuma | um-ngxuma<br>NC3-hole | hole |
| 25 | akukho | a-kukho<br>NEG-there is | there is not (anything) |
| 26 | ingcinga | i-ngcinga<br>NC9-thought | thought |
| 27 | ngaphandle | nga-phandle<br>LOC-outside | outside |
| 28 | wahamba | wa-hamb-a<br>PST-walk-FV | he/she walked |
| 29 | amajoni | ama-joni<br>NC6-soldier | soldiers |
| 30 | okanye | okanye<br>or | or |

**Key**
NC- noun class
NOM- nominative
ADJ-adjectival marker
COP- copulative
LOC- locative
REL- relative marker
ADV- adverbial marker
INSTR- instrumentative