AOSIS

Automaticity in reading isiZulu

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Automaticity, or instant recognition of combinations of letters as units of language, is essential for proficient reading in any language. The article explores automaticity amongst competent adult first-language readers of isiZulu, and the factors associated with it or its opposite - active decoding. Whilst the transparent spelling patterns of isiZulu aid learner readers, some of its orthographical features may militate against their gaining automaticity. These features are agglutination; a conjoined writing system; comparatively long, complex words; and a high rate of recurring strings of particular letters. This implies that optimal strategies for teaching reading in orthographically opaque languages such as English should not be assumed to apply to languages with dissimilar orthographies.

Introduction

Recent years have seen a surge of policy supporting the use of indigenous languages in Africa (Trudell 2010), but literature about reading in African languages is sparse. The article reports on indications of automaticity in a study of competent readers of isiZulu, the most widely spoken indigenous South African language.

Automaticity in reading

'Reading is arguably the most complex cognitive activity in which humans routinely engage' (Reichle, Warren & McConnell 2009), and yet it is taken for granted by millions of experienced readers who barely notice the fine combination of elements of perception and cognitive activity that cohere during reading. In brief, these are that as we read, we shift our focus along lines of text, processing symbols and their locations to generate visual representations of letters and words and select some of these to convert to concepts. As we glean information from each point of focus, we use unclear images in the parafoveal view that suggest word boundaries to plan the next focus shift. Simultaneously, we integrate lexical information gained with semantic and syntactic information from text already read to construct meaning of the text.

This complex combination of skills can become automatically integrated into a relaxed, swift exercise. When this happens, we have developed automaticity and can use brief visual perceptions of symbol clusters to automatically access associated pieces of language and meanings without additional active cognitive decoding (Penner-Wilger 2008). We can then engage imaginatively with meaning, making inferences, links with remembered information and judgements on what the writer has communicated. Without automaticity, it is extremely difficult for readers to construct a growing interpretation of texts as they read, to use context to aid comprehension (Marinelli, Martelli & Zoccolotti 2010), to gain new information from the text (Verhoeven, Reitsma & Siegel 2011), or to perform any higher order skills associated with reading (Abadzi 2012).

Attaining automaticity

Automaticity is regarded as crucial for reading by Helen Abadzi whose work in neuroscience has brought new insight to understanding reading processes. Abadzi describes automaticity as a 'vaccine' and an 'on-off switch' for literacy (2011); without it, competent reading is not possible. Confirming psycholinguistic evidence, neuroscience indicates that to read effectively, readers must move through text fluently and swiftly because human working memory has a capacity of about 12 seconds (Abadzi 2012). To understand messages in text, we must construct them as wholes, and so must read rapidly enough to get from the beginning to the end of each message within 12 seconds. In English, a minimum reading rate of 45–60 words per minute (wpm) appears necessary for reading at a basic level (Abadzi 2012). Complex tasks, like searching for information, require speeds of about 250 wpm (Abadzi 2010). This reading rate can be achieved only through automatic, instantaneous recognition of a significant proportion of words, and to establish

automaticity clusters of letters must be perceived as whole words or units rather than groups of characters. This develops only through extensive exposure to text and repeated association of particular clusters with words or units they represent.

Children who are included in literacy-related practices early and have explicit instruction in developing reading skills and plenty of supported reading practice usually achieve automaticity easily. In contrast, children who have little exposure to literacy practices, mediocre instruction and infrequent reading practice may never achieve it (Abadzi 2012). People who learn to read after adolescence rarely achieve automaticity, and adults learning to read a new script report that although they see all the letters, they must consciously work out what words they represent (Abadzi 1996). In a new script, a word needs to be decoded approximately 3000 times before it is automatically recognised (Abadzi 2012).

Automaticity in different languages and orthographies

Learning to read appears to be easier in languages with consistent orthographies, that is where letters always represent the same sounds. Inconsistent orthographies compel readers to seek cues in large groupings of letters – in other words, in large–grain size units of text (Georgiou, Parrila & Papadopoulos 2008), which assists in the automatic recognition of whole words. Amongst languages used in Europe, the ability to read words accurately takes longest to develop in English, which has the most opaque orthography amongst them (Georgiou *et al.* 2008; Seymour, Aro & Erskine 2003). Children learning to read languages with consistent, transparent orthographies (e.g. Italian, German, Greek, Spanish and Finnish) read words accurately at the end of grade one (Ziegler *et al.* 2010). In comparison, children reading Portuguese, French and Danish (which are orthographically inconsistent and less transparent) cannot read words as accurately. Children learning to read in English, with the least transparent and least consistent orthography in Europe, achieve only 34% accuracy at the end of grade one (Ziegler *et al.* 2010) and lag behind German children in accurately reading words even at age 12, suggesting that English is 'the hardest European orthography to acquire' (Hutzler *et al.* 2004). Comparable information on learning to read in African languages is not available.

Children who read orthographically consistent languages are better at reading pseudo words (pronounceable non-words) than children who read English (Seymour *et al.* 2003). This suggests that they are decoding graphemes directly to phonemes[1], using small grain size orthographic cues (Ziegler & Goswami 2005). This means that they rapidly reconstruct speech sounds on the basis of letter–sound correlation. In contrast, beginner readers of English must learn letter–sound

correlation and develop a mental lexicon based on larger grain size orthographic cues (Seymour *et al.* 2003). Also, readers of opaque orthographies may use knowledge of syntax, vocabulary and contextual cues more than readers of transparent orthographies (Share 2008). This combination of strategies apparently enables readers to cope with contradictory rules as they learn to read words that are visually similar but phonologically distinct, for example 'tough', 'though', 'thought' and 'through'.

In languages whose orthography features clusters of consonants and graphemes of groups of letters, it is relatively difficult to learn decoding skills (Seymour *et al.* 2003). Unsurprisingly, automatic recognition is most easily established where simple visual patterns consistently represent particular word sounds (Abadzi 2011).

Thus, automaticity is likely to develop more easily in orthographies whose printed word forms are obviously dissimilar to one another and with more difficulty in orthographies where unrelated words can look similar. This has particular relevance here because agglutinated isiZulu words may be visually complex and similar, yet not semantically related.

Eye movement and automaticity

Fixations are strongly related to readers' direction of attention (Miellet, O'Donnell & Seren 2009; Paulson 2005), and cognitive procedures of text comprehension and ease or difficulty in identifying words influence eye movements (Paterson, Alcock & Liversedge 2011). This implies that eye movement records can show which units of text are automatically recognised and which are processed only after refixations, indicating that they are decoded with cognitive effort.

Eye movements indicating established automaticity

Word recognition might not always happen exactly in parallel with eye movements (Rayner, Juhasz & Pollatsek 2007). However, in eye movement records of silent reading of continuous alphabetic text, brief fixations separated by wide saccades, plus a reader's good understanding of text point unequivocally to a high level of automaticity. Successive, fleeting fixations without regressions indicate that a reader's focus has moved steadily along lines of text, and visual stimuli have been smoothly transformed into the 'flow of phonetic imagery through the mind' (Coulmas 2003) that characterises fluent silent reading. Elements recognised could be single words, words in a familiar or predictable string or parts of complex single words.

Word recognition

Instant recognition of a word may be an instant response to seeing the printed form [Perfetti & Ehri, cited in Castles and Nation (2008)], but in text passages, short, familiar, predictable

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1.A phoneme is a single speech sound. A grapheme is a representation of a single speech sound and can be a single letter (e.g. 'o' and 'm') or a pair of letters (e.g. 'th' and 'ng') or a cluster of letters (e.g. 'ough'). Phonemes and graphemes differ between languages.

words are often skipped by efficient readers (Paterson *et al.* 2011; Rayner 2009). This suggests that readers use anticipated meaning or word collocations to predict words to the right of their point of focus, and if the indefinite shape perceived matches the prediction, they take the word as read without fixating directly on it (Paterson *et al.* 2011). Word recognition is probably also influenced by a reader's prior knowledge, suppositions activated during reading and construction of meaning of text read so far (Rapp & van den Broek 2005). Within a sentence, complex words are more easily recognised if preceded by semantically related words (Paterson *et al.* 2011). These factors inevitably differ between readers and contexts.

Eye movements indicating absence of automaticity

A high frequency of refixations and regressions implies that a reader is not automatically recognising many words. In English, readers take longer to recognise multisyllabic words than short ones; words incorporating more than nine letters are often read with more than one fixation, and each syllable adds on average 20 milliseconds to recognition time in studies of lexical decision making (New *et al.* 2006). This reflects Paterson's observation (2011) that visual recognition of English words composed of multiple morphemes (e.g. 'multisyllabic') is likely to depend on breakdown into constituent morphemes.

Regressions show that a reader is referring to areas of difficulty in text read (Paulson 2005). Causes of regression include syntactic or semantic complexities, low-frequency words, confusion, disconfirmation of an interpretation, difficulties in word identification, overshooting or undershooting the beginning of a line or returning to words skipped on a first reading (Paulson 2005). Paterson *et al.* (2011) note readers' tendency to regress on the second of two related morphologically complex words in a sentence and suggest similar word forms can inhibit recognition. When regressing, readers seem to maintain a sense of the spatial arrangement of words in text understood so far and can return their point of focus to points that were problematic for them (Rayner, Fischer & Pollatsek 1998). Because readers redirect their focus to points that caused them difficulty, analysis of eye movement records could reveal features in text that attract regressions most frequently.

Reading and Zulu orthography

Literature on reading African languages is minimal compared with English (Pretorius & Mampuru 2007), but comparison of reading skills in isiZulu and English is appropriate because they are the most used languages in KwaZulu-Natal (van der Merwe & van der Merwe 2006) and isiZulu speakers need to learn to read in both of them at school.

Findings from reading research in English cannot be assumed to apply across languages (Share 2008), and readers of English and isiZulu may have to develop contrasting skills for each orthography. In terms of psycholinguistic grain size theory, because isiZulu orthography is consistent and transparent, its readers probably process relatively small–grain size units of text, as do readers of other orthographically consistent languages (Ziegler & Goswami 2005). This small grain size processing might be the optimal strategy for reading isiZulu not only because of its orthographic consistency but also because of its agglutinative nature and conjoined writing system. These features make many words long and complex, composed of short morphemes clustered round central word sterns. To illustrate, one isiZulu word is often the equivalent of four or five words in disjunctive languages such as English, as in the starting sentence of one of the texts used in this study:

> *Wawunezindlu ezingamaqhugwana amathathu wakhiwe ngaphansi kwegquma*
>
> (He had three houses that were [grass] huts built at the base of a hill) (Literal translation: He-had-houses that-were-huts three built at-the-base of-a-hill).

These six isiZulu words translate into 14 English words, but use more line space.

Because long complex words occur frequently even in fairly simple isiZulu text, word length is unlikely to be a salient determining factor of reading difficulty in isiZulu (as explained below). In contrast, in the disjunctive languages of Europe, it is central to measures of reading difficulty (Readability Formulas 2013).

There are high-frequency, short, unagglutinated isiZulu words that have a constant form, for example nouns such as *umuntu/abantu* (person/people), adverbs such as *kahle* (well or slowly), and conjunctives such as *kodwa* (but). Proficient isiZulu readers are likely to automatically recognise these words instantly. They probably also automatically recognise commonly recurring parts of long agglutinated words as 'multiletter units' as suggested by Verhoeven *et al.* (2011). For example, in a word from the sentence above, *Wawunezindlu*, a reader may automatically recognise any or all of the morphemes *wa wu ne zi* or *ndlu.*

This study

Based on recordings of eye movements of proficient readers of isiZulu, and their recall of reading processes, this study seeks to discover their patterns of automaticity. It asks the following questions:

> Which words were instantly recognised and which needed active decoding by nearly all the most proficient readers?
>
> To what extent is their treatment of recurring words consistent?
>
> What can their immediate recollection of reading experiences reveal about processes that combine in reading isiZulu text?

Instruments

According to Shuter & Shooter Educational Publishers, who have published isiZulu novels, poetry and textbooks since the 1930s, no official grading system exists for isiZulu texts;

publishers rely 'on gut feel to gauge the language level for any grade' (S. Zulu, pers. comm., 12 April 2013). So to select texts for this study, three first-language isiZulu lecturers in education at the University of KwaZulu-Natal were asked to judge the readability of excerpts from novels written in (as opposed to translated into) isiZulu (Appendix 1). Notably, their 'gut feel' judgement matched sentence length and complexity. Two texts judged to be easy to read consisted of 19 sentences with an average of 1.4 clauses per sentence and 15 sentences with an average of 1.8 clauses per sentence, respectively. One of two texts judged to be more difficult had 10 sentences with an average of 2.7 clauses per sentence, and the other only six sentences with an average of 4.2 clauses per sentence. Average word length differs by less than one letter across the four texts, and so it is unlikely to have influenced the perceived reading difficulty. The easy texts were seen to reflect current urban isiZulu, whilst the more difficult texts included words and expressions characteristic of 'deep isiZulu' spoken in remote rural areas and formally studied at academic institutions.

The Visagraph eye movement recording system used in this study records fixations, regressions, reading rate and intereye coordination (Compevo 2012). The system uses infrared differential reflectivity to detect eye movement and samples eye position 60× per second (Compevo 2012). Some systems sample eye position at higher rates than this. However, competent readers in other languages[2] make up to 5.2 fixations per second (Hutzler, Braun & Jacobs 2008), so even at this rate, the Visagraph's recording rate would enable each fixation to be recorded approximately 11.5 times. The advantage of Visagraph here is that it operates in natural light, allows free head movement and uses text printed on normal sheets of A4 paper held by readers at reading distances they found comfortable. Thus, although readers wore a mask and knew that their eye movements were being recorded, the reading experience was natural at least in that the text read was authentic continuous text printed on normal paper, and readers sat in ordinary chairs in a natural reading posture.

Sample

Measures of reading proficiency in isiZulu have yet to be standardised (Van Rooy & Pretorius 2013), so selection and screening of participants was necessarily innovative. Sampling was purposive and encouraged competent readers of isiZulu text to self-select. An invitation to proficient readers of isiZulu was inserted in an isiZulu newspaper in Pietermaritzburg and sent to isiZulu-speaking academics, journalists, publishers and high-performing learners at a local high school.

Approximately 150 respondents underwent a reading test[3]. On the basis of their speed and accuracy, the most efficient 25% of respondents (38 of them) were selected, and their eye

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2. There are no comparable studies in isiZulu.

3. For the reading test, see Land, S., 2015, 'Zulu orthography and reading', *South African Journal of African Languages, 35*(2).

movements recorded as they silently read four texts described above. Five participants were excluded because of imperfect recordings. The remaining group of 33 included:

- 15 women and 18 men
- 24 professionals, 5 full-time university students and 4 high school students.

Participants' ages ranged from 16–61, with 25 of them between the ages of 20 and 49.

Because the article focuses particularly on automaticity and the orthography of isiZulu, the analysis and discussion below is based on the 10 swiftest recordings of each text (i.e. 40 recordings). This selection increased the likelihood that the recorded eye movements demonstrated established automaticity. An analysis of the reading patterns of the whole group is discussed in another article (Land 2015).

Data collection

This took approximately one hour for each participant. The mask of the recording system was fitted to the reader's head, its receptors aligned with the pupils of their eyes and their eye movements recorded as they silently read each text. Immediately after reading each text, each reader gave an account of the content to show the extent of their understanding.

The Visagraph system allows recorded eye movements to be viewed in various forms, one of which allows the replay of the movement of the reader's point of focus represented by a moving cursor on an electronic copy of the text read. This was possible through an isiZulu language package using the selected texts, and designed particularly for this research by Reading Plus, an organisation that offers computer-based reading improvement programmes. With the reading experience fresh in her mind, each reader joined the researcher in following and discussing the recorded movement of her point of focus on the text. The purpose of this exercise was not to try and recapture the subconscious reading processes. Instead, because researchers agree that direction of attention and cognitive procedures in reading influence fixations (Paterson *et al*. 2011; Paulson 2005; Miellet *et al*. 2009), it was hoped that readers might recall their thought processes associated with regressions, pauses, refixations and swift progress. Many readers did in fact recall thinking at points where their eye movement records reflected these features. For example, on noting his regression on the second word of the phrase 'isitsha esinezimbali' (a dish with flowers), a reader said he had first misread 'esinezimbali' as 'esinamazambane' (with potatoes) because he had associated 'isitsha' (dish) with food.

Findings

Although all participants had demonstrated their competence, eye movement records showed differences amongst them. In Figures 1–3, vertical sections of graph lines show the duration of each fixation and horizontal sections
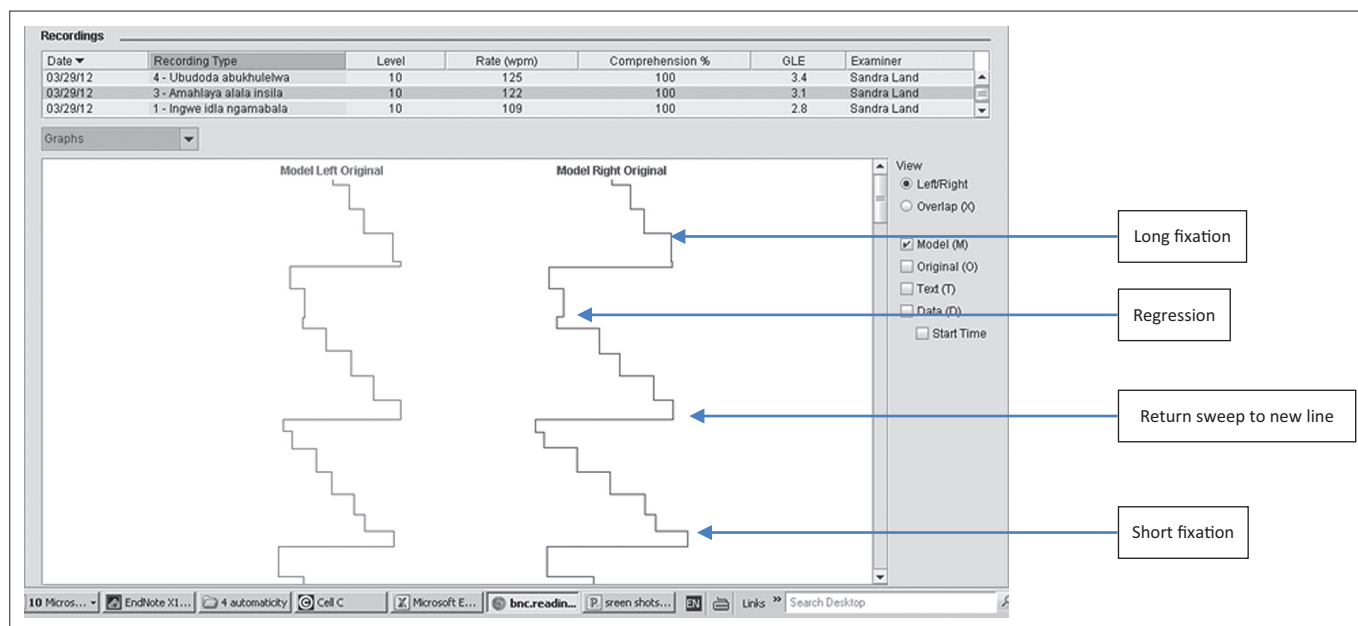
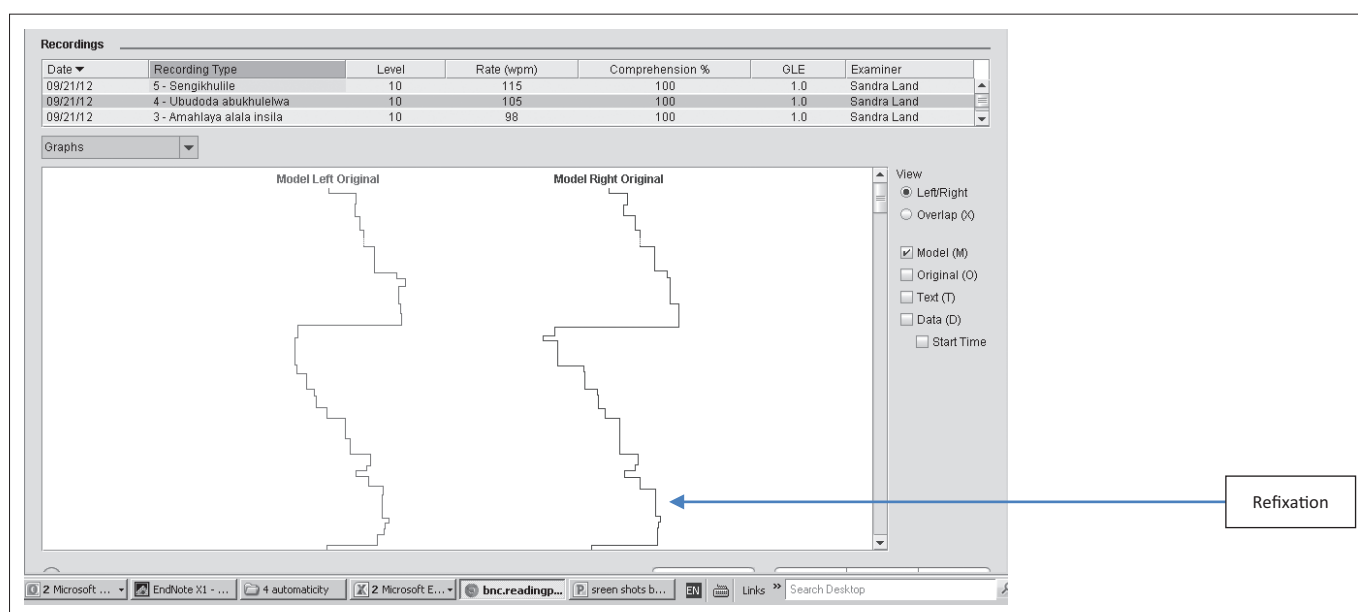**FIGURE 1:** Eye movements of a highly skilled reader.

FIGURE 2: Eye movements of a reader with many refixations.

show movement to the left or right within a line of text and return sweeps to the left to begin a new line.

Figure 1 shows the steady progress of an adept reader through almost three lines of text in approximately 6.5 seconds. The brief vertical line sections show the six or seven fixations he made per line, and the short horizontal line sections show his saccades as his point of focus moved through each line of text. There is one brief regression. Observation of his recorded point of focus moving over the text confirmed that he read many words in a single fixation and passed over some others without fixating on them, indicating a high degree of automaticity.

Figure 2 and Figure 3 show the slower progress of two slightly slower readers. Figure 2 shows very small movements of the

point of focus to the right, indicating short saccades, suggesting a short span of recognition, with repeated fixations on some words.

Figure 3 shows a similar rate of progress, but here the track shows long fixations at line beginnings and frequent regressions, as the reader 'reversed' in the text to have a second (or even third) look at words already passed. Figure 2 and Figure 3 show less instant word recognition than Figure 1.

Textual features and automaticity

As shown in Table 1, sentence length differed markedly across the texts, and reading speed decreased as sentence length increased. The Pearson Product Moment Correlation test showed a moderate, yet significant negative correlation between reading speed and sentence length ($r = -0.413$, $n = 40$, $p = 0.01$).
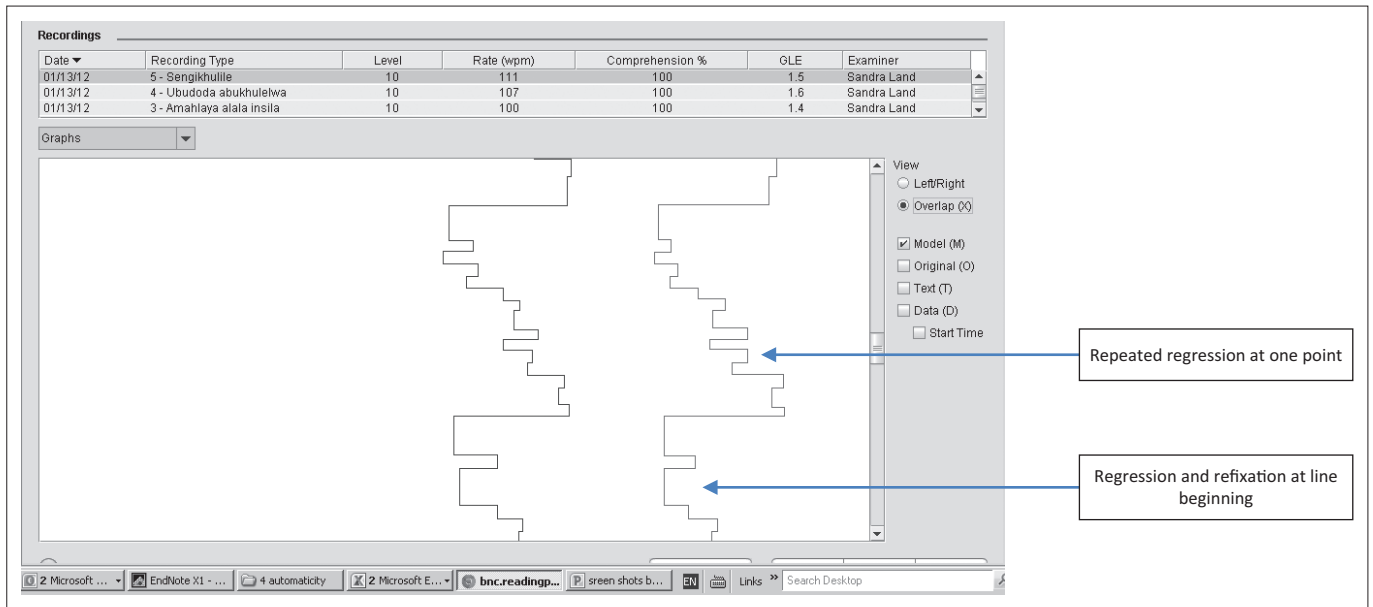
FIGURE 3: Eye movements of a reader with repeated regressions.

TABLE 1: Measures of texts and average reading scores on each.

Text	Average reading rate wpm/letters per minute (lpm)/letters per second (lps)	Average number of fixations	Average number of regressions
1. *Sengikhulile* 100 words 765 letters 16 lines 19 sentences Average number of words per sentence: 5.3 Average number of clauses per sentence: 1.4	159 wpm/ 1214 lpm /20 lps	138	14
2. *Ubudoda abukhulelwa* 100 words 747 letters 14 lines 15 sentences Average number of words per sentence: 6.6 Average number of clauses per sentence: 1.8	145 wpm / 1081 lpm /18 lps	155	14
3. *Amahlaya alala insila* 100 words 831 chars 17 lines 10 sentences Average number of words per sentence: 10 Average number of clauses per sentence: 2.7	117 wpm /974 lpm /16 lps	176	24
4. *Ingwe idla ngamabala* 100 words 749 letters 15 lines 6 sentences Average number of words per sentence: 16.7 Average number of clauses per sentence: 4.2	124 wpm /931 lpm /16 lps	175	31

Readers' rate of fixations increased moderately but significantly as sentence length increased ($r = 0.399$, $p < 0.05$). Their rate of regressions also increased significantly with sentence length ($r = 0.440$, $p < 0.01$).

Sentence length increases across the texts, with an average of 5.3 words per sentence in Text 1, 6.6 in Text 2, 10 in Text 3 and 16.7 in Text 4, showing that Text 3 and Text 4 (judged to be the more difficult of the four texts) were read more slowly, with more fixations and regressions than Texts 1 and 2. This could also be influenced by other less measurable differences, such as unfamiliar vocabulary or other complexities such as the need to infer.

Readers' comments as they watched the replay of the recorded movement of their focus reveal their perceptions of their own reading process at points where their progress slowed:

SL: You see, you slowed down a lot here?

NN: Yes I remember.

SL: What was going on in your head?

NN: 'Ezingaphambiyana nokugawula izihlahla, I think it is the same as the other one before this one. I was trying to understand, to read it and understand it at the same time … because it is talking about amadodana and now it's izihlahla so I am trying to put all of this thing together'.

Illustrating Paulson's (2005) observation that readers regress to problem areas, in this case unexpected information, one reader spoke of her surprise upon reading of war between whites in South Africa (the Boer War):

TM: I was not sure about the sentence because, really I never heard anything about the impi between amaNgisi namaBhunu. I only know the war between Blacks and Boers so … Mmh? Okay then to me it was something new.

SL: So that is why you stuck there because you were thinking …

TM: WHAT? amaNgisi namBhunu? Yes… I had to re-read the sentence to make sure if I was reading the right thing.

Similarly, another reader exemplifies the observation of Paterson *et al*. (2011) that readers tend to regress on the second of related words in a sentence, perhaps because their similarity inhibits recognition (here the words are visually similar, though not related):

SL: And you also regress there, on *kwakuyiloluhlobo*.

CM: Ok there, I am not sure if it was this … *ubuhholohholo* because when I see that I thought there was something familiar.

Average word length did not differ much between the texts (Text 1: 7.65 letters, Text 2: 7.47 letters, Text 3: 8.31, Text 4: 7.49). Unsurprisingly, in view of this small difference, there was no significant correlation between word length and reading speed ($r = -0.118$).

In the 400 words of the combined isiZulu texts used here, 62 three-letter strings occur 10 times or more and 11 four-letter strings occur more than 10 times (Decrypting Text 2013). Analysis of 5000 words of text from *Isolezwe* (http://www.iol.co.za/isolezwe), a popular isiZulu newspaper, showed that in 400 words of text in this newspaper, 30 three-letter strings are likely to occur 10 times or more and 4 four-letter strings are likely to occur more than 10 times (Decrypting Text 2013). In comparison, analysis of 5000 words of text from *Mercury* (http://www.iol.co.za/mercury), a popular English newspaper, showed that in 400 words, only 4 three-letter strings (the, and, -ing and -ent) occur 10 times or more, and no four-letter strings occur more than 10 times (Decrypting Text 2013). This comparison demonstrates frequent repetition of letter strings in isiZulu.

Similarity between word forms hinders easy distinguishability between words in any language (Abadzi 2011), and the high recurrence of the same letter strings may hinder the development of automaticity. In the example above where a reader regressed on *isitsha esinezimbali* (dish with flowers) (Text2), after misreading it as *isitsha esinamazambane* (dish with potatoes) the reader's mistake showed signs of automaticity because he had predicted a word referring to food, and on sight of a long word containing the prefix *esina/e-* followed by a stem containing *z* and *mba*, assumed the stem to be *amazambane*, a miscuing error because of the similarity between word forms. Almost immediately after this regression, the reader had trouble with the same letter combination again, regressing on *ezimbalwa* (several) after misreading it as *izimbazo* (axes).

There is a strong, highly significant correlation ($r = 0.743$, $p < 0.01$) between saccade length and reading rate. A high reading rate is strongly associated with automaticity, and these figures show that the readers whose saccades are long are those who read swiftly. This is apparent in the graphs of readers' eye movements as shown above.
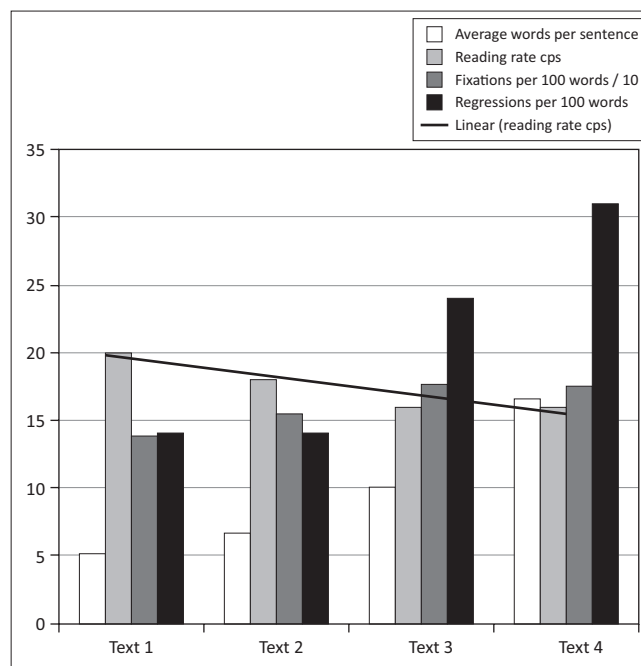

FIGURE 4: Sentence length of texts and average scores.

Less strong, but still significant, was the negative correlation ($r = -0.348$, $p < 0.05$) between saccade length and longer sentences including unfamiliar vocabulary since Texts 3 and 4 included words that readers found obscure:

SL: *Ngezikhadlana* - is that a construction you are familiar with?

MS: Yes, izikhala is [*means*] spaces. So izikhadlana is smaller spaces[4] - but a lot of the language I am not used to.

There was no significant correlation ($r = 0.053$) between the duration of readers' fixations and sentence length, indicating that readers did not increase the duration of their gaze when coping with longer sentences or words they found obscure. This indicates that slower reading rates on texts with longer sentences and obscure words were because of the higher number of fixations (including regressions) made by readers, rather than longer fixations.

The graph in Figure 4 compares sentence length, reading rate, fixations (reduced by a factor of 10 to allow graphic comparison) and regressions across the four texts. The trend line shows how reading rate decreased as sentence length increased and with it the rate of fixations and regressions.

Word recognition

Word recognition might not always coincide exactly with a reader's shifts of focus from word to word, but the number of fixations on a word and the duration of fixations are used by researchers to reflect the ease of word recognition (Rayner *et al*. 2007). Thus, the average number of fixations on a word by different readers and their average duration of fixation indicate how easily a word is recognised. On this basis, each

4.The reference is to a description of gaps in doorways allowing cold wind into houses.

word in each of the four texts was coded according to the number of readers who skipped it, fixated on it once, refixated on it or regressed to it. These data were summarised to show which words appeared to have been instantly recognised in 80% or more of the recordings and which words appeared to have required cognitive work to decipher in 80% or more of the recordings.

Instantly recognised (automaticised) words

Of the words, 24.5% (98 of 400) appear to have been instantly recognised in 80% or more of the recordings. They are listed in Appendix 2. Average word length across the four texts used is 7.73 – significantly longer than the average word length amongst Europe's languages: 4.6 letters in English, 4.7 in Danish, 4.9 in Swedish, 5.6 in German and 7 in Finnish (Björnsson 1983). Average length of words processed in a single brief fixation here is 6.5 letters, indicating that, as in other languages (Paterson *et al.* 2011), shorter words are more likely to be instantly recognised. It is predictable that short, unagglutinated, high-frequency words, such as *nje* (just), *khona* (there) and *futhi* (again), will be instantly recognised by readers, and possibly skipped. Here, only 3 of the 400 words (< 1%) were *skipped* in at least half of the recordings. These were *uma* 'if' or 'when', *indlu* 'house', and *yomuzi* 'of the home' and were skipped where their predictability was high. This is dramatically less than the 25%–30% of the words skipped by readers of English (Rayner 2009; White 2008), suggesting that word recognition differs substantially between isiZulu and English.

Most instantly recognised words consisted of not more than two morphemes. Where words with more than two morphemes were instantly recognised, they were high-frequency word forms and/or were highly predictable such as *um/fo/wa/bo* in the context of '… *wabonakala uDuda umfowabo omncane kaNkalimba…*' ('…could be seen Duda, Nkalimba's little brother …'), where the capital letter of the first name and the context would have cued expectation of 'brother'. Thus, predictably, words with few morphemes appear to be recognised more easily than words with three or more morphemes. It is possible that familiar combinations of morphemes are instantly recognised, as in this instance:

SZ-W: … I just discarded the first beginning part *ezingama-* part and just concentrated on the *qhukwana* part. I thought - What could that be?

SL: Ok because those e-zi-nga-ma - they're all familiar parts of words?

SZ-W: Yes

Many of the words that were instantly recognised at some points in the text were actively decoded at other points. This indicates that factors such as position, collocations, context and the process of meaning construction appear to influence recognition. Notably, no words at the start of a line of text were instantly recognised, even though some of them (*uma, lapho* and *ukuthi*) were instantly recognised elsewhere in the

text. These refixations on words at the beginning of lines accords with the observation by Rayner *et al.* (2007) that fixations at line beginnings often involve corrective saccades, presumably made as readers ensure that they have found the right line. A reader's indefinite perception of this habitual process is clear in the instance below:

CM: I think it's - when I am starting the new line - and then I don't know if I was on the third or the second line, I'm not sure …

SL: So, how do you make sure that you are on the right line? …

CM: Like if I was on the third line or fourth line?

SL: Yes. Do you know?

CM: It only just happens.

Words requiring cognitive work to decipher

In 80% or more of the recordings, 23.5% (94 of 400) were read with two or more fixations or at least one regression. These words are listed in Appendix 3. Only a few of them included uncommon vocabulary, so it appears that readers broke familiar words into their constituent parts to decipher them. Their average length is 11.1 letters (considerably longer than the overall average word length in these texts of 7.73 letters), and they consist of up to seven agglutinated morphemes, for example:

ngi/nga/ka/li/hlangan/is/i, (I had not yet gathered together)

kwa/ku/ngo/wo/ku/phatha (it was to take care of)

a/yi/si/shiya/galo/lu/nye ('that were nine', or literally 'that which leaves digit of one').

In view of the length and amount of information in these multimorphemic words, it is unsurprising that nearly all the readers required more than one fixation to read them and predictable that readers are likely to develop automaticised recognition of only those complex permutations that occur with unusually high frequency. The excerpt below illustrates the strategy of one of the swiftest readers, which appears to exemplify the reconstruction of the speech sounds and small–grain size processing strategy described by Ziegler and Goswami (2005) in relation to transparent and consistent orthographies:

SL: And how do you manage to unravel this because … there's one, two, three four, five six 'bits' [*morphemes*] in that word. How do you do it in your head?

NN: I think I read it slowly like [*mimicking*] kwa-ku-ngo-wo-ku-phatha then I understood it … I say the word, but silently.

The need to process these complex words implies that this small–grain size processing strategy should be explicitly taught to learner readers of languages with orthographies similar to that of isiZulu.

Readers' treatment of recurring words

Interestingly, some words recognised immediately by nearly all skilled readers at some points in the text were read with

multiple fixations and/or regressions at other points[5]. For example, the word *khona* (there) was instantly recognised in 100% of the recordings at three points in the text, but in only 60% of them at another point, where it refers to a pantry. Although the word *khona* is grammatically predictable at that point, a *pantry* might be an unexpected concept for some of these readers.

Ubaba (father) and *phela* (here, an interjection like 'well') recur several times in the text, and were instantly recognised at some points but fixated on more than once or regressed to at others. This suggests that factors other than the distinguishability and familiarity of particular words affect the ease with which they are recognised.

Position on a line of text is salient, with a moderate but significant correlation ($r = 0.399$, $p < 0.01$) between being in the last half of a line of text and the likelihood of being instantly recognised.

Seventeen of 22 instances of frequently recurring words that were recognised immediately in at least 70% of the recordings were in texts 1 and 2, which had less than two clauses per sentence on average. Only 5 frequently recurring words were instantly recognised in the more difficult texts 3 and 4, whose sentences averaged 2.7 and 4.2 clauses respectively.

With regard to the position of words within a sentence, it appears that a relatively short high-frequency word is likely to be recognised with a single fixation (but not skipped) at the beginning of a sentence. It seems more likely to require multiple fixations when appearing further into a sentence because the number of readers instantly recognising a word is lower for words appearing near the end of sentences. Yet surprisingly, and in spite of the strong correlation found between lower reading rates and longer sentences, the correlation between a word's position in a sentence and the likelihood of it being instantly recognised does not reach significance ($r = -0.083$).

Limitations

The enquiry in the article is based on eye movements of the 10 swiftest readers of a sample of 33, recorded as they each read four texts. This narrow selection ensured that only recordings demonstrating established automaticity were used, but more confidence could be placed in data from a larger sample. However, this exploratory study, the first of eye movements of competent readers of isiZulu, may be a useful starting point in the particular research question addressed.

At 60× per second, the Visagraph equipment used has a lower sampling rate than some other systems, but its advantage is that it allows a close simulation of natural silent reading of continuous text, which was the particular focus of

5. For a table showing how words that recurred repeatedly in the texts were read, see Land, S., 2015, 'Reading isiZulu: Reading processes in an agglutinative language with a transparent orthography', PhD thesis, School of Arts, University of KwaZulu-Natal.

this study. The effects of readers' awareness of being recorded as they read are unavoidable, and a limitation in all reading research involving readers' cooperation.

Conclusions and implications

The orthography of isiZulu is shaped by its agglutination, conjoined writing system, comparatively long, complex words and a high rate of recurring strings of particular letters. This makes it less conducive to automaticity than orthographies with short words and high heterogeneity amongst word forms. Data in the study suggest that readers of isiZulu rely on small–grain size orthographic units. In languages where readers do this, there may be less of a distinction between reading by phonological decoding and by automatic whole word recognition than there is in languages where readers rely on large–grain size orthographic units such as English. Perhaps a continuum starting with slow recognition of the root and morpheme synthesis, progressing towards instant recognition and synthesis is a more plausible model for automaticity in these languages?

Reading speeds of participants was highest when reading short sentences and familiar vocabulary. When reading longer sentences with less familiar vocabulary their reading rate decreased, whilst their rate of fixations and regressions increased significantly, but the duration of their fixations did not. Saccade length increased when reading text with familiar vocabulary, indicating a higher rate of automatic recognition. Although it is common across languages for reading rate to slow as textual complexity increases, the data in the study suggest that there are different word recognition processes in isiZulu and English. Almost 25% of words were recognised instantly, although less than 1% were skipped, suggesting that few isiZulu words have enough of a distinctive form to be predicted in the indistinct parafoveal view. Words that were instantly recognised tended to be shorter than average, suggesting that, as in other languages, short words are more easily automatically recognised. One implication of this for teaching reading in isiZulu is that predictive skills could be enhanced by ensuring that new readers recognise a core list of short words that do not agglutinate, such as conjunctives, and take cognisance of their semantic significance in the sentence. Another is that new readers should be given guided practice in spotting common word stems in complex words, as well as common combinations of morphemes.

Readers fixated more than once on almost a quarter of the words in the texts. Predictably, these were longer (often comprising more than 11 letters) and more complex than average, usually comprising three or more morphemes. Readers' clear recall of their thought processes at particular points of their reading suggests that, despite the subliminal nature of many elements of the reading process, the construction of mental representations of meanings are complex and powerful influences on how words are read, and that cognitive processing of words and even sentences sometimes lags behind perception of words in visual focus. Learner readers need to be enabled to disaggregate complex

words into their constituent morphemes and to integrate their semantic value into their mental representation of the meaning of text as they read.

Overall implications of the findings of this study are that reading processes that characterise efficient reading in an orthography such as that of English may not be effective in another, such as isiZulu. An obvious corollary is that methods for teaching reading and for training teachers to teach reading should take into account orthographical features of each language and ensure that learner readers are equipped with strategies to deal with the particular demands of the orthography in which they are learning to read.

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Competing interests

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Appendixes

Appendix 1: Texts used in this study (not in this format)

Words instantly recognised

Wordsread with multiple fixations and/or regressions

1. Memela, N. (1992). *Sengikhulile*. Durban: New Readers Publishers. p.1.

UNomadashimane igama lami. Sengikhulile! Awu! Akukho okudlula lokhu. Ikhulu leminyaka akusiyo into encane. Phela ngazalwa ngempi yamaNgisi namaBhunu. Abanye babewabiza ngokuthi amaDashimane amaBhunu. Igama elithi Nomadashi lasukela lapho. Ubaba wayesebenza epulazini endaweni yase-Bulwer. Kwathi ngokusuka kwempi wathi umlungu kubaba, "Ngiya empini. Hleze ngingabuyi, ngifele khona. Uma ngingabuyanga, ungakhathazeki. Ngiwenzile onke amalungiselelo okuthi umesisi anibheke nezingane zakho." Umama ngalesosikhathi wayekhulelwe. Wazibula ngamawele, umfana nentombazana. Bathi kuzelwe amakhosi. Bangiqamba igama elithi nginguNomkhosi. Kepha ngenxa yokuthi ngazalwa ngempi kwaduma elokuthi nginguNomadashi. Ngakhula-ke sihlezi epulazini. Sasilima, sisenga izinkomo, kudliwa amasi. Kwakujwayelekile ukuthi ingane ekhulele epulazini iwuqale isencane umsebenzi. Ngaqala ukusebenza ngingakalihlanganisi ishumi leminyaka. Umsebenzi wami kwakungowokuphatha izingane zomlungu. Ngaze ngakhula impela ngisebenza kuye lomlungu.

2. Nyembezi, S. (1953). *Ubudoda abukhulelwa.* Pietermaritzburg.: Shuter and Shooter Pty Ltd. p.15.

Lapha kwaMsezane kwakwakhiwe ngempela. Kwakungumuzi ovuthiwe. Indlu yayakhiwe ngesitini esibomvu, esishisiwe. Yayinovulande ezinhlangothini ezimbili. Indlu yayinamakamelo ayisishiyagalolunye. Kwakukhona indlu yokuphola, neyokudlela, nalapho ayesebenzela khona uMsezane nalapho ayegcina khona izincwadi zakhe. Phela kwakungumfo owayekuthanda ukufunda. Kunamakamelo amathathu okulala. Bese-ke kuba yikhishi nendlu lapho kubekwa khona ukudla. Uma ungena endlini yokuhlala, wawukhangwa upiyane olukhulu, luzisho nje ukuthi olwemali. Kwakukhona futhi endlini izihlalo ezithofozelayo, ayethi umuntu uma ehlala kuzo ashone phansi avele ngezindlebe. Phakathi nendawo kukhona itafulana elincane kubekwe phezu kwalo isitsha esinezimbali. Phansi lapha amapulangwe ayembozwe ngocansi lwabeLungu. Kwakuyiloluhlobo othi uma uhamba phezu kwalo

nezigi zife, umuntu athashazise okukamangobe. Ezindongeni kwakulenga izithombe ezimbalwa. Zonke izinto ezikulomuzi zazikhuluma ngokusobala zithi kukwamnumzane lapha.

3. Mkhize, M. T. (1983). Amahlaya alala insila. Pretoria: De Jager-HAUM Publishers. p.1

Umuzi wakubo kaChithimpi Zondi umfo kaNkalimba wawunezindlu ezimangaqhugwana amathathu wakhiwe ngaphansi kwegquma. Iminyango yezindlu yayibheke ngaseNyakatho ukugwema iziphepho ezazivamise ukuqhamuka ngaseNingizimu. NgaseMpumalanga yomuzi kwakunomhoshana okwakwehla kuwo umchachazwana wamanzi owawuze uyongenela emfuleni uMzimayi. Ntambama kwakuye kuheleze umoya obandayo owawuye ungene ngezikhadlana zezicabha kwaZondi. Lamahelehelana ayeqala ngokuphola kamnandi kodwa agcine esebanda ngokumangalisayo lapho sekuphakathi kwamabili ebusuku ikakhulukazi uma kusebusika. Ngalelilanga kunguMgqibelo ntambama iwona lamahelehelana ayesiza ekupholiseni kwaZondi. Phela lapha emzini kaNkalimba ngalelilanga kwakusindwe ngobethole kutatazela omakoti kunjeyaya. Okungamakhehla nezalukazi kwakulokhu kubonakala kuphuma kuthi tshobe ngemva kwezindlu kuchitha lawomanzi ayengasadingeki emizimbeni yawo. Kulobuhholohholo bomsindo wabonakala uDuda umfowabo omncane kaNkalimba engena endlini nezimbuzi ezimbili ayezibambe ngezimpondo eyokuma ngasemsamo. Esemsamo uDuda wabatshela abasendlini ukuthi lezimbuzi kwabe kungezani.

4. Zama, J. M. (1967). Ingwe idla ngamabala. Pietermaritzburg: Shuter and Shooter. p.1

Kwakungenye intambama lapho selibantubahle; kusentwasahlobo iminduze seyiqalile ukuqhakasa, mhla ngiqalayo ukuyizwa inguquko empilweni yami ngoba ngakhanyelwa kusukela ngaleyo ntambama ukuthi akukho lutho oluzenzekelayo nje ngokwalo. Yonke into emhlabeni inembangela nenhloso ethile kulowo nalowo muntu. Leyontambama engiyisusela kuyo lendaba yami ngayiphawula ngoba ubaba, uNqakamatshe, wafikisana kanye nathi esangweni lomuzi wakwethu, kwazise ukuthi sasingaveli ndawonye nobaba. Ubaba wayebuya embizweni eyayibizwe nguGazi iNkosi yethu thina baThembu. Thina sobathathu madodana akhe sasiqhamuka kokumba iziphunzi esikhaleni esasisivule ezinsukwini ezingaphambiyana ngokugawula izihlahla ekupheleni kwehlathi elaligudla insimu kamame omkhulu, uMaButhelezi. Umame omkhulu wayebike kubaba ukuthi isife ayesilima minyaka yonke sase sinciphile ububanzi baso ngenxa yokucinaniswa yimixhantela yezihlahlana ezazimila ezimpandeni zemithi eyayisephethelweni lalelohlathi. Thina sasivela kulowo msebenzi.

Appendix 2

Words that 8 of 10 swift readers recognised automatically

1 morpheme	2 morphemes	3 morphemes	4 morphemes
mhla (day)	yami (my)	ngaleyo (from that)	wayebike (she reported)
nje (just)	ngoba (because)	ethile (certain)	umfowabo (their brother)
lapho (when/where/there)	Yonke (all)	nenhloso (with the purpose)	akusiyo (it is not that)
khona (there)	yethu (our)	nalowo (and that one)	
Phela (Well)	thina (us)	wakhiwe (built)	
futhi (as well/again)	akhe (his)	yezindlu (of the houses)	
Uma (if/when)	kokumba (to dig)	yomuzi (of the home)	
Kepha (yet)	izihlahla (plants)	emfuleni (in the river)	
	insimu (field)	obandayo (cold)	
	sase (until we had)	agcine (they ended up)	
	amathathu (three)	ayeqala (he began)	
	ngaphansi (below)	emzini (in the home)	
	iziphepho (breezes)	ezimbili (two)	
	kuwo (to that)	ayegcina (he kept)	
	wamanzi (of water)	Okulala(to sleep)	
	kwaZondi (of Zondi)	Elincane (that was little)	
	omakoti (brides)	kubekwe (to put away)	
	kuphuma (to exit)	epulazini (on the farm)	
	umoya(wind)	endaweni (in a place)	
	kodwa (but)	ngifele (I may die)	
	kuthi (making as if)	okuthi (so that)	
	yawo (of theirs)	nezingane (and the children)	
	uDuda (boy's name)	kuzelwe (it was born for)	
	Indlu (house)	elithi (that said)	
	zakhe (his)	yokuthi (of the fact)	
	Ukufunda(to read)	ekhulele (grew up)	
	nendlu (and a room)	leminyaka (of years)	
	umuntu (person)		
	kuzo (on it)		
	kwalo (on it)		
	isitsha (dish)		
	othi (made as if)		
	kwalo (on it)		
	encane (little)		
	Abanye (others)		
	Igama (name)		
	Ubaba (father)		
	Kwathi (it was said)		
	kwempi (of the army)		
	wathi (he said)		
	Ngiya (I am going to)		
	Umama (mother)		
	Bathi (they said)		
	ukuthi (that)		
	ingane (child)		
	amasi (curdled milk)		
	Ngaqala (I began)		
	ishumi (ten)		
	wami (my)		
	Ngaze (I did)		
	Impela (really)		

Appendix 3

Words that 8 of 10 swift readers fixated on more than once

1 morpheme	2 morphemes	3 morphemes	4 morphemes	5+ morphemes
Phela (Well)	iminduze (lilies) ukuqhakaza (bloom), ubaba(father) baThembu (of the Thembus) iziphunzi (tree stumps) kamame omkhulu (of the first wife) ububanzi (breadth) ntambama (evening) nendawo (and a place) amapulangwe (planks) izinkomo (cattle) Iminyango (doors)	seyiqalile (it had begun) empilweni (in life) Leyontambama (that evening) ngayiphawula (I told it) uNqakamatshe (person's name) wakwethu, (of ours) uMaButhelezi (Ms Buthelezi) wayebuya (he came back) embizweni (from a meeting) sobathathu (we were three) madodana (sons) sasiqhamuka (we appeared) ngokugawula (of chopping down) esikhaleni (in the space) umchachazwana (spring) ngokuphola (cooling) esebanda (that were cold) sekuphakathi (that was in between) kunguMgqibelo (it was Saturday) ngobethole (of heifers) ngalelilanga (on that day) kaNkalimba (of Nkalimba) nezalukazi (and old ladies) kwezindlu (of the houses) Kwakukhona (there was) okukamangobe (like that of a wild cat) kwakulenga (there were hanging) okudlula (that passes) ngazalwa (I was born) amaDashimane (Dutchmen) lasukela (started from then)	Ngakhanyelwa (I realised) wafikisana (he got there at the same time) esasisivule (that we had opened) elaligudla (that surrounded) ngaseNyakatho (to the north) ngaseNingizimu (from the south). NgaseMpumalanga (to the east) owawuye (that used to) ngezikhadlana (in the gaps) kusebusika (in winter) lamahelehelana (these breezes) kwakusindwe (that was smeared) Yayinovulande (it had a veranda) ezinhlangothini (on its sides) esishisiwe (that were fired) yayinamakamelo (it had rooms) ayesebenzela (where he worked) kwakungumfo (he was a man) owayekuthanda (who liked) Kunamakamelo (there were rooms) wawukhangwa (was displayed) Nentombazana (and a girl) Ngingabuyanga (I had not come back)	oluzenzekelayo (that had been done for) engiyisusela (from where I took this) ezingaphambiyana (that were in front of) yokucinaniswa (because of being crowded) ezingamaqhugwana (that were traditional huts) ezazivamise (that used to) kwakunomhoshana (there was a ravine) ngokumangalisayo (that was surprising) Okungamakhehla (those who were old men) Ayengasadingeki (that was not still needed) Kulobuhholohholo (in that commotion) ayisishiyagalolunye (that were nine) ezithofozelayo (that were soft) esinezimbali (that had flowers) Kwakuyiloluhlobo (it was that kind) ezazikulomuzi (that were of that home) ungakhathazeki (do not worry) wayekhulelwe (she was pregnant) nginguNomkhosi (I was Nomkhosi) nginguNomadashi (I am Nomadashi) Kwakujwayelekile (it was usual) ngingakalihlanganisi (I had not yet gathered together) kwakungowokuphatha (it was to take care of)