COMPARING CORRELATES OF READING COMPREHENSION BETWEEN TRANSPARENT AND OPAQUE ORTHOGRAPHIES: A CASE OF CHINYANJA-ENGLISH BILINGUALS IN ZAMBIA

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Abstract

Orthographic transparency has a significant impact on reading and its development. Transparent orthographies are more beneficial for the reading process compared to opaque ones. This hypothesis was explored to examine the factors contributing to reading comprehension among bilingual children in Zambia. Two groups of fourth to sixth graders were administered equivalent measures of letter discrimination, phonological awareness, word reading, pseudo-word decoding, and reading comprehension skills in both Chinyanja and English languages. The results indicated that overall, reading proficiency is influenced by the writing system. Children tested in the transparent Chinyanja orthography performed better on all subtests compared to their counterparts tested in English, except for phonological awareness. The predictive power of the four variables on comprehension was specific to each orthography, with high correlations within each orthography. Word reading significantly predicted English reading comprehension, while pseudo-word decoding better predicted Chinyanja comprehension. The data from the English language aligned better with the conceptualised model of reading comprehension. This finding supports Share's (2008) argument that reading models centred on the English language cannot be universally applied across orthographies with varying levels of transparency, as the English writing system is considered an exception.

Keywords: Decoding, English, Chinyanja, Orthographic Depth, Reading Comprehension

Until recently, it was widely believed by researchers that letter discrimination (LTD), phonological awareness (PAW), word recognition (WRD), decoding (non- and real-words), and rapid automatised naming (RAN) were universal predictors of reading comprehension in all writing systems, regardless of their orthographic complexity (Hogan, Catts, & Little, 2005; Milankov, Golubović, Krstić, & Golubović, 2021; Moats, 2003; Norton & Wolf, 2012; Share, Jorm, Maclean, & Matthews, 1984; Share, 2008; 2021). However, most of the early research supporting this idea was based on an Anglocentric perspective (Gentaz, Sprenger-Charolles, & Theurel, 2015; National Reading Panel, 2000; Raudszus, Segers, & Verhoeven, 2021; Snowling & Hulme, 2005, Stanovich, 2000), including the theoretical models that explain the development of reading comprehension (Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001; Seidenberg & McClelland, 1989). Now, empirical evidence is emerging that challenges this Anglocentric view and demonstrates that the English writing system has a unique spelling-sound correspondence that does not accurately represent the universal science of reading (Share, 2008, p. 584; Share, 2014). Therefore, as noted by Castles, Rastle, and Nation (2018), reading research should be balanced, informed by development, and based on a deep understanding of language and writing systems by incorporating diverse perspectives from cross-orthography research.

Cross-linguistic comparisons also raise questions about the universality of existing models of reading comprehension from an Anglocentric perspective (Caravolas et al., 2012; Caravolas, Lervag, Defior, Malkova, & Hulme, 2013; Furnes & Samuelsson, 2010, 2011; Holopainen, Ahonen, & Lyytinen, 2001; Müller & Brady, 2001; Oney & Durgunoglu, 1997; Seymour, Erskine, & Aro, 2003; Share, 1995; 2008; 2021). Karanth (2003, p. 19) argued that ‘in order to be a universal model of reading and brain, these models need to be tested with data from different writing systems around the world’. This study aims at contributing to this debate by examining common predictors of reading comprehension across diverse orthographies among Nyanja-English bilinguals in Zambia.

There is very limited empirical knowledge about how existing theories and models of reading, in general, and comprehension, in particular, perform in transparent orthographies (Goswami, 2003; Share, 2008, 2014, 2021), taking into account the cognitive demands associated with orthographic complexity (Goswami, 2005; Share, 1995). Specifically, we need to consider the following questions: (a) To what extent are traditional theories and models of reading development applicable across orthographies? If they are not applicable, what are the main differences that explain reading development? This study seeks to explore answers to these questions in the context of Chinyanja and English languages because bilingual learners in Zambia ‘provide a unique opportunity to study the impact of orthography on reading” (Karanth, 2003, p. 5). Answers to these questions are likely to offer alternative explanations to traditional assumptions about reading and, ultimately, inform reading instruction for beginning readers, especially in resource-poor learning environments.

Development of Reading Skills and Orthographic Depth: Models and Theories

Gough and Tunmer’s (1986) Simple View of Reading (SVR) is a well-established theoretical framework that aims at explaining reading comprehension. According to this framework, reading comprehension is the result of two factors: decoding and listening comprehension proficiency, which are multiplied together (Catts, 2018). While listening comprehension is acquired naturally, decoding is not an innate skill. It needs to be explicitly taught to beginners in order for them to achieve proficient text comprehension (Reid, 1998). Unfortunately, many learners encounter difficulties in acquiring decoding skills, unlike those who effortlessly acquire them (Kaani & Joshi, 2013; National Reading Panel, 2000).

Several theories and models have been proposed to explain the development of decoding and the conceptualisation of reading difficulties (Stanovich, 1990). However, these models often take a one-size-fits-all approach and base their assumptions on findings from the English language (Share, 2008; 2021). Two prominent models of reading development are the Dual Route Cascaded (DRC) (Coltheart et al., 2001) and the Connectionist Triangle models (Seidenberg & McClelland, 1989). Although both models focus on word identification, they represent different perspectives. The DRC model on one hand, explores whether word identification is guided by linguistic rules used to access a word's pronunciation and/or meaning from its written form. On the other hand, the Connectionist Triangle model investigates whether this process can be better described as one in which different types of lexical information provide mutual soft constraints on the generated pronunciations and/or meanings during word identification (Rayner & Reichle, 2010, p. 789).

The DRC model assumes that successful word pronunciation involves two alternative routes or pathways in word processing modules (Castles, 2006; Coltheart, 2005). The sublexical route involves applying grapheme-phoneme correspondence (GPC) rules to map letter-sound conventions in words. The second route relies on the reader's memory store to recall previously encountered and familiar words. Although both routes rely on prior knowledge, they differ significantly in the level at which words are processed. The sublexical path relies on small grain knowledge of letter-sounds to decode both regularly spelled and unfamiliar words. In contrast, the lexical route focuses on large grains, allowing children to read familiar and 'irregular words that do not conform to typical correspondence rules' (Castles, 2006, p. 50) based on previously encountered word patterns or syllables.

In contrast, the Connectionist Triangle model does not differentiate between the processes used to read irregularly and regularly spelled words and letter strings. However, like the DRC models, it supports the idea of a dual pathway system in reading. The main assumption is that 'reading involves the computation of three codes: orthographic, phonological, and semantic' (Seidenberg & McClelland, 1989, p. 526). According to the Connectionist Triangle models, decoding occurs through direct mapping from orthography to phonology and from orthography to phonology through the semantics pathway. This is achieved through three sets of simple processing units: a bank of grapheme units representing orthography, a bank of phoneme units representing phonology, and a bank of semantic units (Powell, Plaut, & Funnell, 2006, p. 230).

Influence of Orthographic Differences on Reading Performance

Unfortunately, according to Share (2008), both the DRC and connectionist triangle models of reading development;

> *arose largely in response to English spelling-sound obtuseness. The model accounts for a range of English-language findings, but it is ill-equipped to serve the interests of a universal science of reading chiefly because it overlooks a fundamental unfamiliar-to-familiar/novice-to-expert dualism applicable to all words and readers in all orthographies* (p. 584).

Furthermore, ideally 'these models are largely based on the interpretation of average data from normal or impaired readers, mainly from English-speaking individuals' (Marinelli, Horne, McGeown, Ziccolotti, & Martelli, 2014, p. 1), and may, therefore, not be extended to languages whose writing systems are orthographically different from English. The English orthography is notoriously idiosyncratic; an almost antithesis of most of the alphabetic writing systems (Goswami, 2003; 2005). Its writing system varies considerably regarding phonology to orthography mapping, whereas most alphabetic orthographies, such as Finnish, Italian, and Spanish, are highly consistent (Borleffs, Maassen, Lyytinen, & Zwarts, 2018; Ellis et al., 2004; Ziegler & Goswami, 2005).

Seymour et al., (2003) classified the orthographic transparency of European languages based on two dimensions. The first dimension relates to syllable complexity, which distributes orthographies on a continuum ranging from simple to complex consonant-vowel (CV) syllable clusters. The orthographic depth is the second dimension that approximates the consistency of grapheme-to-phoneme correspondences (GPCs) from simple one-on-one letter-to-sound ratio to multi-letter grapheme-to-phoneme conventions. Unlike the orthographies of Finnish, Italian, Japanese, Spanish, and Turkish, which predominantly exhibit CV syllable types, in English, syllables can range from 'V [a], CV [go], CVC [cat], CVCC [hold], CCVCC [stamp], CCCVC [spread], and CCCVCC [sprained]' (Goswami, 2010, p. 27 emphasis supplied). This enables beginning readers immersed in consistent languages to master the art of reading with minimal classroom instruction, while children taught struggle significantly to acquire basic reading skills (Goswami, 2005).

Therefore, observed achievement gaps across orthographies are due, in part, to variations in GPC ratios and the multiplicity of CV permutations under consideration (Goswami, 2003; 2005). For example, the Spanish orthography has a GPC ratio of one-to-one because the 29 graphemes in its alphabet correspond and directly map into the 29 phonemes in the language. In the English orthography, this ratio is significantly higher at 1.7, with 44 (20 vowels and 24 consonants) phonemes mapping into 26 graphemes (Joshi, 2010). Thus, navigating and mastering such a wide range of syllable strata and complexity exerts significant cognitive demands on beginning readers in English compared to Spanish.

Consequently, Seymour et al. (2003) classified the 14 main European orthographies (Austrian, Danish, Dutch, English, Finnish, French, German, Greek, Icelandic, Italian, Norwegian, Portuguese, Scottish, Spanish, Swedish) based on syllabic structure and orthographic depth continuum from the more transparent orthography to the opaquest writing system. At one extreme end of this spectrum is Finnish, characterised by a simple open syllable structure and shallow orthography, whereas English orthography lies on the other end of the continuum. GPC variations have significant implications for children's ability to acquire reading skills (Share, 1995; 2008; 2021). Research has shown that these variations affect developmental trajectories, prevalence, and the nature of reading, writing, and spelling abilities among beginning readers (Aro & Wimmer, 2003; Hanley, Masterson, Spencer, & Evans, 2004; Kaani, 2021; Kaani, Mulubale, & Mufalo, 2022; Kaani & Joshi, 2013; Seymour et al., 2003; Wimmer, 1999).

Seymour and colleagues assessed the development and nature of reading among first graders in 14 European orthographies and reported that English children took a minimum of three years of formal instruction to reach the reading ceiling, levels that their Finnish counterparts attained by the end of their first school year. Thus, Spencer and Hanley (2003) stated that bridging this orthography depth-induced achievement gap between English and most European languages may take up to six years of formal reading instruction. Similar cross-language studies reveal similar word-level processing variations. For example, the non-word reading process in English is slower and prone to real-word errors than in German (Frith, Wimmer, & Landerl, 1998; Wimmer & Goswami, 1994), Spanish, French (Goswami, Gombert, & de Barrera, 1998), and Greek children (Goswami, Porpodas, & Wheelwright, 1997). Typically, reading disabilities are more prevalent and severe in opaque orthographies (Landerl, Wimmer, & Frith, 1997; Rapcsak et al., 2007).

The psycholinguistic grain size theory (PGST) theoretical framework attributes cross-orthography variations in word processing to differential strategies used (Ziegler & Goswami, 2005). According to Goswami (2008), 'the kinds of internal representations (the psycholinguistic units) that will develop in a child exposed to a consistent orthography will differ from the kinds of internal representations that will develop if the same child is exposed to an inconsistent orthography' (p. 34). This theoretical framework posits that due to the ubiquity of both regularly spelled words (e.g., hat, sit, bit, hit) and irregularly spelled words (such as choir or cite/site/sight) in the English lexicon, readers tend to switch between large (syllable and word-level processing) and small grain (GPC) sizes to account for varying lexical characterisations in its vocabulary (Goswami, Ziegler, & Richardson, 2008; Kaani, 2014; Kaani et al., 2016; Kaani et al., 2022). In consistent orthographies, the reading development process bypasses the lexical route, and reading relies primarily on the phonologically-mediated lexical route (Milankov et al., 2021).

Dynamics of Predictors of Reading Comprehension

Several studies show marked cross-language discrepancies in dynamics of predictors in comprehension (Caravolas et al., 2012; Caravolas et al., 2013; Furnes & Samuelsson, 2010, 2011; Holopainen et al., 2001; Landerl et al., 2019; Müller & Brady, 2001; Vaessen et al., 2010), as postulated by the SVR (Gough & Tunmer, 1986) and the more comprehensive componential model of reading (Joshi & Aaron, 2000; Nation, 2019). The decoding component of the SVR model consists primarily of skills related to PAW [the ability to identify and manipulate sounds in words into respective phonemes, syllables, etc.], decoding [ability to apply letter-sound relationships to pronounce written words correctly at the sublexical level], and sight recognition [instant recognition of familiar words at the lexical level] (Joshi, 2010; Scarborough, 2001).

Due to variations in orthographic transparency, it is envisaged that the dynamics of the components of the SVR may differ significantly across writing systems. Having been critically tested, the SVR model has been very important in explaining reading development but has been subjected to critical cross-language scrutiny, especially in bilingual populations (Adolf, Catts, & Little, 2006; Bast & Reitsma, 1998; Catts, 2018). Caravolas and colleagues argued that there are 'universal cognitive prerequisites for learning to read in all alphabetic orthographies' (2012, p. 1398), but their predictive influence may vary as a function of orthographic depth. For instance, although PAW is a universal ingredient of all alphabetic writing systems, it has long-term effects in opaque orthographies, while its effects in transparent writing systems are time-limited. Conversely, although RAN has similar effects regardless of the nature of orthography in the long-term, it is more effective in transparent orthographies.

These inter-orthography variations have also been well replicated at the word processing level (Frith et al., 1998). Landerl (1998) compared English- and German-speaking dyslexics' ability to read one-, two-, and three-syllable words with similar orthographic structure in the two languages and found that the latter managed 'to acquire considerable though not sufficient knowledge about the relationship between spoken and written words' (p. 121) than their English counterparts. Furthermore, the reading speed of German dyslexics was slower but more accurate, whereas their English counterparts read more laboriously with low accuracy.

Similarly, when compared to children immersed in transparent orthographies, English-taught children are prone to commit more word recognition (decoding) errors. Several studies report that English first graders commit as many as 40 per cent to 80 per cent real-word and non-word errors (Jorm, Share, MacLaren, & Matthews, 1984; Juel, Griffith, & Gough, 1986; Treiman, Goswami, & Bruck, 1990). In contrast, below 10 per cent of such errors were registered in transparent Greek (Porpodas, 1989) and German (Wimmer & Hummer, 1990), and 20 per cent in Italian (Cossu, Gugliotta, & Marshall, 1995). Analyses of reading and spelling errors in transparent orthographies reveal more susceptibility to non-word substitutions of target words. On the other hand, English readers tend to substitute target words with other real words; for example, there for their and site for sight (Wimmer & Goswami, 1994).

The Current Study

Cross-national studies provide limited insights into the factors that influence reading comprehension across different writing systems. This study examined a model of reading comprehension based on decoding components (phonemic awareness, letter discrimination, single word reading, and pseudo-word decoding) using data from matched measures in transparent (Chinyanja) and opaque (English) writing systems. This study focused on answering the following questions: (a) How does the variation in orthographic depth between the Chinyanja and English languages affect the reading abilities of students in grades 4, 5, and 6? (b) To what extent does the reading data in Chinyanja and English fit with the conceptual model of reading comprehension? (c) Which data set between Chinyanja and English fits the conceptualised reading comprehension model better?

Our hypothesis was that the predictors of reading comprehension would differ significantly between the two writing systems (Holopainen et al., 2001; Landerl, Castles, & Parrila, 2022; Milankov et al., 2021; Müller & Brady, 2001; Furnes & Samuelsson, 2010, 2011). We also considered that the transferability of cross-linguistic skills between the Chinyanja and English languages may influence the differences between the systems (Durgunoglu & Oney, 1999). Therefore, these factors could both positively and negatively impact the outcomes of reading comprehension.

Additionally, the effects of orthographic depth on reading comprehension may be attenuated depending on the linguistic diversity among learners (e.g., bilingual versus multilingual) and socio-economic circumstances, as is the case in Zambia. For example, the influence of reading skills and comprehension acquired in the first language may contribute to some variation in the second language. Previous research has shown that first language word reading and comprehension skills (Jiang, 2011) and metalinguistic awareness skills (Durgunoglu & Oney, 1999) explain variations in phonological recoding, syntactic awareness (Joy, 2011), and reading comprehension across diverse writing systems. However, the degree of transferability depends on the orthographic distance between the first language (L1) and second language (L2). When the distances are small, cross-language transferability is more seamless, and vice versa. Fortunately, although Chinyanja and English have substantial orthographic differences, the availability of reading materials in Zambian schools may help bridge the achievement gap through metacognitive cross-pollination between the two languages.

Education System in Zambia

Zambia, a sub-Saharan country, has a population of 19.6 million people (ZAMSTAT, 2022), with slightly over 46 per cent under the age of 14. In 2018, the per capita GDP was US$1,659 compared to US$59,939 for the United States. The country has a literacy rate of 86.7 per cent (male = 90.6%; female = 83.1%) of the general population, defined as the ability to read and write in English (Worldometer, n.d.). Zambia follows a three-tier education system, starting with seven years of compulsory primary schooling, followed by five years of secondary education. Tertiary education is also available, with the duration varying depending on the certification sought. Additionally, there is an emerging preschool sector, primarily led by fee-paying private institutions. However, the requirement of user-fees makes kindergarten and nursery school education inaccessible for most children from low-income households. Furthermore, there are significant age variations in Zambian schools, despite the education policy stating that children should be enrolled in first grade at seven years old (Stemler et al., 2009).

Unfortunately, Zambia's declining economy has compromised the quality of education in recent years (Kelly & Kanyika, 2000). Simply being enrolled in school does not guarantee a quality education, as classrooms are overcrowded and there is a shortage of teachers, textbooks, and instructional materials (Stemler et al., 2009, p. 161). The country's education quality indicators are concerning. In 2017, the pupil-teacher ratios were 42.1 and 30.2, transition rates were 67.5 per cent and 48.0 per cent, repetition rates were 6.5 per cent and 1.7 per cent, and dropout rates stood at 1.5 per cent and 1.0 per cent for primary and secondary school levels, respectively. Other factors contributing to poor education quality in Zambia include high teacher attrition rates, high student-book ratios, and low contact hours (MoE-Z, 2018). Consequently, Zambian students perform poorly on international literacy assessments, with fourth and sixth-grade students ranking near the bottom on reports such as the 1999 Monitoring Learning Achievement and 1998 Southern African Consortium for Monitoring Education Quality evaluations. Only a small percentage of students meet the minimum expected reading levels (Altinok, Angrist, & Patrinos, 2018; Kelly & Kanyika, 2000). Poor reading ability has a negative impact on students' achievement in other subject areas, especially when instruction is in the challenging English language (Chikalanga, 1991; Serpell, 1978; Williams, 1996).

In recent years, the Zambian Ministry of Education has made efforts to improve students' reading achievement. They replaced the dysfunctional Straight-for-English Zambia Primary Course (ZPC) programme with a Primary Reading Programme (PRP) that focused on grades 1 to 7 and used the local languages (Chinyanja, IciBemba, Chitonga, Silozi, Luvale, Lunda, and KiKaonde). The PRP had three components: Breakthrough to Literacy for first grade, Step-into-English for second grade, and Read-on-Course from third to seventh grade. Although it showed promise, transitioning to English was still challenging.

To address this issue, the authorities implemented a new Primary Literacy Programme (PLP), in 2013. The main difference was that the mother tongue-based instruction period was extended from one to three years, ensuring that students acquired basic literacy skills in their strong languages before introducing English instruction in fourth grade. In second grade, only oral English was taught, while the main focus of instruction was synthetic phonics-based methods. While many learners still struggle with zero word-reading scores, the PLP has shown progress in phonemic awareness, phonics, fluency, vocabulary, and reading comprehension skills; however, the effect sizes have been small. One positive aspect of the PLP is that the transparency of Zambia's local languages' orthography seems to facilitate reading fluency in the less transparent English orthography.

Differences between Chinyanja and English Orthographies

The Chinyanja and English orthographies are based on the Roman alphabet and have shared features, but the Chinyanja orthography is highly transparent, with each letter consistently representing one sound. This regularity makes reading and spelling Chinyanja words relatively easier to master compared to the idiosyncrasies of the English orthography. Basic knowledge of grapheme-phoneme correspondence rules enables beginning readers to employ self-teaching mechanisms to learn to read in Chinyanja.

Despite the various ways in which CV syllables can be combined, the main characteristic of Chinyanja orthography is the consistency of grapheme-phoneme correspondences and the low ratio, which gives novice readers an advantage over English language learners. Several studies have compared the literacy achievement of Zambian language learners (Kaani, 2014; Kaani & Joshi, 2013; Kaani & Joshi, 2021; Sampa, 2005; Sampa et al., 2018; Stemler et al., 2009; Tambulukani et al., 1999) with English learners, and they have shown significant achievement gaps similar to comparisons between English and European languages (Cossu et al., 1995; Frith et al., 1998; Goswami et al., 1998; Goswami et al., 1997; Jorm et al., 1984; Juel et al., 1986; Porpodas, 1989; Seymour et al., 2003; Wimmer & Goswami, 1994; Wimmer & Hummer, 1990). These achievement gaps can partly be attributed to differences in the transparency of writing systems (Share, 2008).

Children who are exposed to transparent writing systems are more likely to learn to read, write, and spell more efficiently because they can use self-teaching mechanisms once they have mastered the basics of the alphabetic principle (Goswami, 2003; Share, 1995). Goswami (2003) observed significant differences in syllable types, which require different approaches to word processing in various writing systems. In transparent writing systems, synthetic phonics skills, which involve manipulating letter-sounds to build syllables, may be sufficient for decoding regular and fine-grained Chinyanja words. However, additional phonics techniques may be needed to handle the irregular and large-grained syllable structures of English. Williams (1998) argued that beginners who understand the alphabetic principle well can transition from manipulating letter-sounds to building syllables using the syllabication approach, which is a self-teaching mechanism based on consonant-vowel patterns (Share, 1995). Based on the evidence presented above, our SVR model predicts that there will be significant differences in the decoding-related predictors of reading comprehension between Chinyanja and English data. These predictors include letter discrimination, phonemic awareness, pseudo-word decoding, and real word reading.

Method

Participants: The study consisted of two samples totaling 240 students in grades fourth to sixth, selected from five primary schools in Lusaka, the capital of Zambia. Of these participants, 190 were given the English language version of the Zambia Achievement Test (ZAT), while 121 received the Chinyanja version. Fifty per cent of the participants were female. The schools chosen for the study were strategically selected to represent the socioeconomic demographics of Zambia. Two schools were selected from lower socioeconomic status (SES) backgrounds, two from higher SES backgrounds, and one predominantly from the middle class. According to school records, none of the participants reported having special education needs. Table 1 below shows the distribution of participants based on age, grade, and assessment language.

Table 1: Distribution of Participants by Grade Level and Language

Grade Level	Age *M*(*SD*)	Chinyanja	English	Total	%
4^{th}	10.8(2.1)	41	40	81	33.75
5^{th}	11.4(1.6)	39	40	79	32.92
6^{th}	12.7(3.5)	41	39	80	33.33
Total	11.7(2.5)	121	119	240	100.00

Reading Measures and Procedures: The study used equivalent versions of Chinyanja and English language reading measures from the Zambia Achievement Test (ZAT) to assess reading skills in both languages (Stemler et al., 2009). The ZAT reading measures consist of five subtests, which are described below:

a. Letter discrimination (LTD): In this subtest, participants are asked to identify individual letters or letter clusters that are either presented alone or embedded in stimuli cards. Participants must choose the correct response from four possible answer choices.
b. Phonological Awareness (PAW): The PAW measures participants' ability to match sounds or discriminate the initial sounds of pictures' names that are presented as target stimuli.
c. Single Word Reading (SWR): In this subtest, participants are required to pronounce words that are presented to them to the best of their ability. The subtest focuses on the participants' word attack skills.
d. Pseudo-Word Decoding (PWD): This subtest is similar to the SWR subtest described above, but the target words are made up of legitimate combinations of letter strings or non-words.
e. Reading Comprehension (RDC): The reading comprehension test assesses participants' ability to comprehend written material. Participants silently read single words or statements and then perform the specified action accordingly.

Scores for subtests 1 to 4 (LTD, PAW, SWR, PWD) were assigned either a 0 or 1, indicating incorrect or correct answers, respectively. The reading comprehension assessment was scored as 0, 1, or 2, depending on how closely the participant's action aligned with the standardised expectations. Raw scores were determined by the number of correct responses on each subtest.

Results

The main objective of the study was to compare the predictive dynamics of LTD, PAW, WRD, PWD, and RDC variables between the two orthographically diverse writing systems in order to ascertain their influence on students' reading comprehension achievement. Specifically, the study endeavoured: (a) To investigate the impact of differences in the depth of spelling between Chinyanja and English on the reading skills of students in grades 4, 5, and 6; (b) To evaluate the extent to which the reading data in Chinyanja and English align with the theoretical framework of reading comprehension; (c) To determine which dataset, Chinyanja or English, aligns better with the conceptualised model of reading comprehension. These models were anticipated to be predicted independently in both Chinyanja and English languages by LTD, PAW, WRD, and PWD. The analyses involved generating descriptive statistics, conducting ANOVA, assessing bivariate correlations, performing path analysis, and evaluating model fit for the reading comprehension models.

Descriptive Statistics, Bivariate Correlations, and Multiple Regression Coefficients

The means, standard deviations, and correlation coefficients of the five subtests are presented in Table 2. The reading performance in Chinyanja was notably superior. The mean differences between the two orthographies were statistically significant, $F(5, 230) = 19.09$, $p < 0.01$; Pillai-Bartlett's $V = 0.29$; partial $\eta^2 = 0.29$. Specifically, apart from PAW, the Chinyanja-tested participants outperformed their English counterparts on LTD, WRD, PWD, and RDC. However, only three out of the five cross-orthography mean differences were statistically significant ($p < 0.05$). These were between NPAW ($M = 13.17$; $SD = 3.93$) and EPAW ($M = 16.20$; $SD = 3.53$), NWRD ($M = 45.65$; $SD = 28.09$) and EWRD ($M = 33.67$; $SD = 21.15$), and NPWD ($M = 21.17$; $SD = 11.33$) and EPWD ($M = 16.77$; $SD = 11.59$). The mean differences between NLTD ($M = 9.79$; $SD = 0.80$) and ELTD ($M = 9.58$; $SD = 1.04$) and NRDC ($M = 21.74$; $SD = 13.82$) and ERDC ($M = 21.33$; $SD = 12.81$) were not statistically significant ($p > 0.05$). This finding is not only interesting, but also a notable indication of the inherent variations in skills required to process print across diverse orthographies, as reported by numerous studies (Holopainen et al., 2001; Muller & Brady, 2001).

To further understand how variations in comprehension dynamics across orthographic transparency affect the results, bivariate correlation analyses were performed to examine specific interactions between variables. The bivariate correlation coefficients are displayed in Table 2 below. The results of the correlation analyses indicate strong associations within each orthography; the Chinyanja variables correlated highly among themselves, while the English predictors showed similar correlational patterns. However, LTD did not show statistically significant correlations with any other variables, both within and across the two orthographies.

Similarly, the only statistically significant cross-orthography correlations were between NLTD and EPWD ($r(119) = 0.22$, $p < 0.05$) and EWRD ($r(119) = 23$, $p < 0.05$).

Multiple regression analyses were conducted to determine variations in the two reading comprehension models, and both analyses yielded statistically significant results: Chinyanja $F(4, 114) = 26.85$, $p < .01$, and English $F(4, 116) = 39.38$, $p < .01$. The regression coefficients for the multiple regression analyses are displayed in Table 2 below. The four predictors (LTD, PAW, WRD, and PWD) explained 58 per cent ($R^2 = 0.58$, Adjusted $R2 = 0.56$) of the variance in reading comprehension in the English model, compared to approximately 49 per cent ($R^2 = 0.49$, Adjusted $R^2 = 0.47$) in the Chinyanja model. Therefore, if we use $R2$ as a measure of goodness of fit, the English data fit the reading comprehension model relatively better than the Chinyanja data.

Table 2: Correlation Coefficients, Descriptive Statistics, and Unstandardised, Beta Weights, and Structure Coefficients

Variable	1	2	3	4	5	6	7	8	9	10	*b*	*b*	r_s
1. NLTD	1										**-.2.86***	**-0.17***	**-0.22***[*]
2. NPAW	0.03	1									0.43	0.12	**0.59**[**]
3. NWRD	0.03	**0.42**[**]	1								**0.20***	**0.41***	**0.93**[**]
4. NPWD	-0.01	**0.53**[**]	**0.87**[**]	1							0.28	0.23	**0.93**[**]
5. NRDC	-0.15	**0.41**[**]	**0.65**[**]	**0.65**[**]	1								
6. ELTD	-0.05	-0.10	0.10	0.12	010	1					0.34	0.03	0.17
7. EPAW	0.07	-0.09	-0.03	0.06	-0.01	0.10	1				0.32	0.09	**0.50**[**]
8. EWRD	**0.23**[*]	-0.11	-0.01	-0.02	-0.14	0.13	**0.40**[**]	1			**0.42***	**0.69***	**0.99**[**]
9. EPWD	**0.22**[*]	-0.07	0.05	0.04	-0.06	0.03	**0.34**[**]	**0.85**[**]	1		0.03	0.03	**0.85**[**]
10. ERDC	0.07	-0.12	0.02	0.05	-0.06	0.13	**0.38**[**]	**0.75**[**]	**0.65**[**]	1			
M	9.79	13.17	45.65	21.17	21.74	9.58	16.20	33.67	16.77	21.33			
SD	0.80	3.93	28.09	11.33	13.82	1.04	3.53	21.15	11.59	12.81			

Note: NLTD = Chinyanja Letter Discrimination; NPAW = Chinyanja Phonological Awareness; NPWD = Chinyanja Pseudoword Decoding; NWRD = Chinyanja Word Reading; NRDC = Chinyanja Reading Comprehension; ELTD = English Letter Discrimination; EPAW = English Phonological Awareness; EPWD = English Pseudoword Decoding; EWRD = English Word Reading; ERDC = English Reading Comprehension. * $p<0.05$. ** $p<0.01$.

The dependent variable for Multiple Linear Regression was reading comprehension. $R^2 = 0.49$ and 0.58; Adjusted $R^2 = 0.47$ and 0.56 in Chinyanja and English orthographies respectively.

More specifically, the Chinyanja model suggests that word reading ($b = 0.41$, $p < 0.05$) and letter discrimination ($b = -0.17$, $p < 0.05$) skills contribute the most to comprehension. In the English model, only EWRD ($b = 0.69$, $p < 0.05$) has a larger impact on reading comprehension. This finding suggests that EWRD is a better predictor of reading comprehension in English compared to Chinyanja. While the regression coefficients indicate that EPAW and EPWD do not significantly contribute to comprehension, the structure coefficients show that all variables, except ELTD, strongly predict comprehension in both models. The patterns of structure coefficients seem to be the opposite of the beta weights; smaller beta weights correspond to larger structure coefficients. These dynamics may suggest suppression effects or collinearity among predictors.

Comparison of Path Coefficients between Reading Comprehension Models

Independent path analyses were conducted to compare the causal effects among variables in the two models, as depicted in the path diagram in Figure 1. The direct standardised and unstandardised path coefficients (similar to multiple regression weights) are presented in Figure 1 and Table 2. Since our aim was to compare the models in two different orthographies, only standardised path coefficients were interpreted 'so that the weights can be compared with each other apples-to-apples' (Thompson, 2006, p. 283).

Chinyanja Reading Model	***English Reading Model***

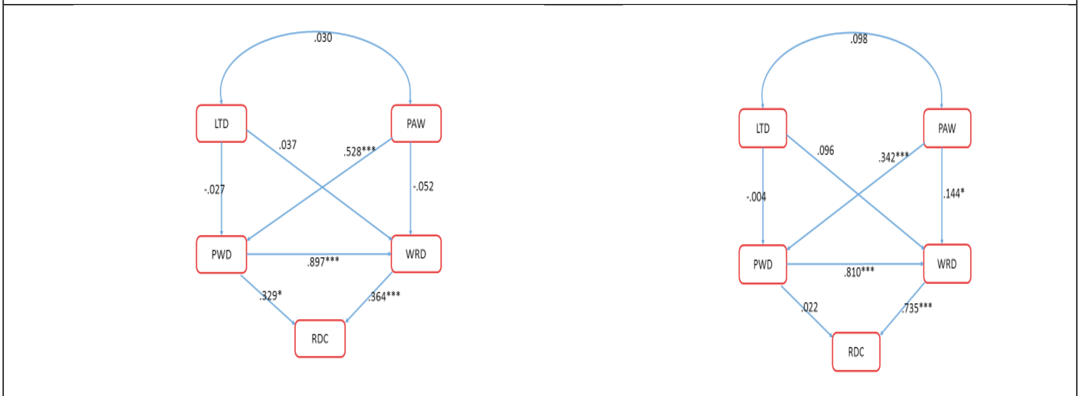

Table 3 below displays the statistically significant path coefficients between PAW and PWD, as well as between PWD and WRD in both orthographies. Moreover, the direct effects of WRD on comprehension were statistically significant in both Chinyanja and English, with English showing a stronger effect. Certain variables had language-specific effects. Specifically, the direct effects of letter discrimination on pseudo-word decoding were only statistically significant in English, as were the direct effects of word reading on PAW.

Table 3: Path Analysis: Path Coefficients in Chinyanja and English Orthographies

Path			**Chinyanja**				**English**			
			b	***β***	***SE***	***P***	***b***	***β***	***SE***	***p***
PWD	<---	LTD	-0.38	-0.03	1.11	0.73	-0.05	-0.00	0.96	0.96
WRD	<---	LTD	1.31	0.04	1.59	0.41	**1.96**	**0.10**	0.95	0.04^{*}
PWD	<---	PAW	**1.52**	**0.53**	0.23	***	**1.12**	**0.34**	0.28	***
WRD	<---	PAW	-0.37	-0.05	0.38	0.33	**0.69**	**0.11**	0.29	0.02^{*}
WRD	<---	PWD	**2.22**	**0.90**	0.13	***	**1.48**	**0.81**	0.09	***
RDC	<---	PWD	**0.40**	**0.33**	0.17	0.02^{*}	0.02	0.02	0.13	0.85
RDC	<---	WRD	**0.18**	**0.36**	0.07	0.01^{**}	**0.45**	**0.74**	0.07	***

Note: LTD = letter discrimination; PAW = phonological awareness; PWD = pseudoword decoding; WRD = word reading; RDC = reading comprehension

Contrastingly, pseudo-word decoding was only statistically significant on comprehension in Chinyanja, which probably suggests that the Chinyanja reading comprehension model is more parsimonious than English. Table 4 shows the Sobel statistics of the mediated effects of each predictive path on reading comprehension. The effects of pseudo-word decoding, when mediated by word reading, were statistically significant in both orthographies: Chinyanja (0.40, $z = 2.60$, $p < 0.01$) and English (0.66, $z = 6.01$, $p < 0.01$). In Chinyanja orthography, only pseudo-word decoding mediated by PAW was statistically significant (0.61, $z = 2.23$, $p < 0.05$). In English, on the other hand, both letter discrimination and PAW on reading comprehension, when mediated by word reading, were statistically significant ($p < 0.05$): 0.87, $z = 1.99$, and 0.31, $z = 2.20$, respectively.

Table 4: Sobel Test Statistics for Mediated Effects on Reading Comprehension

				CHINYANJA			ENGLISH		
	IV		**Med.**	**Ind. Effect**	**Test Stat.**	***P***	**Ind. Effect**	**Test Stat.**	***p***
1.	LTD	®	PWD	-0.15	-0.35	0.73	-0.00	-0.05	0.96
2.	LTD	®	WRD	0.24	0.78	0.46	**0.87**	**1.99**	**0.05***
3.	PAW	®	PWD	**0.61**	**2.23**	**0.02***	0.02	0.19	0.85
4.	PAW	®	WRD	-0.37	-0.91	0.36	**0.31**	**2.20**	**0.03***
5.	PWD	®	WRD	**0.40**	**2.60**	**0.01***	**0.66**	**6.01**	**0.01***

Note: IV = independent variable; Med. = mediating variable; Test Stat. = Test Statistics; Ind. Effect= indirect effect. *. p <0.05.

There were two major differences between the Chinyanja and English reading comprehension models. First, in the Chinyanja model, the mediated effects of pseudo-word decoding (PWD) on word reading (WRD) were statistically significant (p<0.05). Second, in the English model, the indirect effects of PAW on WRD were also statistically significant (p<0.05). This means that PAW skills are important for understanding text in both transparent and opaque orthographies, but they are mediated by different skills. In Chinyanja, pseudo-word decoding plays a key role, while in English, word reading proficiency depends more on letter discrimination and phonological processing. Another interesting finding, although expected, was that PWD positively influenced WRD proficiency in both orthographies (Sánchez-Vincitore et al., 2022). This is interesting because despite the variations among predictors in the two orthographies, comprehension seems to depend on decoding (PWD) and word recognition (WRD) skills.

Model Fit Evaluation for Chinyanja and English Reading Data

The two models of reading comprehension underwent model fit analyses to assess their applicability to the science of reading. The results of these analyses can be found in Table 5 below. The English data seemed to fit the model relatively well, $X^2 = 2.13$ ($df = 2$, $p < .35$, RMSEA = 0.02, NFI = 0.99, and CFI = 1.00). In comparison, the Chinyanja data had a chi-square value of 8.05 ($df = 2$, $p = 0.05$, RMSEA = 0.16, NFI = 0.97, and CFI = 0.98). The English data satisfied all the recommended fit index thresholds according to Mellard, Fall, and Woods (2010), including a non-significant chi-square value (p > 0.05), RMSEA less than 0.05, and NFI and CFI values greater than 0.95. On the other hand, the Chinyanja data only met the NFI and CFI requirements. This finding is not surprising, as Share (2008) argued that most reading models are developed from an Anglocentric perspective.

Table 5: Model Fit Indices for Chinyanja and English Orthographies

Index		Chinyanja	English
Chi-square			
	χ^2-Value	8.05	2.13
	Df	2.00	2.00
	P	0.05	**0.35***
RMSEA		0.16	**0.02***
CFI		**0.97***	**1.00***
NFI		**0.98***	**0.99***

Note. χ^2 = chi-square; *df* = degrees of freedom for the model; *p* = p-value; NFI = normed fit index; CFI = comparative fit index; RMSEA = root mean square error of approximation.
* Met criteria for model fit

Discussion

The primary aim of this study was to compare the dynamics of certain factors—specifically, LTD, PAW, WRD, and PWD—in predicting reading comprehension (RDC) among Zambian bilinguals in two distinct orthographic systems: Chinyanja, which employs a transparent orthography, and English, which employs an opaque orthography. In relation to our main objective, the results demonstrate that the depth of orthography significantly influences the dynamics of variables that facilitate the reading process being examined. This finding not only aligns with the principles outlined in the psycholinguistic grain size theory (Ziegler & Goswami, 2005), but also suggests the need for differentiated approaches to teaching reading for beginning bilingual readers (Goswami, 2005).

Despite anticipating substantial variations in the dynamics of reading processes between Chinyanja and English due to differences in orthographic transparency, these two languages also share certain characteristics. This can be attributed, at least in part, to the fact that both orthographies are based on the Latin alphabet and, therefore, adhere to the same grapheme-phoneme correspondence (GPC) rules (Kaani & Joshi, 2013; Chimuka, 1978). Similar findings have been reported in numerous studies comparing aspects of the reading process between English and other alphabetic European orthographies, such as Finnish (Aro & Wimmer, 2003), German (Landerl et al., 1997), Italian (Thorstad, 1991), Turkish (Oney & Durgunoglu, 1999), and Welsh (Spencer & Hanley, 2003). Furthermore, in the case of Zambia, where children learn to read in both languages, they may be integrating various types of linguistic knowledge in their quest for accurate reading (Alcock & Ngorosho, 2003, p. 635).

Overall, transparent orthographies appear to support reading development and eventual proficiency more effectively than opaque orthographies. This conclusion is based on the superior performance of Chinyanja participants compared to their English counterparts across all reading variables, including LTD, PWD, WRD, and RDC (with the exception of PAW). This finding is supported by studies conducted by Holopainen et al., (2001) and Muller and Brady (2001), who noted that phonological processing skills are crucial for learning English, but not necessary in transparent orthographies like Finnish and Spanish. Similar results were observed among Kiswahili-speaking children in Tanzania (Alcock & Ngorosho, 2003). These writing systems reflect the simple grapheme-phoneme correspondence (GPC) features of Zambian languages (Chimuka, 1978). Holopainen and colleagues found that while phonological awareness played a significant role in differentiating children at various stages of reading development, it did not predict delayed progression in children with learning disabilities in the Finnish orthography. The complexity of the English orthographic structure necessitates novice readers to employ a wide range of sub-skills to navigate its inherent idiosyncrasies (Goswami, 2003; 2005; Share, 1995; 2008; 2022).

One objective of this study was to investigate whether there is transfer of basic literacy skills across orthographies of differing transparency. Traditionally, novice readers are expected to transfer skills acquired in Chinyanja to the English orthography in Zambian schools, as observed among Turkish children (Oney & Durgunoglu, 1999). This is why initial literacy instruction and schooling, in general, are conducted in the children's mother tongue before introducing English language teaching (Sampa, 2005; Sampa et al., 2018; Tambulukani et al., 1999). Unfortunately, our findings did not fully support this hypothesis, as bivariate correlation analyses revealed significant associations within each orthography but weak associations across orthographies. Consequently, it can be concluded that there is limited transfer of skills between the two orthographies, at least in the Zambian context. These findings are supported by Kaani and Joshi (2013) in the context of spelling. This phenomenon may explain why Zambia continues to report low levels of reading and writing proficiency in the English language, despite efforts by stakeholders to improve literacy outcomes through policy changes (Kaani, 2018; Kaani et al., 2016; Jere-Folotiya, 2018; Sampa, 2005; 2016; Tambulukani & Bus, 2012).

The dynamics of skills predicting reading comprehension in Chinyanja and English, as revealed by multiple regression models, also support the argument that orthographic transparency has different effects. This study introduces slight variations in the predictive dynamics of variables that traditionally support reading comprehension. These variables include letter detection (LTD), word detection (WRD), phonological awareness (PAW), and phonological decoding (PWD). Previous studies have emphasised the importance of these variables (Caravolas et al., 2012; Caravolas et al., 2013; Furnes & Samuelsson, 2010; 2011; Holopainen et al., 2001; Landerl et al., 2019, Landerl et al., 2022; Müller & Brady, 2001; Vaessen et al., 2010). This study found that only two of these variables played significant roles in predicting reading comprehension. In the Chinyanja model, comprehension was found to be a function of LTD and WRD skills, while in the English model, only WRD skills showed similar effects. This finding deviates from the current available reading comprehension models (Share, 2008; 2021).

Additionally, a comparison of the idealised path analysis models supports the notion that reading comprehension in these models relies on different reading processes, as noted in previous studies (Holopainen et al., 2001; Landerl et al., 2019; Landerl et al., 2022; Muller & Brady, 2001). Although the path analyses of both models reveal that PAW serves as a fundamental facilitator of reading comprehension in both Chinyanja and English orthographies, it is mediated by different variables. In Chinyanja, PAW is indirectly mediated by PWD through WRD, while in the English model, PAW is mediated by PWD to WRD and also shows a direct link through WRD. Thus, achieving good comprehension in the English language does not necessarily require mastery of PAW. On the other hand, mastering word recognition without phonological recoding poses significant challenges and necessitates systematic instruction and extended teaching periods (Hanley et al., 2004; Seymour et al., 2003; Share, 2001). This is evident in the observed differences in literacy achievement (Kaani, 2014; Kaani & Joshi, 2013; Sampa, 2005; 2018; Sampa et al., 2018; Tambulukani et al., 1999). It is not surprising to see variations in literacy achievement, as each orthography exerts different influences on novice readers and requires distinct word-level processing skills (Goswami, 2003; 2005). This is partly because the idiosyncrasies of the English orthography demand more than just synthetic phonics knowledge (Bowers & Bowers, 2017; Drew, 2020).

The study provides compelling evidence regarding the impact of variations in orthographic transparency on the reading process. The evaluation aimed at assessing the universality of an idealised generic model of comprehension, which was developed based on existing theories of reading. When data from measures of LTD, PWD, PAW, and WRD were applied to the model, it was found that the English data fit better than the Chinyanja data. This outcome challenges traditional explanations and suggests the need to consider alternative models or theories of reading. This finding has significant implications for models aiming at explaining the science of reading, which have been predominantly influenced by an Anglocentric perspective.

In summary, three key findings emerged from the study. Firstly, the presence of orthography-specific correlations among variables contradicts the notion that predictors and cognitive precursors of the reading process are universal. This finding is particularly surprising considering the similarities between the orthographies under investigation. It suggests that there may be cross-orthography transfer of basic literacy skills from one language to another. Previous research has shown that skills acquired in one language can predict reading proficiency in another, especially when the languages share orthographic characteristics. In this case, it was expected that there would be a strong association between the two languages given that early reading instruction in Zambian schools aims at facilitating skills transfer from the mother tongue to English. However, the results indicate a larger gap in cognitive demands between Chinyanja and English, which has important implications for the teaching and learning process of Zambian bilingual beginning readers.

Secondly, reading comprehension in English requires a systematic integration of various interconnected skills that differ from those needed for Chinyanja. English comprehension primarily relies on word recognition (WRD) through intricate and interconnected networks that involve skills such as letter-to-sound decoding (LTD), phonological awareness (PAW), and phonological working memory (PWD). Conversely, in Chinyanja orthography, comprehension is facilitated primarily by PWD skills instead of word reading. Similar findings have been observed in comparisons between French-English (Bruck et al., 1997) and Dutch-English (van den Boschet al., 1995). Clinton, Quiñones, and Christo (2011) attribute these differences to variations in word processing strategies, suggesting that opaque orthographies heavily depend on onset-rime skills, while transparent orthographies rely more on phonological recoding-based decoding. Furnes and Samuelsson (2011) and Holopainen et al. (2001) have also reported similar effects of PAW, arguing that phonological awareness becomes less crucial in transparent orthographies as beginning readers develop self-teaching mechanisms (Share, 1995) that enable decoding of legitimate letter combinations.

Lastly, our findings support the script-dependent theory of reading comprehension (Furnes & Samuelsson, 2010, 2011; Holopainen et al., 2001; Müller & Brady, 2001; Share, 1995, 2008). Model fit evaluations indicate that our conceptual model is more suitable for English data than for Chinyanja language data. Therefore, we can infer that our model may be an oversimplification of reality and may reflect an Anglocentric perspective (Share, 2008). Our results, in line with studies by Caravolas et al. (2012, 2013), Furnes and Samuelsson (2010, 2011), Holopainen et al. (2001), and Müller and Brady (2001), demonstrate that predictors of reading comprehension are relatively universal across orthographic depths. However, the dynamics of these predictors vary significantly. Differences in the nature and predictive power of variables suggest varying demands in the strategies required for decoding and comprehending text (Goswami, 2005; Ziegler & Goswami, 2006). Therefore, relying solely on the English orthography, which is deemed "ill-equipped to serve the interests of a universal science of reading" (Share, 2008, p. 584), when developing reading theories can lead to biased assumptions and models. Instead, reading theories and models should be informed by and developed from empirical evidence drawn from multiple perspectives that encompass writing systems with diverse orthographic depths.

Despite the presence of inherent methodological design weaknesses, this study has successfully yielded significant insights into the impact of orthographic depth on the dynamics of predictors of reading comprehension among bilingual individuals who are in the process of acquiring literacy skills in languages with varying orthographic characteristics. Nevertheless, we suggest that future research should not only aim at expanding the range of predictive variables but also incorporate a longitudinal approach by tracking cohorts of early readers over several years. This will provide a more accurate understanding of the true magnitude of the achievement gap and the duration required for the developmental delay to diminish, particularly in economically disadvantaged developing countries.

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