South African Journal of Childhood Education
ISSN: (Online) 2223-7682, (Print) 2223-7674

Orthographic knowledge as a predictor of reading and spelling in isiXhosa third graders

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Dates:
Received: 10 Nov. 2023
Accepted: 30 Apr. 2024
Published: 31 Oct. 2024

How to cite this article:
Daries, M.A. & Bowles, T.N., 2024, 'Orthographic knowledge as a predictor of reading and spelling in isiXhosa third graders', *South African Journal of Childhood Education* 14(1), a1471. https://doi.org/10.4102/sajce.v14i1.1471

Background: Research acknowledges the importance of phonological processing and orthographic processing for reading and spelling in both consistently and inconsistently written languages. While the focus has tended to be on the role of phonological processing in languages with consistent orthographies, the role of orthographic processing, specifically orthographic knowledge has yet to be as extensively explored.

Aim: To address this gap, this article explores the unique contributions of phonological awareness (PA) and orthographic knowledge for reading and spelling in the consistently written language of isiXhosa. In addition, we investigate the multi-dimensional character of orthographic knowledge by establishing whether letter-sound knowledge is a sub-component of orthographic knowledge, alongside word-specific and general orthographic knowledge.

Setting: A quantitative cross-sectional study was conducted with 182 isiXhosa third graders.

Methods: Participants completed word-specific and general orthographic knowledge tasks, which were specifically designed for the study, along with tasks of oral reading fluency, spelling accuracy, PA, rapid automatised naming and letter-sound knowledge.

Results: Using confirmatory factor analyses along with regression analyses, the findings provide support for the multi-dimensional character of orthographic knowledge inclusive of word-specific orthographic knowledge, general orthographic knowledge and letter-sound knowledge. Further, it was revealed that for this sample of isiXhosa third graders, orthographic knowledge was more influential to reading and spelling performance over and above PA, providing evidence for the importance of orthographic skill for both reading and spelling in isiXhosa.

Conclusion: The present study adds to a growing understanding of the multi-dimensional nature of orthographic knowledge and provides evidence for the importance of orthographic knowledge for reading and spelling in isiXhosa.

Contribution: The findings support the need for phonics instruction that incorporates activities which build learners' orthographic knowledge and other writing-related skills. Further, continuous exposure to books and reading will also strengthen learners' orthographic knowledge.

Keywords: orthographic knowledge; reading fluency; spelling; phonological awareness; literacy; isiXhosa.

Introduction

Phonological awareness has widely been recognised as a robust predictor of reading and spelling ability for languages with consistent orthographies (see Adams 1990; Babayiğit & Stainthorp 2007; Bryant et al. 1990; Caravolas, Hulme & Snowling 2001; Caravolas, Volin & Hulme 2005; Hulme & Snowling 2015; Landerl, Castles & Parrila 2022; Landerl & Wimmer 2008; Leppänen et al. 2006; Öney & Durgunoglu 1997; Zarić, Hasselhorn & Nagler 2021). To a far lesser degree, orthographic knowledge has been found to be influential for reading and spelling in mainly inconsistently written languages such as English (Apel, Wolter & Masterson 2006; Castles & Coltheart 2004; Cunningham, Perry & Stanovich 2001; Ganske 1999; Nag 2007; Roman et al. 2009; Zhao et al. 2017) with some studies attesting to this relationship for consistently written languages (Greek: Georgiou et al. 2008b; Persian: Arab-Moghaddam & Senechal 2001; Dutch: Bekebrede, Van Der Leij & Share 2009; German: Zarić et al. 2021). Very few studies have, however, examined the contribution of orthographic knowledge to both spelling and reading concurrently (Conrad, Harris & Williams 2013; Querido et al. 2020; Zarić et al. 2021). Thus, in order to advance our understanding of both universal and language-specific predictors of reading and spelling, this

article examines the role of both orthographic knowledge and phonological awareness (PA) for reading and spelling in isiXhosa, a consistently written and agglutinative language in South Africa. We thus hope to provide empirical research on orthographic knowledge in isiXhosa, and in doing so, provide an indication of how orthographic knowledge can be measured in transparent and agglutinative languages.

Orthographic knowledge consists of two subcomponents, namely, word-specific orthographic knowledge and general orthographic knowledge.[1] While there is a consensus on the two-dimensional view of orthographic knowledge, there remain differences in whether letter-sound knowledge is considered to be part of orthographic knowledge (see Arciuli & Simpson 2012; Cunningham 2006; Wagner & Baker 1994; Ziegler & Goswami 2005), or whether it should be considered a separate skill outside of the orthographic knowledge domain (Castles & Nation 2006; Cunningham et al. 2001; Deacon, Benere & Castles 2012). To contribute to this debate, we investigate the multi-dimensional nature of orthographic knowledge by establishing whether letter-sound knowledge is a subcomponent of orthographic knowledge in isiXhosa, alongside word-specific and general orthographic knowledge.

Orthographic knowledge and its contribution to reading and spelling

Orthographic knowledge refers to the ability to use one's knowledge of how language should be represented graphically for writing in a particular language (Apel 2011; Conrad et al. 2013).

It thus constitutes 'knowledge particular to print' (McMurray & McVeigh 2016:243). As already mentioned, orthographic knowledge is considered to comprise two separate, but related components, namely, word-specific orthographic knowledge and general orthographic knowledge (Apel 2011; Conrad et al. 2013; Loveall et al. 2013; Rothe et al. 2015; Zarić et al. 2021).

As the name indicates, word-specific orthographic knowledge describes an awareness of the orthographic form of distinct words known by an individual, whereas general orthographic knowledge refers to a more general awareness of the orthographic rules which govern the way in which words are written in a particular language (Apel 2011). General orthographic knowledge thus includes, for example, knowing how letters can be combined and positioned in a language as well as the pattern of how graphemes are written in a language (Apel 2011). For example, <hl> is not a letter combination found in English, but is acceptable in isiXhosa. The grapheme <ng> can only appear in the onset position in isiXhosa, and may not appear in the coda position, whereas in English, it can only appear in the coda position.

Both forms of orthographic knowledge have been recognised as having a critical impact on reading success (Chung et al. 2023; Conrad et al. 2013; Querido et al. 2020). As word-specific orthographic knowledge deals with one's knowledge of specific words, its role in reading can be easily rationalised as it aids in a reader's ability to both recognise and produce words in their language (Ehri 2014; Zarić et al. 2021). However, general orthographic knowledge is argued to be involved in reading as when learners do not know the specific words, they will need to rely on their knowledge of the orthographic rules of the language to identify and produce words (Apel 2011; Ehri 2005, 2014).

Cross-linguistic studies have provided evidence for the role of both word-specific and general orthographic knowledge for reading (Greek: Georgiou et al. 2008b; Persian: Arab-Moghaddam & Senechal 2001; Dutch: Bekebrede et al. 2009; English: Badian 2001; Conrad et al. 2013; Cunningham & Stanovich 1990; Deacon et al. 2012; Rothe et al. 2015; German: Zarić et al. 2021). However, some longitudinal studies have not found orthographic knowledge to contribute significantly to later reading abilities (English: Deacon et al. 2012; Georgiou et al. 2008c).

Compared to research on reading, less is known about the relationship between orthographic knowledge and spelling. Studies that have looked at the relationship between orthographic knowledge and spelling have shown that orthographic knowledge is important for spelling, as learners are expected to engage with the orthographic features of a language, such as the alphabetic principle, within word patterns and syllable structure (Fleisch, Pather & Motilal 2017). Importantly, there are studies that have shown that both word-specific and general orthographic knowledge contribute unique variance to spelling performance, over and above that of phonological skills (English: Conrad et al. 2013; Ouellette & Senechal 2008b; Zhao et al. 2017; Dutch: Zarić et al. 2021; Portuguese: Querido et al. 2020). To date, there are no studies that have considered the role of orthographic knowledge in relation to spelling in an African language. This study provides a catalyst for future research in this area.

Letter-sound knowledge and its contribution to reading and spelling

The goal of the present study is to establish whether letter-sound knowledge forms a subcomponent of orthographic knowledge in isiXhosa. It is therefore important to briefly discuss the relationship which letter-sound knowledge has with reading and spelling.

Letter-sound knowledge refers to the ability to accurately assign a sound or sounds to their corresponding letter form (Huang, Tortorelli & Invernizzi 2014). Letter-sound knowledge has been found to contribute to children's early literacy in alphabetic languages in a number of ways. Specifically, it aids in children's grasping of the alphabetic principle, which is the understanding that spoken language consists of discrete sounds that map onto letters in the alphabet which represent these sounds systematically (Huang et al. 2014). Knowledge of the alphabetic principle is

1.Word specific and general orthographic knowledge are also referred to as lexical and sub-lexical orthographic knowledge in the literature (see Apel et al. 2019).

an early literacy landmark necessary for subsequent development (Liberman, Shankweiler & Liberman 1990). Additionally, letter-sound knowledge has been shown to be a necessary precursor for decoding ability, another key building block of literacy (Huang et al. 2014; Landerl et al. 2022). The literature converges on the importance of letter-sound knowledge for reading in both transparent and opaque orthographies (Bruck, Genesee & Caravolas 1997; Gallagher, Frith & Snowling 2000; Georgiou et al. 2012; Kirby, Parrila & Pfeiffer 2003; Leppänen et al. 2008; Manolitsis et al. 2009; Share et al. 1984; Torppa et al. 2006). In fact, Landerl et al. (2022:113) state that knowledge of the graphic symbols of a language is seen as the 'sine-qua-non of reading acquisition' for languages with varying orthographies. They do, however, acknowledge that the individual writing systems of languages should be considered.

In addition, learners need to have a strong letter-sound knowledge basis in order for them to grasp complex spellings such as consonant blends (Huang et al. 2014). The more systematic the relationships are between the letters and sounds within a language, the easier it will be to master letter-sound knowledge in that language (Evans et al. 2006; Huang & Invernizzi 2012; Justice et al. 2006; McBride-Chang 1999; Scanlon, Anderson & Sweeney 2010; Treiman et al. 1998).

Georgiou et al.'s (2012) longitudinal study of the predictors of reading and spelling in English, Greek and Finnish, languages that vary in orthographic consistency, showed that letter-sound knowledge was the most predictive of subsequent reading and spelling across all three languages when PA and rapid automatised naming were also considered. As Finnish has a transparent orthography similar to isiXhosa, it can be hypothesised that letter-sound knowledge is likely to also be a significant predictor of reading and spelling in this language. This hypothesis is supported by the findings observed in Makaure (2021) and Schaefer (2023) for Northern-Sotho, isiZulu and isiXhosa in which letter-sound knowledge in Grades 1, 2 and beginning of Grade 3 significantly and consistently predicted reading comprehension and spelling.

The importance of letter-sound knowledge for reading success has recently been recognised by the South African Department of Basic Education through the development of benchmark levels of letter-sound knowledge that should be achieved by the end of first grade. Specifically, all learners should be able to recognise at least 40 letter-sounds correctly in their language of instruction by the end of Grade 1 (Ardington et al. 2021).

Letter-sound knowledge and orthographic knowledge

It is evident that letter-sound knowledge is a strong consistent predictor of literacy measures (i.e. reading and spelling) across different languages, but to what extent it forms part of orthographic knowledge is yet to be established. According to Apel et al. (2019), what has routinely been left out of definitions of orthographic knowledge is letter-sound correspondence, or the alphabetic principle.

If we consider the definitions of word-specific and general orthographic knowledge, we can find evidence for the likelihood of a significant relationship between these variables and letter-sound knowledge. For example, word-specific orthographic knowledge requires the mapping of printed words onto single and specific word names (Loveall et al. 2013). One can imagine that learners would need to have letter-sound knowledge to facilitate the accurate mapping of print graphemes to word names. According to Apel (2011) and Arciuli and Simpson (2012), general orthographic knowledge is inclusive of the alphabetic principle, which, as noted above, is strongly linked to letter-sound knowledge. This indicates that general orthographic knowledge development would also necessitate letter-sound knowledge development.

Further, accurate word recognition necessitates an understanding of how letters combine in a language to form specific words (Apel 2011; Loveall et al. 2013), suggesting that letter-sound knowledge is needed for the development of orthographic knowledge.

While some researchers have included letter-sound knowledge as a part of their measures of orthographic processing tasks (see Arciuli & Simpson 2012; Cunningham 2006; Wagner & Barker 1994), others have chosen to assess it as a separate skill, apart from orthographic knowledge (see Castles & Nation 2006; Cunningham et al. 2001; Deacon et al. 2012). Although we assessed letter-sound knowledge separately from orthographic knowledge, we hope to add to the debate concerning the status of letter-sound knowledge as a measure of orthographic knowledge by establishing whether it loads significantly onto a latent variable of orthographic knowledge for isiXhosa.

Phonological awareness and its contribution to reading and spelling

Phonological awareness (PA) describes the ability to consciously identify, and segment spoken language into different sounds (Anthony et al. 2003; Pretorius & Mokhwesana 2009) and is indicated as influential for the development of code-related literacy skills such as alphabet knowledge, decoding and word recognition (Wagner & Torgesen 1987). There are typically three key components analysed as part of PA, namely, phoneme awareness, onset-rime awareness and syllable awareness which can be measured in different ways (Castles & Coltheart 2004). Onset and rime are not assessed in African language studies because of the few consonant clusters in onsets and the small number of closed syllables. Phonological awareness supports reading development in alphabetic languages as it contributes to the development of letter-sound correspondence knowledge, decoding and text-reading skills (Landerl et al. 2022). Phonological awareness has also been found to be important for spelling as it is used to process sounds in words, which are subsequently represented by letters in spelling (Caravolas et al. 2012).

There is a resounding consensus regarding the importance of PA for reading across languages including Indo-European languages (Adams 1990; Babayiğit & Stainthorp 2007; Bryant et al. 1990; Caravolas et al. 2005; Hulme & Snowling 2015; Landerl & Wimmer 2008; Zarić et al. 2020) and languages in Southern Africa (Diemer 2016; Diemer, Van Der Merwe & De Vos 2015; Makaure 2021; Malda, Nel & Van De Vijver 2014; Pretorius & Mokhwesana 2009; Probert 2019; Schaefer 2023; Soares De Sousa, Greenop & Fry 2010; Veii 2003; Wilsenach 2019).

In addition, PA has also been found to be an important predictor of spelling performance across different languages, but in particular in languages with transparent orthographies (Caravolas et al. 2012; De Bree & Van Den Boer 2019; Landerl & Wimmer 2008; Lervåg & Hulme 2010; Veber Nielsen & Juul 2016). Research on Southern African languages has confirmed this, with evidence attesting to the relationship between spelling and PA for isiXhosa learners (Daries, Bowles & Schaefer 2022; Diemer 2016; Schaefer 2023), isiZulu learners (Schaefer 2023), Herero Grade 2 to Grade 5 learners (Veii 2003) and Oshikwanyama Grade 1 and 2 learners (Nghikembua 2020).

The relationship between PA and orthographic knowledge is far less understood. Loveall et al. (2013) examined the relation of phonological recoding and alphanumeric and non-alphanumeric rapid automatised naming (RAN) to both word-specific and general orthographic knowledge. Their results showed that after controlling for intelligence quotient (IQ), phonological recoding explained 15% of the variance in word-specific orthographic knowledge and marginally accounted for 9% of the variance in general orthographic knowledge. While this relationship was not wholly expanded upon by Loveall et al. (2013), and phonological recoding was assessed and not PA, their findings point to a potential relationship between phonological skill and word-specific and general orthographic knowledge. Further research is required which investigates the specific relationship between word-specific and general orthographic knowledge and phonological skills. Stanovich (1992) argues that PA is a necessary, but insufficient, condition for efficient reading acquisition. Further, he argues that there needs to be an additional condition necessary for reading acquisition to flounder which he suggests is the ability to form accurate orthographic representations (Stanovich 1992; Stanovich, West & Cunningham 1991). The importance of automaticity in the recognition of orthographic-phonological connections has been stressed by several researchers (see Adams & Bruck 1993; Ehri 1992). In particular, evidence points to the role of phonological skills in early word reading, while orthographic skills become increasingly important in later reading. Thus, this study aims to compare the phonological and orthographic skills of Grade 3 readers to further understand the PA and orthographic knowledge relationship.

Rapid automatised naming and its contribution to reading and spelling

Rapid automatised naming refers to a reader's ability to name out loud presented stimuli (e.g. colours, objects, numbers or letters) as fast and as accurately as possible (Hulme & Snowling 2013; Kirby et al. 2010), and is another foundational literacy skill which has been found to be a robust predictor of reading across languages with varying degrees of transparency (Caravolas et al. 2012; Compton 2003; Georgiou et al. 2008a; Kirby et al. 2003; Parrila et al. 2004), including in Southern African languages in which research has found moderate correlations between RAN and literacy measures for Northern Sotho (Makaure 2016), isiXhosa (Schaefer 2023; Schaefer, Probert & Rees 2020) and Oshikwanyama (Nghikembua 2020). Specifically, Makaure (2016, 2021) observed that RAN was a significant predictor of reading fluency in Northern Sotho after controlling for phonological processing skills (e.g. PA, digit span and non-word reading).

There is less research which has looked at the relationship between RAN and spelling, with contradictory findings observed. Some cross-sectional studies have shown that RAN is not linked to spelling in languages with mostly consistent grapheme to phoneme mappings (e.g. German: Landerl & Wimmer 2008; Greek: Nikolopoulos et al. 2006; Turkish: Babayiğit & Stainthorp 2007 as cited in Georgiou et al. 2012). Conversely, Symythe et al. (2008) observed influential effects of RAN on spelling in English (inconsistent orthography) and Hungarian (consistent orthography), with Georgiou et al. (2012) also finding that RAN had a unique predictive variance in spelling in English (inconsistent orthography) and Greek (consistent orthography).

Makuare (2021) found that RAN was a significant predictor of literacy development in both Northern Sotho and English. Rapid automatised naming was related to different reading domains (i.e. letter knowledge, letter reading, word reading, fluent reading and reading comprehension) and spelling. In support of these findings, Schaefer (2023) in her longitudinal study on isiXhosa and isiZulu learners found a significant effect of alphanumeric RAN on both reading and spelling at all concurrent time points. However, this relationship was indirect and mediated via letter-sound knowledge. According to Schaefer (2023), alphanumeric RAN may thus relate to reading and spelling because it indexes the ability to make orthography-phonology connections. In terms of theoretical understanding of the relationship between RAN and literacy skills, Wagner and Torgesen (1987) state that RAN provides an indication of the speed at which phonological representations can be retrieved from one's memory. Thus, according to the authors, RAN is often correlated with reading and spelling tasks because phonological representations are accessed during reading and spelling. Further, when learning in transparent orthographies, one would need to decode by employing grapheme-to-phoneme conversion rules and thus RAN should be more important for reading as the rapid retrieval of phonological information

is necessary for the effective conversion of graphemes to phonemes (Georgiou et al. 2012). Others suggest that RAN is linked to reading through its relationship to orthographic processing, in that RAN indexes orthographic processing (Bowers, Sunseth & Golden 1999; Bowers & Wolf 1993). Thus, RAN is hypothesised to be linked to reading as it helps with the establishment of a foundation in orthographic processing (Georgiou et al. 2012). However, recent findings from Georgiou et al (2016) found that RAN had a direct effect on reading fluency independent of phonological processing and orthographic processing in English, Chinese or Finnish indicating that further research is needed to be able to accurately interpret the RAN–reading relationship and that special consideration of the characteristics of the language of study should be undertaken.

The few studies that have looked at the relationship between RAN and orthographic knowledge have shown that they are interlinked (Bear & Baronne 1991; Denckla & Cutting 1999; Georgiou et al. 2008a; Loveall et al. 2013; Manis, Doi & Bhadha 2000; Manis et al. 1999; Sunseth & Greig Bowers 2002; Torgesen et al. 1997).

IsiXhosa language structure

The language of the focus in the current study is isiXhosa, a Southern-Bantu language (S40) (Doke 1954) spoken in Southern Africa and which belongs to the Nguni language group that is inclusive of isiXhosa, isiZulu, isiNdebele and SiSwati (Guthrie 2017). IsiXhosa is an alphabetic language with a transparent orthography and a simple open CV (consonant-vowel) syllable structure (De Vos et al. 2014). In isiXhosa, there are five vowel sounds represented by letters /a, e, i, o, u/. Vowel length is only contrastive for the vowels /i/ and /o/ within a set of noun class markers to indicate plurality. This is represented in the orthography by a double vowel, for example, oomama (English: mothers) vs. umama (English: mother) (Vanderstouwe 2009). isiXhosa features a large inventory of consonant sounds, which include, pulmonic egressive sounds (such as those found in English), velaric ingressive sounds (clicks) and one glottic ingressive sound (implosive) (see VanderStouwe 2009). There are 52 consonant phonemes, represented in the orthography by 26 letters (Vanderstouwe 2009). This means that there are many sounds in isiXhosa that are represented by orthographically complex letter groups (Doke 1954; Saul 2013). For example, complex graphemes and consonant blends in which multiple letters correspond to a single sound, for example, <tsh>, <ng>, <ph>, <kh>, <kw>. This results in a large inventory of letter-sound correspondences, and the presence of complex graphemes can make words substantially longer and denser in isiXhosa. Consequently, this impacts the pace of decoding in isiXhosa (Diemer 2016; Land 2015), and research by Daries and Probert (2020) has shown that the complex consonant graphemes in isiXhosa have significant consequences for spelling accuracy.

Further, the language is agglutinative and is written conjunctively (Taljard & Bosch 2006). Words are much longer and morphologically rich in isiXhosa, with relatively few monosyllabic words (Daries & Probert 2020). An examination of the effects of orthographic transparency for reading and spelling in isiXhosa is beyond the scope of this article, but through an observation of the aforementioned linguistic qualities of isiXhosa, we can assume that isiXhosa learners may have greater challenges with spelling than reading because of unequivocal nature of the phoneme to grapheme correspondences, which seems to be more transparent, and grapheme to phoneme correspondences, which seem to be less transparent in isiXhosa.

The present study

The main goal of the current study is to provide empirical research on orthographic knowledge in isiXhosa by establishing the unique contributions of orthographic knowledge to both reading and spelling in isiXhosa while controlling for age, PA and RAN. Building on previous research findings (e.g. German: Rothe et al. 2015; Zarić et al. 2020; Persian: Arab-Moghaddam & Senechal 2001; Dutch: Bekebrede et al. 2009; English: Zhao et al. 2017), it is expected that orthographic knowledge will contribute significantly to both reading and spelling in isiXhosa along with PA and RAN. This hypothesis will be tested by performing multiple regression analyses with reading and spelling as respective outcome variables, while controlling for age, PA and RAN and including orthographic knowledge as the key predictor in both models.

Of special interest to the current study was to investigate the multi-dimensional nature of orthographic knowledge by establishing whether letter-sound knowledge is a subcomponent of orthographic knowledge alongside word-specific orthographic knowledge and general orthographic knowledge. In line with the argument put forward by Apel (2011), we hypothesise that orthographic knowledge in isiXhosa will be multi-dimensional in nature and consist of word-specific and general orthographic knowledge, alongside letter-sound knowledge.

To this end, a confirmatory factor analysis (CFA) was conducted to assess whether letter-sound knowledge loads significantly onto the latent factor of orthographic knowledge alongside word-specific and general orthographic knowledge.

An additional aim of the study is to contribute to the field by providing measurements of orthographic knowledge in the transparently written, conjunctive language of isiXhosa, given the lack of consistency in measures of orthographic awareness (Apel, Henbest & Masterson 2019). This aim is addressed in the Method section which outlines the development of the orthographic knowledge tasks.

The following research questions are addressed:

1. What are the unique contributions of orthographic knowledge to both reading and spelling in isiXhosa while controlling for age, PA and RAN?

2. To what extent is letter-sound knowledge a subcomponent of orthographic knowledge alongside word-specific orthographic knowledge and general orthographic knowledge?

Research methods and design

Participants

The participants included in this study were 182 third-grade home-language isiXhosa-speaking children from five non-fee-paying schools in a small low socio-economic township[2] in the Eastern Cape, South Africa. Approximately half the sample were girls ($n = 74$, 53%). The participants self-reported their ages, and the average age was 8.42 years old (standard deviation [SD] = 0.95). The selection criteria for the participating schools were that isiXhosa was used as the language of learning and teaching (LoLT) from Grades 1 to 3, and that all schools were geographically situated in the same township.

All third-grade learners who were present at the schools (15–75 learners per school) at the time of data collection were assessed in the first school term of 2021. According to the South African language policy, learners are taught in their mother tongue up until the third grade, until they transition to English medium of instruction in the fourth grade. Thus, at the time of testing, the participants had been instructed in isiXhosa for 3 years and are assumed to have a level of mastery in foundational literacy skills in their home language, given that it is their final year of being taught in their home language before transitioning to English.

Measures

Participants completed measures of orthographic knowledge, letter-sound knowledge, PA, RAN, oral reading fluency (ORF) and spelling. The tasks administered were metalinguistic in nature as they required participants to actively think about and reflect on their knowledge of the skills being assessed. The orthographic knowledge task was specifically designed by the authors for the study. The spelling task was taken from Daries and Probert (2020). The letter-sound knowledge, PA, RAN and ORF tasks were taken from the isiXhosa Early Grade Reading Assessment. All tasks used in this study can be found on the Open Science Framework (OSF) (https://osf.io/6yrc4/?view_only=bb03c95d95774eed904ee6807f30dc19).

Orthographic knowledge tasks

Participants completed two subtasks of orthographic knowledge which assessed their word-specific and general orthographic knowledge, respectively. The tasks were conducted non-phonetically, meaning participants were only required to evaluate the written form of the stimuli presented in the tasks.[3]

2.Within the South African context, townships refer to underdeveloped urban areas typically located on the periphery of towns and cities.

3.Detailed information regarding task development can be found in Daries (2022).

Word-specific orthographic knowledge

Typically, an orthographic choice task, also termed homophone choice task, is used to assess word-specific orthographic knowledge (see Conrad 2008; Loveall et al. 2013; Olson et al. 1994; Papadopoulos, Georgiou & Kendeou 2009; Ricketts et al. 2008; Sears et al. 2008; Tong et al. 2009). However, because of the transparent and conjunctive orthography of isiXhosa, this task type was not feasible as the language does not have a variety of homophonic sounds or short non-complex words which are easy to parse for the assessment of third-grade orthographic knowledge. Thus, a word-specific orthographic knowledge task was specifically designed for this study which was more suited for the assessment of third-grade isiXhosa learners' word-specific orthographic knowledge. Participants were required to identify an incorrectly added letter in familiar words. For example, participants had to identify that the 'h' in zonkhe (English: all, correct spelling: zonke) and 'a' in umhlabaa (English: the world, correct spelling: umhlaba) were incorrectly added. Words were selected from the top 300 most frequent words in a corpus of isiXhosa children's literature (see Rees & Randera 2017). Further, the words used were limited in morphological intricacy (less than three morphemes per word) and these words ranged in length in syllables (from two to four syllables) and grapheme complexity with some words containing complex graphemes (e.g. digraphs and click sounds represented by multiple letters). There were 12 items in the task. The participant received one point for every correct answer. The internal consistency coefficient for this task was $\alpha = 0.84$.

General orthographic knowledge

To examine general orthographic knowledge, an adaptation of the letter-string choice task was used (see Apel et al. 2012; Cunningham et al. 2001; Levy et al. 2006; Verhoeven, Schreuder & Baayen 2006). For this task, learners had to choose the most orthographically correct or 'real-word-like' word from a list of three non-words. The use of nonwords meant that learners could not rely on their word-specific orthographic knowledge nor grapho-phonemic knowledge, ensuring that individuals would have to use their knowledge of the specific orthographic patterns of isiXhosa. The order in which the correct item appeared in the set of three words was randomised to ensure that learners could not rely on a pattern when identifying the item. For example, 'phendi' is the most orthographically correct word in isiXhosa in the following list of non-words: 'phend, phendi, phedni'. This is because of the fact that isiXhosa words require a vowel in the word-final position, and 'dn' is not a permissible letter combination in isiXhosa. In total, there were 12 task items and two practice items included. The words used for the nonwords were sourced from the top 300 most frequent words in a corpus of isiXhosa children's literature (see Rees & Randera 2017). The participant received one point for every correct answer. The order of the three words was randomised and ranged in word length (ranging from two to four syllables). The task reliability was $\alpha = 0.64$.

Letter-sound knowledge

Letter-sound knowledge was assessed using a fluency task which required the participants to read aloud letters for 1 minute. In total, 110 letters and letter groups were presented to the participants inclusive of both simple (e.g. {b}, {t}, {a}) and complex graphemes (e.g. {hl}; {bh}; {nc}) in isiXhosa, and the errors made by the learners during the task were extracted from the total number of letters read in 1 minute to deduce letters correct per minute (lcpm) score.

Phonological awareness

For this task, there were 12 items, inclusive of three phoneme identification items, three-syllable identification items, three phoneme elision items and three-syllable elision items. The PA measure was found to be reliable ($\alpha = 0.84$).

Rapid automatised naming

Rapid automatised naming was assessed with a non-alphanumeric task which required participants to name 36 items orally in isiXhosa as rapidly as possible. The items consisted of five pictures of common items which were repeated to create the list of 36 items used in the task (i.e. sun, dog, table, star, hand and book). The number of incorrectly named items was subtracted from the total number of items named. This total was then divided into the time taken by the learner to complete a task in seconds to provide an item correct per second (icps) score.

Oral reading fluency

For the ORF task, learners were tasked with reading an isiXhosa grade-appropriate text aloud for 1 minute. A words correct per minute (wcpm) score was calculated by deducting the total number of words read incorrectly from the total number of words read by the participants. The passage used was entitled *Uhobe noMbovane* [Ant and Dove] and was 72 words long with a mean of 5.1 words per sentence, and 7.8 letters per orthographic word.

Spelling accuracy

The spelling accuracy task included 12 real words which ranged from two to four syllables in length. The task was adapted from Daries and Probert (2020) and a number of linguistic considerations relating to word frequency, word length in syllables and grapheme complexity were accounted for in the design of the task. The task was scored using a binary set of codes, that is, correct and incorrect per item with the item scores summed for each learner. The measure was found to be reliable ($\alpha = 0.93$).

Procedures

Trained first-language isiXhosa-speaking research assistants assessed the children individually for all tasks except spelling, which was group-administered. The order of the tasks administered was fixed, with children completing tasks in the following order: word-specific orthographic knowledge, general orthographic knowledge, letter-sound knowledge, PA, ORF and spelling accuracy.

Data analysis strategy

Data analyses were performed with the open-source software R (version 4.2.2, R Core Team 2021). Using the lavaan package (Rosseel 2012), a CFA was conducted to examine the role of letter-sound knowledge for orthographic knowledge. To assess the contribution of orthographic knowledge and PA for reading and spelling, we ran multiple regression models.

The models were fitted with latent variables extracted for orthographic knowledge and PA, as predictors, along with the scaled control variables RAN and age (self-reported), with reading and spelling as outcome variables.

Ethical considerations

Ethical clearance to conduct this study was obtained from the Rhodes University Human Ethics Committee (RU-HEC) (reference no.: 2020-1195-3307).

Results

Table 1 presents the descriptive statistics for all measures used in the study along with Pearson correlations using the raw scores from each of the measures. Compared to reading benchmarks set for the Southern-Bantu Nguni languages (isiXhosa, isiZulu, SiSwati and isiNdebele), 98 learners (70%) were not reading at Grade 2 lower fluency threshold of 20 wcpm (Ardington et al. 2021) at the start of Grade 3. The children in this sample are therefore reading well below the appropriate grade level ($M = 12.7$ wcpm). As expected, the learners also scored low on tasks assessing their foundational literacy skills such as PA ($M = 5.24$), letter-sound knowledge (37 lcpm)[4] and RAN (0.7 icps). The learners were assessed directly after extensive coronavirus disease 2019 (COVID-19)-related school closures which may result in lower-than-expected scores (see Ardington et al. 2021). The results reported, however, are largely representative of South African learners' performance at this grade level (Spaull, Pretorius & Mohohlwane 2020).

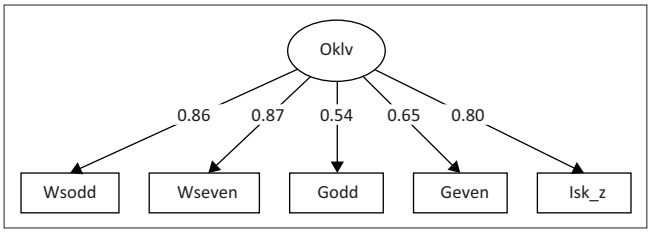
All variables correlated significantly with reading and spelling, supporting the relationship between the known contributors of reading and spelling. Word-specific orthographic knowledge and letter-sound knowledge were the strongest correlates of both reading fluency and spelling accuracy ($r = 0.7$–0.8) with reading and spelling having a strong correlation ($r = 0.8$) to one another. Moderate to strong correlations were found between letter-sound knowledge, word-specific orthographic knowledge and general orthographic knowledge ($r = 0.5$–0.7).

4.The Nguni threshold for Grade 1 learners is 40 lcpm (Ardington et al. 2021). The Grade 3 learners in this sample are reading below this threshold at the start of Grade 3.

TABLE 1: Descriptive statistics and Pearson correlations for word-specific orthographic knowledge, general orthographic knowledge, letter-sound knowledge, phonological awareness, rapid automatised naming, reading, spelling and age.

Variable	1. Age	2. Word specific OK	3. General OK	4. LSK	5. PA	6. RAN	7. Reading	8. Spelling
Descriptives								
N	176	178	178	178	180	180	177	181
Mean	8.4	6.9	7	37.3	5.2	0.7	12.9	6.9
SD	0.9	3.4	2.7	21	3	0.2	13.7	4.8
Min–max	6–12	0–12	1–12	0–97	0–12	0–2.2	0–70	1–12
Pearson correlations								
2. Word specific OK	-0.11	-	-	-	-	-	-	-
3. General OK	-0.25	0.58**	-	-	-	-	-	-
4. LSK	-0.06	0.70**	0.54**	-	-	-	-	-
5. PA	-0.09	0.62**	0.47**	0.59**	-	-	-	-
6. RAN	0.08	0.22*	0.07	0.26**	0.13	-	-	-
7. Reading	-0.16	0.73**	0.60**	0.74**	0.57**	0.30**	-	-
8. Spelling	-0.07	0.76**	0.53**	0.78**	0.60**	0.19*	0.76**	-

SD, standard deviation; OK, orthographic knowledge; LSK, letter-sound knowledge; PA, phonological awareness; RAN, rapid automatised naming; Min–max, minimum–maximum.
**, $p < 0.01$; *, $p < 0.05$.



Oklv, orthographic knowledge latent factor; Wsodd, word-specific orthographic knowledge odd items; Wseven, word-specific orthographic knowledge even items; Godd, general orthographic knowledge odd items; Geven, general orthographic knowledge even items; lsk_z, letter-sound knowledge scaled.

FIGURE 1: Indicator loadings for orthographic knowledge.

Confirmatory factor analysis

To address the research question which sought to provide evidence that letter-sound knowledge is a potential sub-component of orthographic knowledge, a CFA was conducted to determine whether letter-sound knowledge loaded significantly onto orthographic knowledge (Figure 1). The initial model hypothesised that the indicators of orthographic knowledge were the odd and even counterparts of the word-specific and general orthographic knowledge tasks along with the scaled scores for the letter-sound knowledge. This model was found to have a fair fit $\chi^2(7.6) = 5$ $p = 0.18$; adjusted goodness of fit index (AGFI) = 0.9; comparative fit index (CFI) = 0.99; Tucker–Lewis index (TLI) = 0.9; root mean square error of approximation (RMSEA) = 0.06 (90% confidence interval [CI]; 0, 0.123; standardised root mean square residual [SRMR] = 0.028), indicating that letter-sound knowledge loads significantly onto orthographic knowledge providing evidence for the multi-dimensional nature of orthographic knowledge inclusive of letter-sound knowledge, word specific orthographic knowledge and general orthographic knowledge. An extended analysis of the nature of letter-sound knowledge would need to be conducted to confirm these preliminary findings.

Phonological awareness was hypothesised to have four indicators inclusive of phoneme identification, phoneme deletion, syllable identification and syllable deletion.

TABLE 2: Multiple linear regression for reading and spelling with latent factors of orthographic knowledge and phonological awareness.

Variable	Reading			Spelling		
	β	*t*	95%CI	β	*T*	95%CI
Intercept	-0.03	-0.65	-0.13–0.06	0.05	0.85	-0.06–0.15
Age	-0.01	-0.24	-0.11–0.08	0.04	0.69	-0.07–0.15
RAN	0.15**	2.90	0.05–0.25	0.05	0.80	-0.06–0.16
OK_lv	0.68**	10.08	0.54–0.80	0.74**	9.67	0.58–0.88
PA_lv	0.17*	2.39	0.02–0.31	0.11	1.28	-0.05–0.27

OK_lv, orthographic knowledge_latent variable; PA_lv, phonological awareness_latent variable; RAN, rapid automatised naming; CI, confidence interval.
**, $p < 0.001$; *, $p < 0.01$.

An evaluation of the correlation coefficients showed that syllable identification correlated poorly with the variables in the model ($r < 0.25$) and thus was excluded from the model. The model which excluded syllable identification was found to have a good fit $\chi^2(58) = 3$ $p < 0.05$; AGFI = 0.9; CFI = 1; TLI = 1; RMSEA = 0 (90% [CI; 0, 0]; SRMR = 0).

The model fits were evaluated by interpreting the following indexes: Chi-square statistics, the CFI, the TLI, the Akaike information criterion (AIC), the Bayesian information criterion (BIC), RMSEA, SRMR and adjusted goodness of fit (AGDI) all of which were satisfactory in the interpreted models (see acceptable values in Hu & Bentler 1999; Kline 2005; Brown & Moore 2012).

Prediction of reading and spelling: Regression analyses

In order to ascertain the unique contributions of PA and orthographic knowledge for reading fluency and spelling accuracy, linear regression models were fitted using the latent constructs of orthographic knowledge and PA along with the scaled control variables RAN and age. Latent variables represent common variables among observed indicators and thus reduce the effect of measurement error (Bollen 1989; Kline 2005). In line with the results of the CFA, for the purposes of this analysis, letter-sound knowledge was included as part of orthographic knowledge along with word-specific and general orthographic knowledge. The latent variable for PA was inclusive of phoneme

identification, phoneme elision and syllable elision. Table 2 presents the results of the respective linear regression model.

The models for reading ($R^2 = 0.68$, $p < 0.001$) and spelling ($R^2 = 0.61$, $p < 0.001$) accounted for similar overall variance with orthographic knowledge contributing the greatest variance in both models. Both PA (β = 0.17) and RAN (β = 0.15) were also found to be significant predictors of reading, while only orthographic knowledge (β = 0.74) was found to be a significant predictor of spelling.

Discussion

Phonological awareness is understood by many as a universal predictor of reading and spelling success (see Adams 1990; Babayiğit & Stainthorp 2007; Bryant et al. 1990; Caravolas et al. 2001, 2005; Hulme & Snowling 2015; Landerl et al. 2022; Landerl & Wimmer 2008; Leppänen et al. 2006; Öney & Durgunoglu 1997; Zarić et al. 2020). It has been argued that unless we examine the role of different literacy skills across different languages, we cannot develop a full comprehension of the universal and language-specific factors which contribute to reading and spelling development. As research continues to expand in its discovery of the universal predictors of reading and spelling, this study sought to further investigate the importance of orthographic knowledge for reading and spelling in relation to key literacy universals such as PA and RAN. Thus, the primary aim of this study was to investigate the contribution of orthographic knowledge, alongside that of PA, RAN and age for reading and spelling in a consistently written and agglutinative language, namely, isiXhosa.

The findings from our study confirm the role of orthographic knowledge for both reading and spelling in isiXhosa suggesting that orthographic knowledge contributes to the development of reading and spelling in consistently written languages. This both supports our initial hypothesis and research in this area (see Adams 1990; Bekebrede et al. 2009; Cunningham et al. 2001; Fleisch et al. 2017; Loveall et al. 2013; Arab-Moghaddam & Senechal 2001; Ouellette & Senechal 2008a; Rakhlin et al. 2019; Templeton & Morris 2000; Zarić et al. 2020; Zhao et al. 2017). Specifically, orthographic knowledge was found to contribute to both reading and spelling over and above PA for reading and spelling in a sample of isiXhosa third graders. Rapid automatised naming and PA were found to be significant predictors of reading but to a far lesser degree than that of orthographic knowledge supporting their role as control variables which influence literacy development. This supports the findings of Zarić et al. (2021) for German elementary children who similarly found that orthographic knowledge significantly predicted reading and spelling above PA and general intelligence. Further, it provides support for the argument put forth by Schaefer et al. (2020) who indicated that the role of PA in reading fluency in isiXhosa, and possibly other Southern Bantu languages, may have so far been overestimated. Another way to interpret these findings is that once phonological skills are sufficiently developed, there are more robust predictors of literacy outcomes, such as orthographic knowledge. The findings of the current study suggest that for this sample of third-grade isiXhosa learners, orthographic knowledge, encompassing our stored memory of orthographic learning, is vital for reading and spelling.

Specifically, our findings showed that using the latent variables of PA and orthographic knowledge as predictors of reading and spelling in multiple regression analyses, orthographic knowledge explained slightly more variance (74%) for spelling than it did for reading fluency (68%). These findings are in line with those reported by Zarić et al. (2021) who found that word-specific and general orthographic knowledge explained more variance of spelling compared to reading in their sample of German elementary learners. The greater role of orthographic knowledge for spelling is easily rationalised as learners have to engage more with the print components of language inclusive of orthographic features.

Our findings support the above reasonings and support the literature which indicates that orthographic knowledge is important for reading and spelling (Greek: Georgiou et al. 2008b; Persian: Arab-Moghaddam & Senechal 2001; Dutch: Bekebrede et al. 2009; English: Conrad et al. 2013; Cunningham & Stanovich 1990; Deacon et al. 2012; Rothe et al. 2015; German: Zarić et al. 2020).

The study further sought to contribute to understanding the multi-dimensional character of orthographic knowledge. We hypothesised that orthographic knowledge is a complex metalinguistic variable in that it consists of sub-constructs, much like PA, with its subcomponents of onset-rime, syllable and phoneme awareness. The constructs in question in this study were word-specific orthographic knowledge, general orthographic knowledge and letter-sound knowledge. Our hypothesis was partially supported with a CFA indicating that these constructs load significantly as factors of the latent variable orthographic knowledge.

While the two-dimensional nature of orthographic knowledge has been found in the literature (Apel 2011; Conrad et al. 2013; Loveall et al. 2013; Rothe et al. 2015; Zarićet al. 2020), only a handful of researchers have explicitly examined letter-sound knowledge as part of general orthographic knowledge (Arciuli & Simpson 2012; Cunningham 2006; Vellutino et al. 1995; Wagner & Barker 1994; Ziegler & Goswami 2005), making this study the first to do so with an African language. Intuitively, it seems plausible that letter-sound knowledge forms part of orthographic knowledge given that general orthographic knowledge deals with knowledge of letter rules and patterns in language. Further, accurate word recognition necessitates an understanding of how letters combine in a language to form specific words (Apel 2011; Loveall et al. 2013) suggesting that letter-sound knowledge is needed for the development of orthographic knowledge. This is in line with the argument put forward by Cunningham (2006) who argued that young children depend on these orthographic units (e.g. syllables and affixes), as well as letter-sound correspondence

knowledge to learn new written words. Thus, the lack of research which has included letter-sound knowledge as part of general orthographic knowledge may have led to misrepresentations of orthographic knowledge and its relationship to literacy measures (Apel et al. 2019). Further empirical research into the nature of the letter-sound knowledge–orthographic knowledge relationship is suggested to better understand this relationship.

The findings of this study emphasise the significance of orthographic knowledge for reading and spelling, particularly in isiXhosa language education and thus further research is needed to confirm the findings of the current study. Standardised measures of word-specific and general orthographic knowledge for Southern Bantu languages are needed to enhance consistency and facilitate comparative analysis in educational studies. Further, it is suggested that exposure to written materials should coincide with the simultaneous instruction of PA and letter-sound knowledge. As such, phonics instruction should combine verbal and written approaches to help students connect print and sound. Further research is needed to develop phonics instruction that incorporates orthographic knowledge and other writing-related skills to support literacy development.

Because of the correlational nature of the present study, there are limits to the pedagogical and practical inferences that can be made. However, the findings suggest that instructional attention to orthographic knowledge and in particular letter-sound knowledge would benefit not only reading but also spelling development for isiXhosa learners. Unfortunately, the general orthographic knowledge task reliability score ($\alpha = 0.64$) was not optimal. Apel et al. (2019) suggests that researchers need to be more specific in their choices when creating tasks relating to general orthographic knowledge, for example, word position knowledge, orthographic sequence knowledge, knowledge of orthographic patterns or a combination of these. Because of the novice nature of the current general orthographic knowledge task, this was not performed but is suggested for future research. Future researchers should also consider conducting longitudinal studies which would also assist in contributing towards a better understanding of how orthographic knowledge, along with its subcomponents develops over time. Finally, given that the sample of learners in this study was reading far below grade level, it is unclear whether the findings would be replicable for a higher-achieving sample of readers. We suggest that future researchers explore whether the pattern of findings in this study is found for readers of differing reading ability levels.

In summary, the present study adds to a growing understanding of the multi-dimensional nature of orthographic knowledge and provides evidence for the importance of orthographic knowledge for reading and spelling in isiXhosa. The findings support the need for phonics instruction that incorporates activities which build learners' orthographic knowledge and other writing-related skills. Further, it is recommended that learners are continuously exposed to books and reading as this will strengthen their orthographic knowledge.

Acknowledgements

A special thanks to Maxine Schaefer for her feedback on earlier drafts of this article, as well as her invaluable input into the data analysis strategy. The authors wish to extend their sincere thanks to the schools and learners for their generous participation in the study. We would also like to thank the Rhodes University Centre for Social Development, funded by the Volkswagen Community Trust, for providing us with access to the data used in this study.

This article is partially based on the author's thesis entitled 'Orthographic knowledge in isiXhosa and its relation to phonological recording, letter-sound knowledge, reading and spelling' towards the degree of Master of Arts in the Department of Linguistics and Applied Language Studies, Rhodes University, South Africa on 14 October 2022, with supervisor Ms Tracy Nicole Bowles. It is available here: http://vital.seals.ac.za:8080/vital/access/manager/Repository/vital:70300?site_name=GlobalView

Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Authors' contributions

M.A.D. contributed to the conceptualisation, methodology, analysis, writing of the original draft, and review and editing. T.N.B. contributed to the conceptualisation, writing of the original draft, review and editing, and supervision.

Funding information

This work was supported by The Volkswagen Community Trust, The National Research Fund (grant number 122991) and the Guy Butler Research Grant.

Data availability

The materials used in the study are available in whole or as links via OSF (https://osf.io/6yrc4/?view_only=bb03c95d95774eed904ee6807f30dc19). The dataset generated and/or analysed during the current study is available from the corresponding author, M.A.D., on reasonable request.

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