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Examining the bilingual phonological processing and reader profiles of (non)readers of three consistent orthographies: evidence from South Africa

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Word count (excluding abstract, key words, tables, figures and references) = 7481

Acknowledgements

We thank Patricia Makaure for making the data from her PhD (Makaure, 2021) available to the rest of the project team for this analysis.

Disclosure statement

The authors declare that they have no financial or personal relationship(s) that may have inappropriately influenced them in writing this article. The views expressed in the submitted article are the authors' own and not an official position of the institution or funder.

Funding

This research was funded by the Research Directorate of the University of South Africa through a Women in Research Grant (2019 – 2021) awarded to Carien Wilsenach (Principal Investigator) and Maxine Schaefer (Co-Principal Investigator).

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Background: Developmental delays in phonological awareness (PA) and rapid autotomized naming (RAN) contribute to reading difficulties, even in consistent orthographies. In South Africa, evidence suggests that these skills correlate with reading in African languages. However, the extent to which PA and RAN contribute to different reading profiles is not known and little information exists about whether reading profiles are similar across South African languages.

Objectives: This longitudinal study examined the phonological processing and reader profiles of isiXhosa, isiZulu and Northern Sotho speaking children at two points in time to determine whether consistent profiles emerged.

Method: 59 isiXhosa- and 58 isiZulu-speaking children (analysed as one Nguni group) and 131 Northern-Sotho speaking children were assessed at different points in the foundation phase. Children completed a battery of tests assessing PA, RAN, word reading accuracy, and text reading fluency in their first language and English.

Results: Latent profile analysis revealed four profiles found in each group and time point: reader, developing reader, delayed PA and double deficit. These groups differed clearly in terms of PA and RAN.

Conclusion: The findings support the universality of PA and RAN for (bilingual) reading and support the need for explicit and systematic phonics instruction for reading development.

Keywords: South Africa; early literacy; latent reading profiles; phonological awareness; rapid automatized naming (RAN); word reading; oral reading fluency; low-SES

Introduction

Recent studies suggest that South African children struggle to reach age-appropriate literacy levels, despite substantial financial investment in the education system (Department of Basic Education 2014; Mullis, Martin, Foy & Hooper 2017). The South African Early Grade Reading Studies (Cilliers et al., 2022; Taylor et al., 2017), which use the Early Grade Reading Assessment (EGRA), have produced large-scale data on letter-sound recognition fluency, letter-, word- and text reading, reading comprehension, listening comprehension, vocabulary and phonological awareness. This data has been used to establish reading fluency benchmarks, as well as thresholds for letter and text reading at which reading comprehension is supported in South Africa for Nguni languages (Ardington, Wills, Pretorius, et al., 2021), Sotho-Setswana languages (Mohohlwane et al., 2022) and English as an additional language (Wills et al., 2022). As in other developing contexts where the EGRA has been used, the identification of nonreaders (children who score zero or close to zero on reading tasks), is common in South Africa. For example, Menendez and Ardington (2018) reported that in a sample of almost 10 000 isiXhosa- and isiZulu-speaking children in Grades 2 - 4, 24% could not read any words in their first language (L1). Unfavorable socio-economic and complex sociolinguistic factors (poverty, overcrowded schools, limited resources and inadequate L1 instruction) contribute to this situation (Hunt, 2007; Pretorius & Currin, 2010) and South African research has previously focused predominantly on these factors, neglecting the contribution of psycholinguistic factors to reading in African languages. Emerging evidence suggests that poorly developed phonological processing skills (*phonological awareness* (PA), *phonological working memory* (PWM) and *rapid automatized naming* (RAN)) are associated with poor reading outcomes at both the word- and text reading level in consistently written African languages (Diemer, 2016;

Makaure, 2021; Malda et al., 2014; Schaefer et al., 2020; Wilsenach, 2013, 2019). However, to date, very little is known about the individual reader profiles of South African children who do (not) develop adequate decoding skills in their L1 and in English, and it is not clear whether a specific combination of phonological processing deficits or assets contribute to children's reading difficulties and strengths, at different points in time.

This paper presents data from a longitudinal project which investigated the relationship between phonological processing skills and literacy in emergent bilingual isiXhosa-English, isiZulu-English and Northern Sotho-English speaking children. Our aim here is to identify, using Latent Profile Analysis (LPA), the reading profiles in these groups at different points in time. LPA has, to our knowledge, not been used to establish bilingual reader profiles in children learning to read in an African language and in English in the South African context. The present study addresses this gap, and contributes a more nuanced understanding of the cognitive risk factors in the phonological processing domain that contribute to reading failure in isiXhosa-English, isiZulu-English and Northern Sotho-English speaking children learning to read simultaneously in consistent (L1) and inconsistent (English) orthographies. By presenting data from underrepresented languages, we also enhance cross-linguistic understanding of the role of PA and RAN in learning to read across different orthographies.

PA, RAN and the Double Deficit Hypothesis

PA reflects an individual's ability to detect and manipulate sounds (phonemes, syllables, onsets and rimes) within words. PA is widely acknowledged as a strong predictor of early reading success, regardless of the phonological structure, the orthography and the writing system of the language in which a child learns to read (Castles & Coltheart, 2004; Newman et al., 2011; Ziegler & Goswami, 2005), and accounts for individual variation in word-level reading throughout the early grades of formal schooling (Steacy et al., 2014). Children with poor PA typically experience difficulties in decoding, spelling and orthographic processing (Landerl et al., 2022; Torppa et al., 2012; Wimmer et al., 2000). Since PA skills support and are influenced by reading development, explicit systematic instruction in letter sound correspondences can support children's PA and reading development (Ehri, 2020).

RAN – a measure of one's ability to rapidly name known stimuli such as objects, colors, digits, or letters – has been associated with reading fluency (Landerl et al., 2022; Torppa et al., 2012; Wimmer et al., 2000), reading comprehension (Schatschneider et al., 2004) and spelling (Torppa et al., 2012; Wimmer et al., 2000). RAN requires quick access to word pronunciations, and thus to the phonological output lexicon. For this reason, RAN is often conceptualized as a phonological processing skill, but research shows that RAN also constitutes a unique predictor of both concurrent and future reading achievement, even when PA (and other factors such as socioeconomic status (SES) and IQ) are controlled (Georgiou et al., 2016; Norton & Wolf, 2012). Kirby et al. (2010, p. 356) concluded that "naming speed is phonological, but not only phonological". Cross-linguistic longitudinal precursor studies indicate that RAN is a universal and – in contrast to PA – unidirectional precursor of reading and that differences between orthographies do not affect the nature of this relationship (Landerl et al. 2022).

Considering the role of PA and RAN in reading disability, the Double Deficit Hypothesis (DDH) (Wolf & Bowers, 1999) proposes that these skills are independent correlates of word reading ability, in other words, RAN is a unique and independent core deficit of reading disability. The DDH proposes four reader profiles: typically developing; phonological deficit; rapid naming deficit; and double deficit (a combination of deficient RAN and PA) (Steacy et al., 2014). Children with deficient RAN and PA are theorized to have more severe reading impairment than the single deficit groups (de Groot et al., 2015; Wolf & Bowers, 1999). This proposal has mixed support with data supporting (e.g. Dutch: de Groot et al., 2015; Finnish: Torppa et al., 2012; Greek: Papadopoulos et al., 2009) and failing (e.g. Dutch: Vaessen et al., 2009) to support it.

The importance of mitigating reading difficulties early on is well-documented – Lovett et al. (2017), for instance, report that reading intervention implemented in the first grade is more effective than when implemented in Grade 2 or later. Identifying the risk factors that point to potential reading failure, and then screening children early on to detect developmental delays in these variables, as suggested in Gutiérrez et al. (2022), are equally important, yet this does not systematically happen in high-poverty contexts. Furthermore, the need to identify reader profiles is crucial in ensuring that reading interventions are targeted (Holopainen et al., 2020; Ozernov-Palchik et al., 2017; Steacy et al., 2014; Swanson, 2017; Verwimp et al., 2020). Thus, while it seems reasonable that identifying the cognitive-linguistic profiles, including the phonological processing profiles, of different groups of struggling readers would advance the quality of reading interventions, these profiles have received far less attention in high-poverty contexts than in more affluent contexts. Researchers tended to assume that reading difficulties in high-poverty environments are, first and foremost, due to external factors (Diuk et al. 2019). ‘Specific reading disability’ was perceived as a developmental disorder with a cognitive-linguistic base, independent from ‘other types’ of reading failure, which was assumed to be caused by factors such as low IQ, poverty, inadequate schooling, physical disability, stunting and deficit thinking in social institutions (Ozernov-Palchik et al., 2017; C. E. Snow et al., 1998; Valencia, 2010). Therefore, theories such as the DDH were proposed as an explanation of dyslexia specifically, and not of reading failure in the population at large. However, reading achievement amongst low-SES children is variable, as sub-groups of children develop even poorer literacy skills than their peers who grow up in a similar impoverished environment. These more pronounced difficulties could be explained, at least partially, by poor phonological processing. For instance, Diuk et al. (2019) explored the phonological processing profiles of poor readers in a low-SES context in Argentina, and found that short-term memory, RAN (both non-alphanumeric and alphanumeric) and phoneme awareness (only on more difficult tests) were underdeveloped. Ozernov-Palchik et al. (2017) used latent profile analysis to determine various risk profiles in pre-reading and early-reading English speaking children. They found an overrepresentation of children with RAN or PA deficits in low-SES schools, but not many children with a double deficit. (Ozernov-Palchik et al., 2017, p. 14) concluded that, possibly, “social factors have a higher impact on the single-deficit groups, whereas the double-deficit is influenced more by hereditary factors”.

To accommodate this heterogeneity in poor readers worldwide, explanatory models of reading difficulty have moved away from “deterministic, single causal models to more probabilistic multi-factorial models” (Nag & Snowling, 2011, p. 658). Poor readers in high-poverty contexts should be evaluated using an ‘additive risk factors model’ (Bishop, 2006), which suggests that various factors, such as low SES and instructional environment, may be interacting with cognitive and/or linguistic vulnerabilities. It is improbable that all poor readers in low-SES contexts are 'specifically reading disabled', given the multitude of risk factors that could cause reading failure. Support for this position is growing (see Parrila et al., 2020, for an overview), with scholars agreeing that multifactorial etiological models provide "a more realistic account of developmental disorders, their comorbidity, and the nondeterministic relationships between disorders and their presumed causes" (Parrila et al., 2020, p. 3).

The present study

In this study, we extend work on early grade reading profiles in low SES contexts by examining biliterate readers' phonological processing and reading skills in three consistently written African languages (Northern Sotho, isiZulu and isiXhosa), and an inconsistent orthography (English), at two points in time. Northern Sotho, isiZulu and isiXhosa are characterized by their simple vowel, and large consonant inventory (Nurse & Philippson, 2003). All three languages have simple (V or CV) syllable structures, and agglutinating morphology where grammatical morphemes are added to noun and verb roots (Nurse & Philippson, 2003). In isiZulu and isiXhosa, agglutination often leads to phonological changes such as consonantalization, vowel coalescence, and vowel elision (Nurse & Philippson, 2003). For these phonological reasons, and historical ones, these languages are written conjunctively (affixes appear next to the root with no orthographic spaces). Northern Sotho is more disjunctive – verbal suffixes are added to the verb root with no orthographic spaces, but verbal prefixes occur as separate orthographic words.

The present study utilized LPA to identify the latent reading profiles in these groups at different points in time. LPA identifies profiles of individuals who share similar patterns of variables and compares different profiles, both in terms of how the variables combine to form the profiles, and how those combinations are differentially related to predictors and outcomes A better understanding of individual phonological processing profiles in low-SES learners, generally, and in South Africa specifically, where reading failure is widespread, is needed to develop appropriate reading interventions. The following questions guided the current study:

1. What bilingual phonological processing and reader profiles emerge in a latent profile analysis of emergent-bilingual learners who speak isiXhosa, isiZulu or Northern Sotho as L1, and are these profiles similar at different points in time?
2. To what extent do similar phonological processing and reader profiles emerge in each language group?

Based on existing research, and our knowledge of the present low-SES research setting, we hypothesized *a priori* that five reader profiles would emerge, as follows: i) typically developing profile, including learners who have well-developed PA, RAN, LK and reading skills; ii) lack of instruction profile, including learners who have fair PA and RAN skills but poor LK and poor reading skills; iii) phonological deficit profile, including learners who have weak PA and reading skills, but fair RAN and LK skills; iv) RAN deficit profile, including learners who have weak RAN and reading skills, but fair PA and LK skills and v) double-deficit profile, including learners who are weak in both PA and RAN, have poor LK and very poor reading skills.

Method

Research design, participants and setting

The data presented here were gathered during a longitudinal cross-linguistic project that investigated the relationship between cognitive-linguistic and literacy skills in isiZulu, isiXhosa and Northern Sotho speaking children. Participants were followed over a period of roughly 24 months (end of Grade 1 to end of Grade 3) and were sampled from five public schools in South Africa. For the purpose of this analysis, the participants were divided into two groups, based on their L1. These groups are: isiXhosa/isiZulu L1 (sampled from two schools in Gauteng and one school in the Eastern Cape) and Northern Sotho L1 (sampled from two schools in Gauteng). isiXhosa children were sampled from the Eastern Cape province as schools in Gauteng do not use isiXhosa as MOI. The isiZulu and isiXhosa learners were grouped together to ensure that this language group would be big enough for an LPA approach. This was acceptable given the linguistic similarity of these Nguni languages, similar reading development trajectories (Ardington, Wills, Pretorius, et al., 2021), and the close resemblance between the isiZulu/isiXhosa language measures (see below).

The Northern-Sotho children were assessed at the beginning of Grade 2 (Time 1a: February 2019) and at the end of Grade 2 (Time 2a: August – September 2019). The isiZulu and isiXhosa learners were assessed at the end of Grade 1 (Time 1b: August-September 2019) and at the beginning of Grade 3 (Time 2b: March-April 2021). The delay in the collection of isiZulu and isiXhosa data was caused by the COVID-19 pandemic, since no face-to-face research was allowed during 2020 in South African schools, and it is likely that these students experienced learning loss at Time 2b (Ardington, Wills, & Kotze, 2021). In summary, six months passed between Time 1 and

2 in the Northern-Sotho groups, whereas 18 months passed between Time 1 and 2 in the isiZulu and isiXhosa groups.

The sample consisted of 248 children, including 59 (35 girls) isiXhosa speaking children ($M_{Age\ t1}$ = 6.9, $SD_{Age\ t1}$ = 0.5; $M_{Age\ t2}$ = 8.4, $SD_{Age\ t2}$ = 0.5), 58 (30 girls) isiZulu speaking children ($M_{Age\ t1}$ = 6.8, $SD_{Age\ t1}$ = 0.4; $M_{Age\ t2}$ = 8.4, $SD_{Age\ t2}$ = 0.4) and 131 (77 girls) Northern-Sotho speaking children ($M_{Age\ t1}$ = 7.3, $SD_{Age\ t1}$ = 0.4; $M_{Age\ t2}$ = 7.9, $SD_{Age\ t2}$ = 0.4). Children were introduced to English as an additional language in Grade 1. All five schools were situated in urban or semi-urban low SES areas and were part of the National School Nutrition Programme. The Northern Sotho children attended schools that had school libraries, but these were not used systematically as an educational resource during the study. The isiZulu and isiXhosa schools did not have school libraries.

Ethical clearance for the research was obtained from the University and Provincial Departments of Education. Parents provided informed consent at the outset, and learners provided verbal assent before each test session. All assessments were conducted in individual sessions and were administered to the children by trained isiZulu-, isiXhosa- and Northern Sotho-speaking field workers.

Instruments

Phonological processing skills (PA and RAN) were measured with the second edition of the *Comprehensive Test of Phonological Processing* (CTOPP). To measure isiZulu, isiXhosa and Northern Sotho, PA and RAN, the researchers developed tests (modelled after the CTOPP), as no standardized measures of phonological processing exist for these languages. Letter Knowledge (LK) was measured once with a one-minute letter reading task – children responded with either L1 or English letter-sounds (both responses were accepted). Word reading (English) was measured with the *Diagnostic Test for Word Reading Processes* (DTWRP) (Forum for Research in Literacy and Language Institute of Education, 2012) while tests were developed to assess word reading in the African languages. The Cronbach's alpha reliability for all instruments is presented in Table 1. Oral reading fluency (ORF) in both English and the L1 was measured via one-minute reading tasks (as described in Dubeck & Gove, 2015). All tasks were preceded by a training phase to ensure that children understood what was required.

Phonological Awareness

English PA was measured via the *sound matching*, *blending*, *elision* and *sound isolation* tasks of the CTOPP. The English PA tests were different in the different L1 groups, as the structure of the L1 determined which CTOPP sub-tests could be adapted as L1 measures. In the isiZulu/isiXhosa group, English PA was measured using *blending, sound isolation* and *elision.* In the Northern-Sotho groups, English PA was measured using *blending, sound matching* and *elision* (elision, however, was only measured at Time 2a and was not included in the LPA of the Northern-Sotho children). Tests were discontinued and raw scores calculated, as described in the CTOPP manual.

isiZulu/isiXhosa PA was measured through *blending, elision and sound isolation.* Test items were the same in both languages, as far as possible. *Blending* consisted of four items at syllable-level (e.g. children had to blend *u-bi-si* into *ubisi*) and six items at the phoneme level (e.g. children had to blend *i-j-e-z-i* into *ijezi*). *Elision* was measured at the syllable level (e.g. *isifo* without *fo* is *isi*; six items) and at the phoneme level (e.g. *bona* without *b* is *ona;* four items). *Sound isolation* consisted of five items that varied in length; children had to identify a phoneme at the beginning, final, middle and second position (e.g. the last sound of *ona* is *a*). A total PA score (blending, elision and isolation) was calculated by awarding one mark for each correct answer. The maximum raw score was 25.

Northern-Sotho PA was measured through *sound matching, blending* and *elision* (elision was only measured at Time 2a and was thus not included in the analysis). In *sound matching* (10 items), children were presented with a target picture word, and then had to select the picture words that matched the beginning or end sound of the target word (e.g. *katse* had to be matched with the picture word *kefa*, when presented with the distractors *tonki* and *puku* – initial sound matching; and *letšatši* had to be matched with *lebati*, when presented with the distractors *kolobe* and *sesepe* – word-final sound matching). *Blending* (15 items) was similar to what has been described above; children were required children to blend syllables (e.g. ba-sa-di) and phonemes (e.g. b-i-n-a) into the whole words *basadi* and *bina*. A total PA score (blending and sound matching raw score was calculated by awarding one mark for each correct answer (maximum score 25).

Rapid Automatized Naming

RAN was measured using the rapid digit naming and rapid letter naming tasks from the CTOPP, as well as a custom-made rapid object naming task that was administered in the L1. RAN digits were not assessed in the L1, as pilot testing indicated that children were unfamiliar with digit names in the L1, possibly because English digits are used in school, regardless of the medium of instruction. Likewise, RAN letters were not assessed in the L1, as the alphabet is produced as letter sounds, rather than letter names. A RAN composite score was created for each language group by taking the average naming time (in seconds) for the available RAN indicators. For the Northern Sotho sample, an average of letter, digit and object naming was used. The isiXhosa/isiZulu group was not very familiar with letter naming at Time 1b, resulting in a lot of missing data. The RAN composite for this group was thus an average of object and digit naming at both time points.

Letter knowledge

LK was operationalized as a one-minute letter reading task that assessed letter recognition fluency, and was taken from the EGRA (Department of Basic Education & University of the Witwatersrand, 2020). The task consisted of 110 letters (e.g. <m>) and letter combinations (e.g. <sh> and <ngw>) that occur in the children's respective L1s. The items were presented on a chart in both lower and upper case and were organised in eleven rows and ten columns. The number of letters read correctly in a minute represented the letter-recognition fluency score. Children typically responded with L1 letter sounds, but English letter names were also accepted. The task was discontinued if participants were unable to read the first five letters. The maximum raw score for this task was 110.

Word reading

English word reading was measured using the nonword (e.g. *vip*, *tek*), exception word (e.g. *people*, *treacherous*) and regular word (e.g. *frog*, *hill*) reading tasks from the DTWRP. Equivalent word lists of 20 items were created for isiXhosa, isiZulu and Northern-Sotho. For the Nguni languages (isiXhosa and isiZulu), dictionaries were used to identify words that had the same or almost the same spelling, the same meaning and same frequency, which meant that these tasks were almost identical. All lists progressed from simple to complex items. Task administration processes from the DTWRP test manual were followed: children were asked to read the words on each chart out loud, they received no feedback (other than being asked to blend sounds together if they sounded out letters), no time limit was imposed, and the test was discontinued after five consecutive errors. The score per task was the total number of words read correctly.

Oral Reading Fluency

ORF was measured using the EGRA, a one-minute text reading task in English and in the child's L1. Children were asked to read a grade level text for one minute. Errors were recorded and subtracted from the total number of orthographic words read to provide a words correct per minute score. The orthographic differences between the disjunctively written Northern-Sotho and conjunctively written isiZulu and isiXhosa resulted in comparatively more words being read in Northern-Sotho and English.

Table 1.

Internal consistency (Cronbach's Alpha) estimates of untimed instruments per sample

		Cronbach's Alpha	
Instrument	**Total Items**	**Northern Sotho**	**isiXhosa/isiZulu**
L1 PA			
Sound-matching	10	.99	-
Blending	10 (X/Z); 15 (NS)	.98	.80
Elision	10	-	.80
Isolation	5	-	.64
Total test	25	-	.90
Eng PA (CTOPP)			
Sound Matching	26	.98	-
Blending	33	.86	.93
Elision	34	.96	.93
Isolation	32	-	.93
Total test (Xhosa/Zulu)	99	-	.97
Total test (N. Sotho)	59	-	-
L1 Word Reading	20	.98	.86
Eng Word Reading (DTWRP)			
Eng Regular Word reading	30	.90	.96
Eng Nonword Reading	30	.70	.95
Eng Sight Word Reading	30	.75	.96

Data analysis plan

We performed LPA in R (R Core Team, 2021) for each sample and timepoint using mclust (Scrucca et al., 2016) and tidyLPA (Rosenberg et al., 2018). TidyLPA, runs on mclust with the advantage that it produces similar output to and is benchmarked against Mplus (Rosenberg et al., 2018). LPA is an exploratory technique used to identify the unobserved or latent profiles (i.e. more homogenous groups) which affect the responses on variables in a heterogenous sample (Hickendorff et al., 2018; Johnson, 2021). LPA assigns a probability to each participant for their latent profile membership (Bauer, 2019), thereby addressing problems with using cut-off points in DDH research. The analytic technique seeks to maximize the similarity of participants within a profile, and the differences between participants in different profiles (Hickendorff et al., 2018), thereby allowing the identification of classes that differ qualitatively from one another. Models which specify different numbers of profiles, and relationships among variables for each profile are compared. The final model is selected considering the model fit, and theoretical interpretability of the number of profiles (Hickendorff et al., 2018; Johnson, 2021).

All variables were included in the analysis in their original metric as recommended by Johnson (2021). The number of profiles was estimated through four different model specifications available in tidyLPA and described by Rosenberg et al. (2018): Model 1 - equal variances and covariances fixed to zero; Model 2 - varying variances and covariances fixed to zero; Model 3 – equal variances and equal covariances; Model 6 – varying variances and varying covariances. The number of profiles was determined by evaluating various model fit indices. We used the Bayesian Information Criterion (BIC), the Sample Size Adjusted BIC (SABIC) and Akaike Information Criteria (AIC), with smaller values indicating better model fit. We used the

Bootstrapped likelihood ratio test (BLRT) to determine whether the model improved with the addition of a profile, with a non-significant test indicating the current model is better than the model with one additional profile. We also examined the average posterior class probabilities to determine how accurate the profile classification was, with values equal to or greater than .70 as the benchmark (Bauer, 2019). We considered the interpretability of the number of profiles in competing models, when the model fit indices were not clear cut.

Results

The mean, standard deviation, median, minimum and maximum scores, and the proportion of children who scored zero per task are presented in Table 2. The scores improved between time 1 and time 2 for both samples. There was a larger proportion of children scoring zero in the isiXhosa/isiZulu sample because the sample was assessed in Grade 1, and probably due to the impact of COVID-19 on education in South Africa, where Grade 2 children in 2020 lost up to 70% of a year of learning (Ardington, Wills, & Kotze, 2021). The correlation matrices for each sample are presented in Table S1 and Table S2, available on the Open Science Framework (https://osf.io/dsknv/).

Table 2.

Descriptive statistics for the Northern Sotho sample at T1 and T2 (start and end of Grade 2) and the isiXhosa/isiZulu sample at T1 and T2 (end of Grade 1 and the start of Grade 3)

	Time 1						Time 2					
Task (unit / max)	**M**	**SD**	**Mdn**	**Min**	**Max**	**% zero scores**	**M**	**SD**	**Mdn**	**Min**	**Max**	**% zero scores**
Northern Sotho group: N = 131												
L1 (Northern Sotho)												
PA Total (25)	11.5	4.9	10	0	25	1.5	14.3	6.5	13	0	27	0.8
PA: Blending (15)	7.2	3.1	6	0	15	1.5	8	4.5	6	0	17	5.3
PA: Sound Matching (10)	4.2	2.7	4	0	10	5.3	6.4	3	6	0	12	3.1
RAN Composite (s)	56.3	15.6	52.3	29	109.7	0	46.2	12.6	43	25.3	80	0
RAN Letters (s)	65	34.2	54	24	195	0	46.2	21	40	19	106	0
RAN Objects (s)	60.9	18.3	59	7	118	0	56.3	16.5	55	25	117	0
Letter Reading Fluency (lcpm)	19.4	7.3	19	1	55	0	31.6	13.3	30	2	65	0
Regular Word Reading (20)	7	3.3	7	0	20	0.8	10.6	6.4	10	0	20	3.1
Text Reading Fluency (wcpm)	7.3	7.9	5	0	58	4.6	19.1	16.1	16	0	71	3.1
English												
PA Total (59)	18.2	8.4	17	1	41	0	22.2	10.9	21	4	44	0
PA: Blending (33)	7.5	4	6	0	19	1.5	7.9	5.3	6	0	21	3.1
PA: Sound Matching (26)	10.7	5.6	11	0	24	1.5	14.3	7.1	15	2	26	0
RAN Digits (s)	43	12.1	40	24	88	0	36.1	12.1	34	19	85	0
Nonword Reading (30)	4.3	2.9	4	0	25	6.9	9.4	6.6	7	0	28	0.8
Regular Word Reading (30)	5.3	3.6	5	0	29	3.1	10.7	7.5	8	1	29	0
Sightword Reading (30)	4.9	3.1	4	0	27	4.6	10.4	7.3	9	1	28	0
Text Reading Fluency (wcpm)	6.3	7	4	0	48	12.2	21.1	18.3	14	1	67	0
isiXhosa/isiZulu group: N = 117*												
L1 (isiXhosa/isiZulu)												

	Time 1						Time 2					
Task (unit / max)	**M**	**SD**	**Mdn**	**Min**	**Max**	**% zero scores**	**M**	**SD**	**Mdn**	**Min**	**Max**	**% zero scores**
PA Total (25)	6.7	4.2	6	0	21	0.9	11	6.2	11	0	23	0.9
PA: Blending (10)	3.4	2	3	0	10	4.3	5.1	2.7	5	0	10	5.1
PA: Elision (10)	1.3	1.9	1	0	8	47	3.2	2.8	3	0	10	19.7
PA: Isolation (5)	2	1.3	2	0	5	13.7	2.6	1.5	3	0	5	12
RAN Composite (s)	50.6	12.6	49	29	82.5	0	42.9	14.7	40.5	22.9	133.7	0
RAN Objects (s)	54.7	12.7	52.8	31.7	101.3	0	51.4	16.6	49	20	133.7	0
Letter Reading Fluency (lcpm)	14.8	12.4	13	0	61	6	33.8	20.8	34	0	80	1.7
Regular Word Reading (20)	3.9	6.4	0	0	20	55.6	10.4	8.5	14	0	20	26.5
Text Reading Fluency (wcpm)	2	4.5	0	0	27	63.2	8.9	11.2	3	0	49	44.4
English												
PA Total (99)	14.5	12.3	11	0	61	1.7	24	16.9	19	0	71	0.9
PA: Blending (33)	4.3	4.2	3	0	17	20.5	5.5	6	3	0	33	19.7
PA: Elision (34)	3.3	4.1	1	0	22	31.6	7.1	6.6	5	0	28	17.9
PA: Isolation (32)	6.9	5.8	6	0	25	12	11.4	6.8	11	0	28	6
RAN Digits (s)	46.2	16.8	42.2	22.1	98.4	0	33.5	13.4	29.5	19.1	95	0
Nonword Reading (30)	2	4.1	0	0	25	64.1	4.7	6.5	2	0	30	34.2
Regular Word Reading (30)	1.1	3.1	0	0	22	72.6	4.7	7.2	1	0	30	45.3
Sightword Reading (30)	0.8	2.1	0	0	15	74.4	3.6	6.3	0	0	29	50.4
Text Reading Fluency (wcpm)	3.6	9.3	0	0	77.5	59	16.5	21.2	7	0	110.1	19.7

Note: * n = 117, except for Time 1 RAN digits (n = 113), and Time 2 RAN digits (n = 116). RAN composite score is the average of both RAN digits and RAN objects for the isiXhosa/isiZulu group. When RAN digits was missing, only RAN objects time was used.

Latent Profile Analysis

Tables S3 to S6 report the model fit statistics of estimated one to nine profiles using four model specifications for each sample and timepoint. We found that the best model specification, according to BIC, was model 3 which specified equal variances and equal covariances for each profile. The selection of the number of profiles and their interpretation per sample and time point, using this model specification, are addressed below. The number of profiles and sample means are presented in Table 3, and Figure 1(a – d).

Figure 1. Means per task per profile for each sample at time 1 and time 2

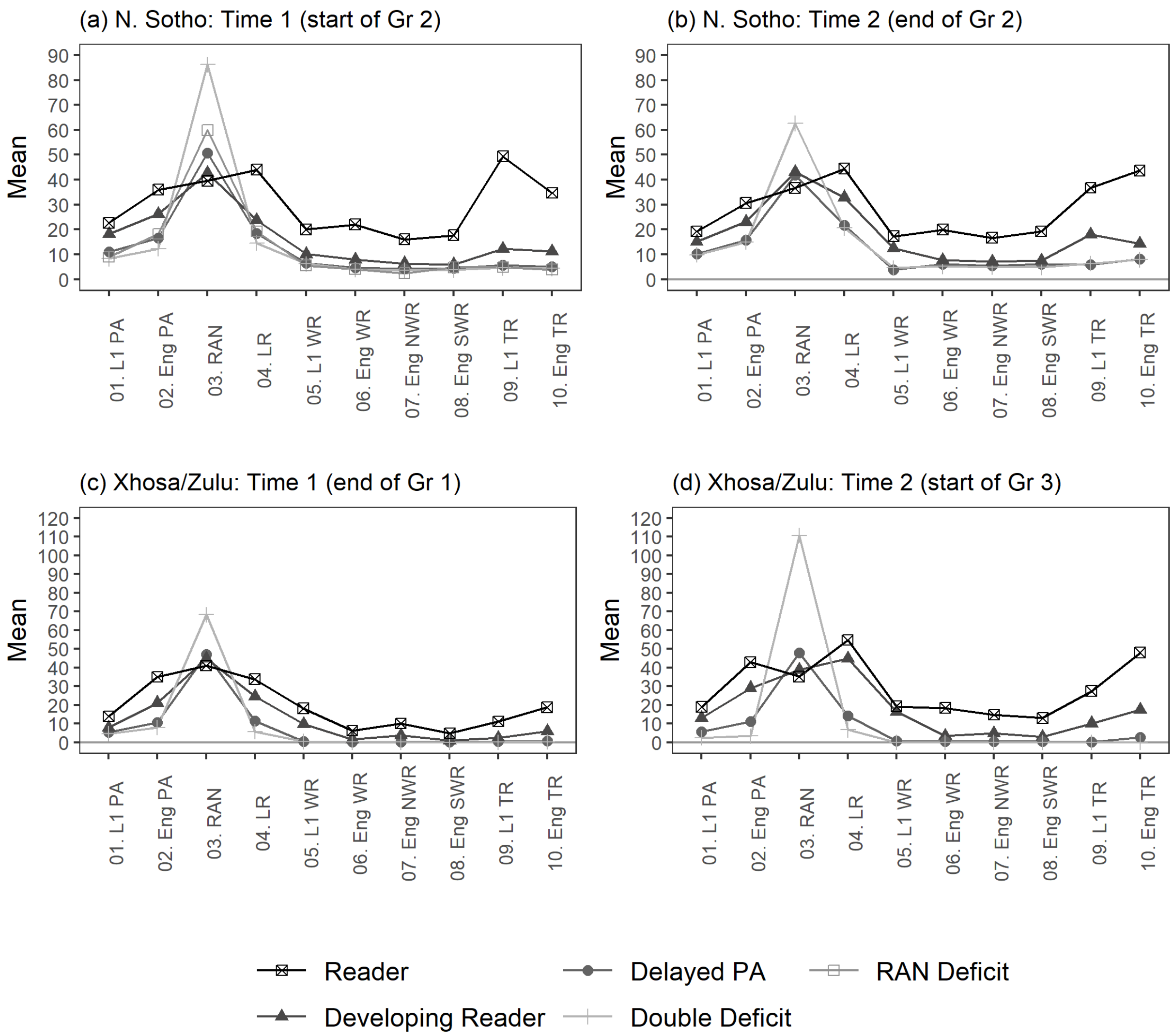

Table 3. Means and standard errors per profile for each sample and timepoint, including profile size

Group	**N. Sotho T1: start of Grade 2**										**N. Sotho T2: end of Grade 2**							
Profile	**Reader n = 3**		**Developing Reader n = 18**		**Delayed PA n = 61**		**Double Deficit n = 19**		**RAN Deficit n = 30**		**Reader n = 42**		**Developing Reader n = 36**		**Delayed PA n = 17**		**Double Deficit n = 36**	
Variable	**M**	**se**	**M**	**se**	**M**	**se**	**M**	**se**	**M**	**se**	**M**	**se**	**M**	**se**	**M**	**se**	**M**	**se**
L1 PA	22.7	2.2	18.3	1.1	11.1	0.6	8.4	0.5	9.0	0.7	19.3	0.94	15.2	1.26	10.2	1.5	9.9	1.3
Eng PA	36.0	3.8	26.2	2.2	16.6	1.1	12.3	1.2	18.2	1.5	30.6	1.68	23.1	2.41	15.7	2.3	15.0	1.7
RAN	39.6	5.6	42.7	1.7	50.6	1.3	86.2	4.3	59.9	1.6	36.7	1.29	43.0	1.46	41.8	2.8	62.6	1.9
LK	44.0	5.7	23.7	1.1	18.5	0.8	14.6	1.2	19.3	1.2	44.4	2.30	32.9	1.66	21.7	2.5	20.6	1.7
L1 WR	20.0	0.0	10.1	0.9	6.4	0.3	6.3	0.6	5.6	0.4	17.3	0.58	12.4	0.94	3.9	0.9	4.6	0.5
Eng WR	22.0	3.7	8.0	0.6	4.6	0.3	4.0	0.4	4.1	0.4	19.9	0.80	7.8	1.17	6.1	1.2	5.3	0.5
Eng NWR	16.0	4.2	6.4	0.5	4.2	0.3	3.7	0.3	2.5	0.4	16.6	1.00	7.2	0.92	5.6	1.0	4.9	0.4
Eng SWR	17.7	4.3	6.0	0.7	4.4	0.3	3.8	0.3	4.8	0.4	19.2	0.88	7.6	1.03	6.1	1.3	4.9	0.5
L1 TR	49.3	4.1	12.2	1.5	5.7	0.5	4.6	0.4	4.9	0.9	36.7	2.76	18.0	2.14	5.9	1.9	6.4	0.9
Eng TR	34.7	8.5	11.3	2.5	5.1	0.6	4.4	0.7	3.9	0.6	43.7	2.46	14.3	2.70	8.2	2.5	8.0	1.4

Group	**isiXhosa/isiZulu T1: mid Grade 1**										**isiXhosa/isiZulu T2: start Grade 3**							
Profile	**Reader n = 15**		**Developing Reader n = 15**		**Delayed PA n = 64**		**Double Deficit n = 23**				**Reader n = 20**		**Developing Reader n = 49**		**Delayed PA n = 46**		**Double Deficit n = 2**	
Variable	**M**	**se**	**M**	**se**	**M**	**se**	**M**	**se**			**M**	**se**	**M**	**se**	**M**	**se**	**M**	**se**
L1 PA	13.9	1.0	7.9	1.0	5.5	0.5	4.7	0.6			18.9	0.7	13.1	0.7	5.7	0.5	2.5	1.3
Eng PA	35.0	3.2	21.1	2.6	10.6	1.4	7.9	1.6			42.8	3.2	29.1	1.9	11.3	1.4	3.3	3.8
RAN	41.0	2.5	44.9	3.1	47.2	1.5	68.3	2.9			35.2	1.8	38.7	1.4	47.8	3.5	110.8	28.1
LK	33.7	3.9	24.5	1.8	11.5	1.3	5.8	1.5			54.7	3.2	44.9	1.8	14.1	1.8	6.7	5.9
L1 WR	18.1	0.6	9.7	0.8	0.4	0.1	0.4	0.2			19.1	0.3	16.3	0.5	0.7	0.2	0	0.8
Eng WR	6.2	1.5	1.7	0.7	0.1	0.0	0.1	0.1			18.4	1.7	3.4	0.5	0.5	0.2	0	0.2
Eng NWR	10.1	1.5	3.8	0.6	0.3	0.1	0.1	0.1			14.7	1.9	4.8	0.6	0.6	0.2	0	0.3
Eng SWR	4.9	0.9	1.0	0.3	0.1	0.1	0.0	0.0			13.0	2.2	2.9	0.6	0.4	0.2	0	0.1

L1 TR	11.1	1.7	2.3	0.8	0.4	0.1	0.1	0.1		27.4	2.2	10.2	1.1	0.1	0.1	0	0.2
Eng TR	18.7	5.0	6.0	1.4	0.8	0.2	0.3	0.2		48.0	5.7	17.4	2.2	2.7	1.2	0	1.1

Note: PA – phonological awareness, RAN – rapid automatized naming, LK – letter recognition fluency, WR – word reading, NWR – nonword reading, SWR – sight word reading, TR – text reading Latent Profile Analysis: Northern Sotho Start of Grade 2 (T1a)

The AIC (7063.8), SABIC (7032.5) and BLRT (45.12, p = .030) (Table S3) supported a five-profile model, whereas the BIC (7367.1) was lowest for a three-profile model. Inspection of the profile sizes and the classification probabilities supported the five-profile model – based on their characteristics we labelled these profiles as ‘Reader’, ‘Developing Reader, ‘Delayed PA’, ‘RAN deficit’ and ‘Double Deficit’.

The smallest and most distinct profile (Reader) included three participants and was characterized by very high scores on all variables, and the fastest naming time. The next most distinct profile (Developing Reader) included 18 participants (13.7% of the sample). The Developing Readers’ PA and RAN scores overlapped with the Readers, and were better than the other three profiles. This profile’s reading scores were above the sample mean; specifically, their reading scores were lower than the Readers and higher than the other three profiles.

The remaining three profiles were similar on word reading but differed on PA and RAN scores. Inspection of the means and their 95% confidence intervals indicated that the Double Deficit group (n = 19) was characterized by very slow naming speed, by lower scores on L1 PA compared to the Delayed PA group (n = 61), and by lower scores on English PA compared to RAN Deficit group (n = 30). The RAN Deficit group had faster naming speed than the Double Deficit Group, but was weaker in RAN than the Delayed PA group. These profiles (Delayed PA, RAN Deficit and the Double Deficit) had similar reading ability, except for the RAN Deficit group that scored significantly poorer on English nonword reading.

Latent Profile Analysis: Northern Sotho End of Grade 2 (T2a)

The various fit indices (Table S4) indicated different profile numbers for the Northern Sotho sample at T2. The AIC was smallest for four profiles, the BIC was smallest for two profiles, the sample size adjusted BIC was smallest for 7 profiles, and the bootstrapped likelihood ratio test was significant for two profiles. We examined the two-profile model means and found that the profiles included an advanced reader group and a poor reader group. The four-profile model retained the advanced reader group and attempted to identify sub-groups of participants in the poor reader group. We therefore decided on four profiles since the sample size adjusted BIC was the second lowest, and this profile level was supported also by the AIC. Although there was evidence to support the seven-profile model we deemed this number of profiles as too many to provide sufficient information for the current sample, given the sample size of 131.

The largest and most distinct profile included 42 participants and was characterized by high scores on all variables, and the fastest naming speed. We again used the term ‘Reader’ to support continuity in our discussion, but this profile consists specifically of readers who can read both Northern Sotho and English. As mentioned above, this profile already emerged when only two profiles were estimated. The next most distinct profile (‘Developing Reader’) included 36 participants, which (at T2) were more precisely Developing L1 Dominant Readers. The Developing Readers had lower scores compared to the Readers, but had higher PA scores than the other two profiles and faster RAN than the Double Deficit group. The Developing Readers were dominant in L1 reading compared to the Delayed PA and Double Deficit groups, but did not differ in their English reading. The Double Deficit profile also had 36 participants and was characterized by a very slow RAN, and low PA and reading scores. Finally, the Delayed PA profile was the smallest profile (n = 17). It was similar to the Double Deficit Group in all respects except RAN, where the naming speed was the same as the Developing (L1 Dominant) Readers.

Latent Profile Analysis: isiXhosa/isiZulu End Grade 1 (T1b)

The AIC, BIC, and sample size adjusted BIC were smallest for the four profile model (Table S5). The bootstrapped LRT first became significant for two profiles, became non-significant for three profiles and was significant again for four profiles. As the four profile model allows us to explore the differences for the slower readers, we selected the four profile model.

The two smaller profiles (Table 3), with 15 participants each, included participants who could read. The Reader profile had higher scores on PA than all other profiles, their naming speed overlapped with that of the Developing Reader and Delayed PA profiles, and they had the highest reading scores compared to other groups. The Developing Reader profile had higher PA and reading scores than the Delayed PA and Double Deficit profiles, but lower PA and reading scores than the Readers. The Developing Readers' naming speed was similar to the Delayed PA profile, and faster than the Double Deficit profile. The Delayed PA and Double Deficit profiles included nonreaders, with the most noticeable difference being that the Double Deficit profile (n = 23) had slow naming speed on average, lower letter-reading fluency and slightly lower PA scores, compared to the Delayed PA profile (n = 64).

Latent Profile Analysis: isiXhosa/isiZulu Start Grade 3 (T2b)

The AIC, sample size adjusted BIC and bootstrapped LRT supported the estimation of four profiles, while the BIC supported three profiles (Table S6). We selected the four profile model as most of the model fit statistics supported this number of profiles.

The smallest profile (n=2) had very slow naming, very poor PA, and could not read. We termed this profile the Double Deficit Group. The next smallest profile (n = 20) was the (Biliterate) Reader group. This group had the highest English and L1 PA, their naming speed was similar to Developing Readers, but faster than the Double Deficit and Delayed PA profiles, and they had the best reading scores. The Developing L1 Dominant Reader group (n = 49) had higher PA, faster naming speed and higher reading scores than the Delayed PA and Double Deficit profiles. The Developing Readers were dominant in L1 compared to English reading. Finally, the Delayed PA profile was the largest (n = 46; 39%), and included nonreaders, with some letter reading fluency. Their PA was lower than both Reader and Developing Reader profiles, and their naming speed was slightly slower than the Developing Readers. Again, we are uncertain if the low PA and lack of reading ability is due to a PA deficit or lack of instruction considering that a large proportion of the sample is in this group.

Discussion

Our research aimed to identify latent phonological processing and reading profiles of bilingual children reading in both a consistent orthography (isiXhosa/isiZulu and Northern Sotho) and in the inconsistent orthography of English, their additional language, at different points in development. isiXhosa-English, isiZulu-English and Northern Sotho-English speaking children were assessed on PA, RAN, LK, word reading accuracy, and ORF in L1 and English at two points in time. We examined, using LPA, whether there were latent profiles that grouped similar participants together in each group and at each time point. We expected the four profiles postulated by the DDH (i.e. typically developing, PA deficit, RAN deficit, and Double Deficit) but also anticipated that instruction would affect reading skills such that it may be possible to have a fifth profile of participants with intact PA and RAN, but poor reading skills.

Number of profiles for each language group and time point

At both time points, and in both groups, at least four profiles emerged which included a Reader profile, a Developing Reader profile, a Delayed PA profile, and a Double Deficit profile. Common to all models was that the Reader profile had the highest PA, fastest LK, most accurate word reading and most fluent reading in both L1 and English compared to the other profiles at each time point and group. RAN was similar in the Reader and Developing Reader profiles. Thus, our hypothesized typically developing group was actually found to be two groups (Reader and Developing Reader). In terms of the external validity of these profiles, the Reader profiles at Time 1, and the Developing Reader and Reader profiles at Time 2 had letter reading scores above 40 letters correct per minute, which is the benchmark postulated by Ardington et al. (2020). Similarly, the isiXhosa/isiZulu Reader profile had a mean of 27 words correct per minute, which is above the lower fluency benchmark (20 words correct per minute) for Nguni text reading (Ardington, Wills, Pretorius, et al., 2021).

The Delayed PA profile likely included both children with a PA deficit as well as those who require additional instruction. We were unable to disentangle these two hypothesized profiles. Since PA and reading are bidirectionally related, a PA deficit becomes clearer to identify only once sufficient instruction in letter-sound correspondences is provided. We found only partial support for the DDH. A RAN deficit group was only found for Northern Sotho at Time 1. Additionally, because reading levels were low in general, the Double Deficit groups did not perform much worse than the Delayed PA groups in reading.

The data presented here suggest that isiXhosa/isiZulu and Northern Sotho speaking children are particularly at risk of reading failure if they exhibit both PA and RAN deficiencies in the phonological processing domain. Our results, therefore, support the universality of PA and RAN for reading in both consistent and inconsistent alphabetic orthographies (Landerl et al., 2022) using evidence from South Africa. The Reader and Developing Reader profiles had higher levels of both L1 and English PA, and had the strongest RAN skills. The profiles which included participants with low means on PA were inaccurate and slow readers, or nonreaders, in L1 and English for both groups and timepoints.

Our results also emphasize the role of instruction in developing PA and reading skills (in any language) (Landerl et al., 2022). Approximately three quarters of the Northern Sotho and isiXhosa/isiZulu groups had a PA delay relative to the Reader profile at T1, and at T2 this was approximately 40% of the sample. PA delayed children in the Northern Sotho sample were able to read some words in L1 and English at T2, but the PA delayed children in the isiXhosa/isiZulu group (who had much less instruction due to the pandemic) were nonreaders. In the absence of instruction, these participants were unable to develop their PA and reading skills in either language. We concur with Diuk et al. (2019) that lack of explicit instruction in phonics in low-SES contexts puts PA delayed children at risk of reading failure, as many children in the sample were nonreaders after three years of formal literacy instruction. Nevertheless, the Reader and Developing Reader profiles did increase in size from T1 to T2, indicating that some children did benefit from the reading instruction offered, or possibly had more support to develop reading in their home environment.

In our study, the Double Deficit profile had similar reading performance to the Delayed PA profile, supporting what Vaessen et al. (2009) found for a sample of Dutch dyslexic readers, and contradicting the findings of Papadopoulos et al. (2009) for Greek. We also found evidence of a RAN delay profile only at T1a for the Northern Sotho group. Thus, it appears that in this instructional context, where many children do not learn how to read well in either their L1 or English, there is insufficient variability in reading ability to determine whether profiles differ from one another on reading accuracy and fluency.

The instructional context also influenced the reader profiles we found. Both the Reader and Developing Reader profiles had strengths in L1 reading compared to English reading. We did not find a profile that was L2 dominant, perhaps except for the RAN delayed group at T1a who had a relative strength in English PA compared to L1 PA. This finding is in contrast to Swanson (2017) where an L2 English dominant reader profile emerged of Spanish-English readers in English instruction in the United States. Although some of the participants in our sample attended an English medium of instruction school, they were not (yet) identified at a latent level as being L2 dominant. The instructional context also affects the speed with which children become accurate readers. Previous research has found that readers of inconsistent orthographies reach high levels of accuracy early in reading development (Seymour et al., 2003) so reading fluency rather than accuracy differentiates reader profiles. For example, Torppa et al. (2012) report that almost a third of Finnish children can read before formal school starts. Even though isiXhosa, isiZulu and Northern Sotho are consistently written, the low SES South African context, and inconsistent quality of literacy instruction result in these children taking much longer to reach high levels of accuracy, and fluency (Ardington, Wills, Pretorius, et al., 2021; Spaull et al., 2020). Only the Reader profile at T1a and T1b had a mean L1 word reading accuracy of 100% (or 20/20 as a similar task was used for Northern Sotho and isiXhosa/isiZulu). Fortunately, the number of children reading in L1 at high levels of accuracy increased at T1b and T2b to 60% of the sample. English word reading accuracy was still relatively lower, supporting the findings of

Seymour et al. (2003) that it takes even longer to read accurately in English which is written inconsistently.

Practical Implications

With exception of the Reader profile, the other profiles, on average, read inaccurately and dysfluently at T1a and T1b in both L1 and English. At T2a and T2b, the Developing Reader profile included L1 dominant readers, but the Delayed PA and Double Deficit groups were still inaccurate and dysfluent in both languages. These results indicate that phoneme awareness and its connection to letters needs to be targeted explicitly in reading intervention programmes in this instructional context. Since the developing readers in this sample *also* did not read at a level that would support reading comprehension and obtained significantly lower scores in phoneme awareness than basic readers in both languages, it seems that readers in these and similar languages would benefit from a reading pedagogy that includes systematic synthetic phonics instruction using grapheme-phoneme subunits. Current estimations in South Africa are that instruction at the phoneme level is not crucial, since the Southern African Bantu languages are syllable timed, and since syllable awareness develops more intuitively in young children (Schroeder, 2013). Correspondences between graphemes and phonemes are typically taught through syllables, meaning that /b/ would be taught via rote learning of syllables such as *ba*, *be*, *bi*, *bo*, *bu* (De Vos et al., 2015). This grapho-syllabic approach is also used in literacy instruction in other languages with simple syllables, such as Spanish (Martínez & Goikoetxea, 2020; C. Snow, 2015) and Brazilian Portuguese (Sargiani et al., 2021). Nurturing learners' ability to detect sounds at the phoneme level is important, as it enhances children's ability to form phoneme-grapheme mappings. For example, Sargiani et al. (2021) found that Brazilian

Portuguese nonreaders who were trained using a grapheme-phoneme approach to read syllables outperformed both a group of learners trained via a grapho-syllabic approach to read syllables and a group of learners taught isolated grapheme-phoneme without syllable reading instruction. Children in the grapheme-phoneme approach also reached the criterion level of performance faster than those in the grapho-syllabic group. We, therefore, argue that an integrated approach to literacy instruction should be developed for the consistently written languages in South Africa, with some time dedicated to systematic synthetic phonics teaching. This entails “that letter-sound correspondences and blending skills are taught early on and at a relatively fast pace so that children quickly have a method to read independently” (Logan & Johnston, 2010, p. 176).

While the pedagogical implications of underdeveloped PA are clear and have much support in literature, the pedagogical implications for slow naming speed are less clear, due to mixed evidence and a lack of theoretical clarity. The evidence to date indicates that children with slow naming speed can improve their naming speed over time (as there is a developmental trajectory), but their performance relative to peers of the same age will remain low (Åvall et al. 2019). Recent research suggests that early exposure to literacy can improve naming speed for young children (Peterson et al. 2018). Current understanding for pedagogical interventions for children with slow naming speed is that they require more than a phonological intervention. Multicomponent literacy instruction, which focuses the reader’s attention explicitly on the phonology, morphology, syntax, semantics and orthography of the language, is needed (Kirby et al. 2010; Norton & Wolf 2012), and such instruction should emphasize both fluency (especially repeated readings) and text comprehension (Wolf et al. 2009). Because of large class sizes, poor naming speed will be difficult to remediate in the classroom as part of ordinary instruction in the South African context. Still, if children at risk of reading failure could be identified by using screening tools which include measures of naming speed, such children should ideally receive individual remediation, and could be provided with additional repeated readings for homework. Existing screening tools, such as the Bellavista Dyslexia Screening Tool (Clark, Naidoo, & Lilenstein 2019), should therefore be updated to include RAN measures. Additionally, norms for naming speed should be determined so that they can inform screening (McWeeny et al., 2022).

Limitations

Our study has several strengths including multiple measures of PA, RAN, and word reading, the inclusion of both L1 and English variables, and the inclusion of three different groups of participants reading consistent orthographies measured at two points in time. This kind of research could be strengthened further through use of latent transition analysis to determine the probability of children remaining in or changing from one profile to another over the developmental period, such as Steacy et al. (2014) and Swanson (2017) have done. Additionally, it would have been insightful to determine what other factors, such as sex, SES and vocabulary knowledge, contributed to children's probability of being assigned to a profile. It would also be interesting to address how the profiles were related to other outcome variables, such as reading comprehension measured at a third point in time. Unfortunately, at the time of this writing, latent transition analysis and the analysis of covaries and distal outcomes was not supported in R (Bauer, 2019). Extracting the profile assignment directly from the model without some form of bias correction is not advised (Bakk & Kuha, 2021; Bauer, 2019). Finally, it was beyond the scope of this study to observe how literacy was instructed in the schools where the sample was selected. Because of these limitations, it is not possible to say whether SES status, hereditary factors, or instructional factors (or a combination of these) caused impaired PA and RAN abilities in the nonreaders. Future research could also assess learners before the start of formal literacy instruction so that a PA delay is no confounded with literacy instruction (Torppa et al., 2012).

Conclusion

This study presented bilingual phonological processing and reading data from readers of consistent (isiXhosa/isiZulu/Northern Sotho) and inconsistent (English) orthographies at two points in time, from low SES contexts. Despite differences in the first languages and when children were assessed, we found similarities in the number and characteristics of reading profiles. It is clear from our analysis that high levels of PA and RAN co-occur with (higher) L1 and English reading ability, supporting the universality of these phonological processing skills for reading development. In line with recent studies that utilized LPA, we found LPA to be a useful procedure to identify latent bilingual reading profiles in South African children, and similar analyses of larger data sets would benefit the development of targeted and scaled reading interventions. Our results emphasize the importance of regular and systematic instruction in the South African context. Since the African languages studied here are written transparently, regular phonics instruction will support children to map sounds onto graphemes early one, which will lead to successful decoding. Our data demonstrate that without adequate systematic reading instruction, a large proportion of children will be delayed in both their PA and reading skills. Despite these challenging circumstances, some children were able to learn to read, and future research could identify the supportive factors in these children's home and school environments that contributed to their success.

References

Ardington, C., Wills, G., & Kotze, J. (2021). COVID-19 learning losses: Early grade reading in South Africa. *International Journal of Educational Development*, *86*(July), 102480. https://doi.org/10.1016/j.ijedudev.2021.102480

Ardington, C., Wills, G., Pretorius, E. J., Mohohlwane, N., & Menendez, A. (2021). Benchmarking oral reading fluency in the early grades in Nguni languages. *International Journal of Educational Development*, *84*, 102433. https://doi.org/10.1016/j.ijedudev.2021.102433

Åvall, M., Wolff, U., & Gustafsson, J. E. (2019). Rapid automatized naming in a developmental perspective between ages 4 and 10. *Dyslexia*, *25*(4), 360–373. https://doi.org/10.1002/dys.1631

Bakk, Z., & Kuha, J. (2021). Relating latent class membership to external variables: An overview. *British Journal of Mathematical and Statistical Psychology*, *74*(2), 340–362. https://doi.org/10.1111/bmsp.12227

Bauer, J. (2019). *A primer to latent profile and latent class analysis*. 0–1.

Bishop, D. V. M. (2006). EPS mid-career award 2005: Developmental cognitive genetics: How psychology can inform genetics and vice versa. *Quarterly Journal of Experimental Psychology*, *59*(7), 1153–1168. https://doi.org/10.1080/17470210500489372

Castles, A., & Coltheart, M. (2004). Is there a causal link from phonological awareness to success in learning to read? *Cognition*, *91*(1), 77–111. https://doi.org/10.1016/S0010-0277(03)00164-1

Cilliers, J., Fleisch, B., Kotze, J., Mohohlwane, N., Taylor, S., & Thulare, T. (2022). Can virtual replace in-person coaching? Experimental evidence on teacher professional development and student learning. *Journal of Development Economics*, *155*(January 2021), 102815. https://doi.org/10.1016/j.jdeveco.2021.102815

Clark, A., Naidoo, K., & Lilenstein, A. (2019). Adapting a screening tool for dyslexia in isiXhosa. *Reading & Writing*, *10*(1), 1–10. https://doi.org/https://doi.org/10.4102/rw.v10i1.235

de Groot, B. J. A., van den Bos, K. P., Minnaert, A. E. M. G., & van der Meulen, B. F. (2015). Phonological Processing and Word Reading in Typically Developing and Reading Disabled Children: Severity Matters. *Scientific Studies of Reading*, *19*(2), 166–181. https://doi.org/10.1080/10888438.2014.973028

De Vos, M., Van der Merwe, K., & Van der Mescht, C. (2015). A Linguistic Research Programme for Reading in African Languages to underpin CAPS. *Journal for Language Teaching*, *48*(2), 148. https://doi.org/10.4314/jlt.v48i2.7

Department of Basic Education, & University of the Witwatersrand. (2020). *Early grade reading study 2019, Wave 4*. DataFirst. https://doi.org/10.25828/h109-3y92

Diemer, M. (2016). *The contributions of phonological awareness and naming speed to the reading fluency, accuracy, comprehension and spelling of Grade 3 isiXhosa reader*. Rhodes University.

Diuk, B., Barreyro, J. P., Ferroni, M., Mena, M., & Serrano, F. (2019). Reading Difficulties in Low-SES Children: A Study of Cognitive Profiles. *Journal of Cognition and Development*, *20*(1), 75–95.

https://doi.org/10.1080/15248372.2018.1545656

Dubeck, M. M., & Gove, A. (2015). The early grade reading assessment (EGRA): Its theoretical foundation, purpose, and limitations. *International Journal of Educational Development*, *40*, 315–322. https://doi.org/10.1016/J.IJEDUDEV.2014.11.004

Ehri, L. C. (2020). The Science of Learning to Read Words: A Case for Systematic Phonics Instruction. *Reading Research Quarterly*, 1–16. https://doi.org/10.1002/rrq.334

Forum for Research in Literacy and Language Institute of Education. (2012). *Diagnostic Test of Word Reading Processes*. GL Assessment Limited.

Georgiou, G. K., Parrila, R., & Papadopoulos, T. C. (2016). The anatomy of the RAN-reading relationship. *Reading and Writing*, *29*(9), 1793–1815. https://doi.org/10.1007/s11145-016-9653-9

Gutiérrez, N., Rigobon, V. M., Marencin, N. C., Edwards, A. A., Steacy, L. M., Compton, D. L., Gutiérrez, N., Rigobon, V. M., Marencin, N. C., & Edwards, A. A. (2022). Scientific Studies of Reading Early Prediction of Reading Risk in Fourth Grade : A Combined Latent Class Analysis and Classification Tree Approach Early Prediction of Reading Risk in Fourth Grade : A Combined. *Scientific Studies of Reading*, *00*(00), 1–18. https://doi.org/10.1080/10888438.2022.2121655

Hickendorff, M., Edelsbrunner, P. A., McMullen, J., Schneider, M., & Trezise, K. (2018). Informative tools for characterizing individual differences in learning: Latent class, latent profile, and latent transition analysis. *Learning and Individual*

Differences, *66*(October 2017), 4–15. https://doi.org/10.1016/j.lindif.2017.11.001

Holopainen, L., Hoang, N., Koch, A., & Kofler, D. (2020). Latent profile analysis of students' reading development and the relation of cognitive variables to reading profiles. *Annals of Dyslexia*, *70*(1), 94–114. https://doi.org/10.1007/s11881-020-00196-9

Hunt, G. (2007). Failure to thrive? The community literacy strand of the Additive Bilingual Project at an Eastern Cape Community School, South Africa. *Journal of Research in Reading*, *30*(1), 80–96. https://doi.org/10.1111/j.1467-9817.2006.00327.x

Johnson, S. K. (2021). Latent profile transition analyses and growth mixture models: A very non-technical guide for researchers in child and adolescent development. *New Directions for Child and Adolescent Development*, *2021*(175), 111–139. https://doi.org/10.1002/cad.20398

Kirby, J. R., Georgiou, G. K., Martinussen, R., Parrila, R., Bowers, P., & Landerl, K. (2010). Naming Speed and Reading: From Prediction to Instruction. *Reading Research Quarterly*, *45*(3), 341–362. https://doi.org/10.1598/rrq.45.3.4

Landerl, K., Castles, A., & Parrila, R. (2022). Cognitive Precursors of Reading: A Cross-Linguistic Perspective. *Scientific Studies of Reading*, *26*(2), 111–124. https://doi.org/10.1080/10888438.2021.1983820

Logan, S., & Johnston, R. (2010). Investigating gender differences in reading. *Educational Review*, *62*(2), 175–187. https://doi.org/10.1080/00131911003637006

Lovett, M. W., Frijters, J. C., Wolf, M., Steinbach, K. A., Sevcik, R. A., & Morris, R.

D. (2017). Early intervention for children at risk for reading disabilities: The impact of grade at intervention and individual differences on intervention outcomes. *Journal of Educational Psychology*, *109*(7), 889–914. https://doi.org/10.1037/edu0000181

Makaure, P. (2021). *The contribution of phonological processing skills to early literacy development in Northern Sotho-English bilingual children - A longitudinal investigation* [University of South Africa]. https://uir.unisa.ac.za/handle/10500/28389

Malda, M., Nel, C., & van de Vijver, F. J. R. (2014). The road to reading for South African learners: The role of orthographic depth. *Learning and Individual Differences*, *30*, 34–45. https://doi.org/10.1016/j.lindif.2013.11.008

Martínez, N., & Goikoetxea, E. (2020). Predictors of Reading and Spelling Words Change as a Function of Syllabic Structure in Spanish. *Psicologia Educativa*, *25*(2), 37–48.

McWeeny, S., Choi, S., Choe, J., LaTourrette, A., Roberts, M. Y., & Norton, E. S. (2022). Rapid Automatized Naming (RAN) as a Kindergarten Predictor of Future Reading in English: A Systematic Review and Meta-analysis. *Reading Research Quarterly*, 1–25. https://doi.org/10.1002/rrq.467

Menendez, A., & Ardington, C. (2018). *Impact Evaluation of USAID/South Africa Story Powered School Program - Baseline* (Issue August). https://nalibali.org/sites/default/files/media/rsa_sps_baseline_report_final_public.pdf

Mohohlwane, N., Ardington, C., Wills, G., Sebaeng, M. L., Zwane, Z., Pooe, E., Ramagoshi, R., Makgabo, C., Maledu, A., Ramabenyane, M. J., Pretorius, E. J., Beggs, C., & Jodar, P. (2022). *Sesotho-Setswana Early Grade Reading Benchmarks Report*. https://www.education.gov.za/Resources/Reports.aspx

Nag, S., & Snowling, M. J. (2011). Cognitive profiles of poor readers of Kannada. *Reading and Writing*, *24*(6), 657–676. https://doi.org/10.1007/s11145-010-9258-7

Newman, E. H., Tardif, T., Huang, J., & Shu, H. (2011). Phonemes matter: The role of phoneme-level awareness in emergent Chinese readers. *Journal of Experimental Child Psychology*. https://doi.org/10.1016/j.jecp.2010.09.001

Norton, E. S., & Wolf, M. (2012). Rapid Automatized Naming (RAN) and Reading Fluency: Implications for Understanding and Treatment of Reading Disabilities. *Annual Review of Psychology*, *63*(1), 427–452. https://doi.org/10.1146/annurev-psych-120710-100431

Nurse, D., & Philippson, G. (2003). Introduction. In D. Nurse & G. Philippson (Eds.), *The Bantu Languages* (pp. 1–12). Routledge.

Ozernov-Palchik, O., Norton, E. S., Sideridis, G., Beach, S. D., Wolf, M., Gabrieli, J. D. E., & Gaab, N. (2017). Longitudinal stability of pre-reading skill profiles of kindergarten children: implications for early screening and theories of reading. *Developmental Science*, *20*(5), 1–18. https://doi.org/10.1111/desc.12471

Papadopoulos, T. C., Georgiou, G. K., & Kendeou, P. (2009). Investigating the double-deficit hypothesis in Greek: Findings from a longitudinal study. *Journal of Learning Disabilities*, *42*(6), 528–547. https://doi.org/10.1177/0022219409338745

Parrila, R., Dudley, D., Song, S., & Georgiou, G. K. (2020). A meta-analysis of reading-level match dyslexia studies in consistent alphabetic orthographies. *Annals of Dyslexia*, *70*(1), 1–26. https://doi.org/10.1007/s11881-019-00187-5

Peterson, R. L., Arnett, A. B., Pennington, B. F., Byrne, B., Samuelsson, S., & Olson, R. K. (2018). Literacy acquisition influences children's rapid automatized naming. *Developmental Science*, *21*(3), e12589. https://doi.org/10.1111/desc.12589

Pretorius, E. J., & Currin, S. (2010). Do the rich get richer and the poor poorer?. The effects of an intervention programme on reading in the home and school language in a high poverty multilingual context. *International Journal of Educational Development*, *30*(1), 67–76. https://doi.org/10.1016/j.ijedudev.2009.06.001

R Core Team. (2021). *R: A language and environment for statistical computing*. https://www.r-project.org/

Rosenberg, J. M., Beymer, P. N., Anderson, D. J., Van Lissa, C. J., & Schmidt, J. A. (2018). tidyLPA: An R Package to Easily Carry Out Latent Profile Analysis (LPA) Using Open-Source or Commercial Software. *Journal of Open Source Software*, *3*(30), 978. https://doi.org/10.21105/joss.00978

Sargiani, R. de A., Ehri, L. C., & Maluf, M. R. (2021). Teaching Beginners to Decode Consonant–Vowel Syllables Using Grapheme–Phoneme Subunits Facilitates Reading and Spelling as Compared With Teaching Whole-Syllable Decoding. *Reading Research Quarterly*, 1–20. https://doi.org/10.1002/rrq.432

Schaefer, M., Probert, T., & Rees, S. (2020). The roles of phonological awareness, rapid automatised naming and morphological awareness in isiXhosa. *Per Linguam*, *36*(1), 90–111. https://doi.org/10.5785/36-1-878

Schatschneider, C., Fletcher, J. M., Francis, D. J., Carlson, C. D., & Foorman, B. R. (2004). Kindergarten prediction of reading skills: A longitudinal comparative analysis. *Journal of Educational Psychology*, *96*(2), 265–282. https://doi.org/10.1037/0022-0663.96.2.265

Schroeder, L. (2013). Teaching and assessing independent reading skills in multilingual African Countries: Not as simple as ABC. In *Language Issues in Comparative Education* (pp. 243–264). Brill. https://brill.com/view/book/edcoll/9789462092181/BP000015.xml

Scrucca, L., Fop, M., Murphy, T. B., & Raftery, A. E. (2016). {mclust} 5: clustering, classification and density estimation using {G}aussian finite mixture models. *The {R} Journal*, *8*(1), 289–317. https://doi.org/10.32614/RJ-2016-021

Seymour, P. H. K., Aro, M., Erskine, J. M., Wimmer, H., Leybaert, J., Elbro, C., Lyytinen, H., Gombert, J. E., Le Normand, M. T., Schneider, W., Porpodas, C., Ragnarsdottir, H., Tressoldi, P., Vio, C., De Groot, A., Licht, R., Iønnessen, F. E., Castro, S. L., Cary, L., … Olofsson, Å. (2003). Foundation literacy acquisition in European orthographies. *British Journal of Psychology*, *94*(2), 143–174. https://doi.org/10.1348/000712603321661859

Snow, C. (2015). Early literacy development and instruction: An overview. In M. Kucirkova, C. Snow, V. Grøver, & C. McBride-Chang (Eds.), *The Routledge International Handbook of Early Literacy Education : A contemporary guide to literacy teaching and interventions in a global contextducation : A contemporary guide to literacy teaching and interventions in a global context* (pp. 5–13). Routledge.

Snow, C. E., Burns, M., & Griffin, P. (1998). *Preventing reading difficulties in young children: Committee on the prevention of reading difficulties in young children*. National Research Council.

Spaull, N., Pretorius, E. J., & Mohohlwane, N. (2020). Investigating the comprehension iceberg: Developing empirical benchmarks for early grade reading in agglutinating African languages. *South African Journal of Childhood Education, 10*(1), a773. https://doi.org/10.4102/sajce.v10i1.773

Steacy, L. M., Kirby, J. R., Parrila, R., & Compton, D. L. (2014). Classification of Double Deficit Groups Across Time: An Analysis of Group Stability From Kindergarten to Second Grade. *Scientific Studies of Reading*, *18*(4), 255–273. https://doi.org/10.1080/10888438.2013.873936

Swanson, H. L. (2017). A Latent Transition Analysis of English Learners With Reading Disabilities. *Topics in Language Disorders, 37*(2), 114–135. https://doi.org/10.1097/TLD.0000000000000117

Taylor, S., Cilliers, J., Prinsloo, C., Fleisch, B., & Reddy, V. (2017). *The Early Grade Reading Study: Impact evaluation after two years of interventions*. *October*. https://www.jet.org.za/clearinghouse/projects/primted/resources/language-and-literacy-resources-repository/egrs-technical-report-13-oct-2017.pdf

Torppa, M., Georgiou, G. K., Salmi, P., Eklund, K., & Lyytinen, H. (2012). Examining the Double-Deficit Hypothesis in an Orthographically Consistent Language. *Scientific Studies of Reading*, *16*(4), 287–315. https://doi.org/10.1080/10888438.2011.554470

Torppa, M., Parrila, R., Niemi, P., Lerkkanen, M. K., Poikkeus, A. M., & Nurmi, J. E.

(2013). The double deficit hypothesis in the transparent Finnish orthography: A longitudinal study from kindergarten to Grade 2. *Reading and Writing*, *26*(8), 1353–1380. https://doi.org/10.1007/s11145-012-9423-2

Vaessen, A., Gerretsen, P., & Blomert, L. (2009). Naming problems do not reflect a second independent core deficit in dyslexia: Double deficits explored. *Journal of Experimental Child Psychology*, *103*(2), 202–221. https://doi.org/10.1016/j.jecp.2008.12.004

Valencia, R. R. (2010). Dismantling contemporary deficit thinking: Educational thought and practice. In *Dismantling Contemporary Deficit Thinking: Educational Thought and Practice*. https://doi.org/10.4324/9780203853214

Verwimp, C., Vanden Bempt, F., Kellens, S., Economou, M., Vandermosten, M., Wouters, J., Ghesquière, P., & Vanderauwera, J. (2020). Pre-literacy heterogeneity in Dutch-speaking kindergartners: latent profile analysis. *Annals of Dyslexia*, *70*(3), 275–294. https://doi.org/10.1007/s11881-020-00207-9

Wills, G., Ardington, C., Pretorius, E. J., Pooe, E., Ramagoshi, R., & Sebaeng, M. L. (2022). *Benchmarking early grade reading skills in South Africa: Technical Report English First Additional Language*. https://www.education.gov.za/Resources/Reports.aspx

Wilsenach, C. (2013). Phonological skills as predictor of reading success: An investigation of emergent bilingual Northern Sotho/English learners. *Per Linguam*, *29*(2), 17–32. https://doi.org/10.5785/29-2-554

Wilsenach, C. (2019). Phonological awareness and reading in Northern Sotho – Understanding the contribution of phonemes and syllables in grade 3 reading attainment. *South African Journal of Childhood Education*, *9*(1), 1–10. https://doi.org/10.4102/sajce.v9i1.647

Wimmer, H., Mayringer, H., & Landerl, K. (2000). The double-deficit hypothesis and difficulties in learning to read a regular orthography. *Journal of Educational Psychology*, *92*(4), 668–680. https://doi.org/10.1037/0022-0663.92.4.668

Wolf, M., Barzillai, M., Gottwald, S., Miller, L., Spencer, K., Norton, E. S., Lovett, M., & Morris, R. (2009). The RAVE-O intervention: Connecting neuroscience to the classroom. *Mind, Brain, and Education*, *3*(2), 84–93. https://doi.org/10.1111/j.1751-228X.2009.01058.x

Wolf, M., & Bowers, P. G. (1999). The double-deficit hypothesis for the developmental dyslexias. *Journal of Educational Psychology*. https://doi.org/10.1037/0022-0663.91.3.415

Ziegler, J. C., & Goswami, U. (2005). Reading acquisition, developmental dyslexia, and skilled reading across languages: A psycholinguistic grain size theory. *Psychological Bulletin*, *131*(1), 3–29. https://doi.org/10.1037/0033-2909.131.1.3