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Instruction influences cross-language transfer of reading skills: evidence from a longitudinal randomized controlled trial

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Abstract

Longitudinal data from the Early Grade Reading Study (EGRS I) in South Africa ($N = 4538$) were used to examine the role of instructional contexts in the relations of literacy skills between children's home language (L1 Setswana) and a second language (L2 English). All children received literacy instruction in Setswana in Grades 1 to 3. However, children in the treatment condition were provided with explicit and systematic Setswana language instruction in phonological awareness and phonics ($n = 1964$), whereas those in comparison condition received business-as-usual instruction ($n = 2574$). Children's literacy skills were assessed four times: Time 1 in the beginning of Grade 1, Time 2 at the end of Grade 1, Time 3 at the end of Grade 2, and Time 4 at the end of Grade 4. Literacy data in Setswana were collected in all four time points, whereas data in English were collected in Times 3 and 4. Results from confirmatory factor analysis and structural equation modeling showed that L1 Setswana literacy skill strongly predicted concurrent L2 English reading skill across instructional contexts. However, the longitudinal relation from Grade 2 Setswana literacy skill to Grade 4 English reading skill was found only for those in the treatment condition, but not for those in the comparison condition, after accounting for concurrent relations between Setswana and English. These results suggest that instructional contexts in L1 have implications for the nature relations between L1 and L2 literacy skills.

Keywords Crosslinguistic relations · Developmental interdependence · Transfer · South Africa · Reading

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Introduction

Literacy acquisition in L2 does not occur in a vacuum. According to the developmental interdependence hypothesis (Cummins, 1979), L2 skill is partially a function of the child's L1 skill before exposure to L2 begins. In other words, individuals use their knowledge and skill developed in L1 literacy acquisition for their L2 literacy acquisition. If this is the case, L1 literacy and L2 literacy skills should be related. Indeed, studies have shown the relation between L1 and L2 reading skills (e.g., Baker et al., 2011; Cummins, 1979; Kim & Piper, 2019; Manis et al., 2004; Proctor et al., 2006; Skutnabb-Kangass & Toukomaa, 1976; Wang et al., 2006, 2009). In the present study, our goal was to extend prior work by examining the relation between L1 (Setswana) and L2 (English) literacy skills, and the role of instructional contexts in the L1-L2 relations, using data from a large-scale randomized controlled trial in South Africa.

All writing systems encode the language system although details of encoding vary across writing systems and orthographies (e.g., which phonological units map onto graphic symbols; Perfetti, 2003). Therefore, learning to read in multiple languages requires an understanding of general mapping principle between "a language and the writing system that encodes the language" (p. 12), a language-general aspect, as well as language-specific constraints on mapping details (Koda, 2007). According to Cummins (1979), L1 and L2 literacy skills are related because they draw on shared underlying competencies. Underlying competencies differ depending on reading sub-skills such as word reading and reading comprehension. Specifically, for development of word reading skill, one's knowledge and awareness of phonology, orthography, and morphology are crucial (Adams, 1990; Rayner et al., 2001; Seidenberg, 2005). Reading comprehension is supported by a complex set of language and cognitive skills and knowledge beyond word reading, including vocabulary, syntactic knowledge, listening comprehension, topic/content knowledge, world knowledge, discourse knowledge, executive function such as working memory, inhibitory and attentional control, and shifting, higher order cognitive skills and regulation such as inference, reasoning, perspective taking, and comprehension monitoring, and social-emotional aspects such as attitude and motivation (e.g., Ahmed et al., 2016; Cain et al., 2004; Cromley & Azevedo, 2007; Kim, 2017, 2020). Of these, certain skills and knowledge are posited to transfer across languages such that once these skills are developed in a language (e.g., L1), they are available for and facilitate L2 literacy acquisition (Koda, 2007). One such example is metalinguistic insights about functions of print such as the alphabetic principle and structure of speech sounds (phonological awareness) and meaning (e.g., morphemes)—a recognition and insights about how language elements (speech sounds and meaning elements) are encoded in the writing system (Koda, 2007; Perfetti, 2003). A robust body of correlational studies has shown that metalinguistic awareness such as phonological awareness transfers across languages (e.g., Spanish–English, French–English, Arabic–English, Chinese–English, Korean–English, Hindi–English; Abu-Rabia & Siegel, 2002; Barnum-Martin et al., 2012; Comeau et al., 1999; Durgunoglu et al., 1993; Kim,

2009; Melby-Lervåg & Lervåg, A., 2011; Patel et al., 2022; Wang et al., 2006, 2009). Beyond correlational data, causal evidence indicates transfer: instruction of phonological awareness and alphabetic principle in L1 improves phonological awareness and alphabetic principle in L2 as well as in L1, which, in turn, improves word reading in L2 (Vaughn et al., 2006; Wawire & Kim, 2018). Additionally, crosslinguistic relations have been also found for metalinguistic awareness of morphology and orthography (Ke & Xiao, 2015; Ramirez et al., 2013; Saiegh-Haddad & Geva, 2008; Wang et al., 2006, 2009). Beyond metalinguistic awareness, evidence also suggests that higher order skills such as story comprehension and retelling (Cenoz, 2003; Proctor et al., 2006), and higher order cognitive skills such as inferencing, perspective taking, and comprehension monitoring are crosslinguistically related (Kim et al., 2022).

As noted above, prior literacy learning in L1 is expected to influence L2 literacy learning (Cummins, 1979; Koda, 2007). Then, instructional contexts or nature of literacy instruction in L1 may impact the nature of L1-L2 relations. If literacy instruction in L1 systematically and explicitly targets key underlying skills and knowledge that are important for literacy acquisition such as metalinguistic awareness (e.g., phonological awareness, alphabetic principle) and metalinguistic awareness transfers crosslinguistically, then children are more likely to use these underlying skills in their L2 literacy acquisition. Therefore, whether or not reading and its underlying skills are explicitly and systematically taught would influence L1-L2 relations. To our knowledge, this question has been scarcely addressed. An exception is a recent study using longitudinal data for primary grade children in Kenya learning to read in Kiswahili and English (Kim & Piper, 2019). In this study, children in the treatment condition received explicit and systematic instruction on phonological awareness, phonics, and decoding in Kiswahili and English whereas children in the comparison or business-as-usual condition did not have such instruction, and instead learned to read by memorizing whole words (a whole word approach). Results overall showed bidirectional relations between L1 and L2 skills including phonological awareness, letter sound knowledge, decoding, and reading fluency skills. Importantly, there was some support for the impact of instructional conditions on the nature of L1–L2 relations—bidirectional relations in letter sound fluency between Kiswahili and English were found only for children who received explicit and systematic instruction (i.e., treatment condition), but not for those in the comparison/counterfactual condition.

The present study builds on prior work and expands our understanding of the role of instructional context in L1–L2 relations by utilizing a large-scale randomized control trial in South Africa. Specifically, teachers in treatment condition received professional development and instructional materials to support explicit and systematic instruction in phonological awareness and phonics in Setswana (a familiar language or L1) whereas those in the comparison condition did not. Therefore, if there were differential relations in L1-L2 relations as a function of treatment conditions, we can infer the role of explicit and systematic instruction in L1 Setswana in L2 English acquisition. It is important that this study design differs from that of Kim and Piper's (2019) research, where explicit and systematic instruction was provided in a familiar language (L1, Kiswahili) *and* in a less familiar language (L2, English).

Characteristics of and literacy development in Setswana

The languages in South Africa employ alphabetic writing systems and are classified into three broad categories: the West-Germanic Indo-European languages, South African Sign Language, and Southern Bantu languages. Southern Bantu languages, representing the majority, are known for their agglutinating nature, often referred to as 'African languages.' Setswana is a Southern Bantu language that is spoken in Southern Africa. It is one of the eleven official languages of South Africa and a lingua franca in Botswana (Lekgoko & Winskel, 2008; Probert, 2019). Setswana forms part of the three languages known as the Sesotho-Setswana language group, the others are Sesotho, the lingua franca of Lesotho, as well as Sepedi spoken mostly in the Northern part of South Africa. Similar to other Bantu languages, words in Setswana are composed of open syllables with consonant clusters allowed (e.g., CCV, CCCV). Like English, Setswana employs the Roman alphabet letters. Unlike English, however, grapheme-phoneme correspondences in Setswana are highly transparent (see Lekgoko & Winskel, 2008 for details). Setswana has a small vowel system with 7 vowels (sounds), unlike English which has approximately 20 different vowel sounds depending on dialectal varieties. Setswana has a large code set that includes simple and more complex consonants, digraphs, trigraphs and complex consonant clusters.

Instruction in the foundation phase (Reception year, which is equivalent to kindergarten in the US, to Grade 3) takes an additive bilingualism approach for learners. Throughout the foundation phase, home language is used as the medium of instruction, while English as First Additional Language is taught alongside learners' home language. The time allocation for home language is significant, amounting to 7–8 h a week, and 2 or 3 h for English. According to the South African Foundation Phase Curriculum and Assessment Policy Statement implemented since 2012, building a base in L1 (home language) is expected to lead to stronger acquisition of L2 (English). In the majority of schools, English then becomes the medium of instruction beginning in Grade 4.

Literature on reading development and precursors of reading in Setswana is convergent with previous studies in languages other than Setswana. Phonological awareness, word reading, text reading fluency, and reading comprehension in Setswana were moderately to strongly related for third graders in South Africa (Malda et al., 2014). Similarly, phonological awareness was moderately related to text reading fluency for fourth graders (Probert, 2019). With regard to L1-L2 relations, reading skills in Setswana and English were related: Pseudoword reading in Setswana was strongly related with word reading in English ($r = .73$) and phonological awareness in Setswana was moderately related with word reading and pseudoword reading in English for second graders in Botswana (Lekgoko & Winskel, 2008). More recently, Makaure (2021) examined the contribution of phonological skills to literacy acquisition in both Setswana and English emergent bilingual children. The strongest predictors of literacy skills for both Setswana and English were phonological awareness and rapid object naming, and phonological awareness was also the strongest cross-linguistic predictor of literacy skills. Please see Spall and Pretorious (2022) for details on early grade reading achievement in South Africa.

Present study

By now, a rich body of literature indicates that L1 reading and L2 reading skills are related (see above). However, our understanding of L1-L2 relations as a function of instructional contexts is limited. The present study fills this gap and is guided by the following research questions: How is L1 Setswana literacy skill from Grade 1 to Grade 4 related to L2 English reading skill in Grades 2 and 4 for children in South Africa? Do the relations vary by instructional context (treatment conditions)? These questions were addressed by using a large-scale randomized control trial where children in treatment conditions were exposed to 3 years of systematic and explicit instruction on reading, whereas children in a third treatment arm and under the comparison condition received business-as-usual instruction (see below for details). These children were followed longitudinally from Grade 1 to Grade 4. We posited that literacy skill in Setswana would predict literacy skill in English and the relation might be stronger for children who received higher-quality systematic and explicit literacy instruction in Setswana.

Note that the focus of the present study is *not* about the treatment effect itself (please see Taylor et al., 2019 for details regarding the treatment effect). Rather, the central focus of this study was to examine how treatment status or instructional context impacts L1-L2 relations.

Methods

Participants

Data were from a large-scale randomized control trial involving 4538 children (2244 boys, 1953 girls, and 341 children missing information on biological sex) in the North West province of South Africa (Taylor et al., 2019). The province comprises rural areas, where many families had lower economic means compared to the other regions in South Africa. In addition, Setswana is used relatively homogenously as home language in this region compared to other regions (see Taylor et al., 2019 for greater details). Random assignment was conducted at the school level: the study included 230 schools, which were randomly assigned within strata that consider school size, socioeconomic status, and pervious performance on the national standardized exam. Of the 230 schools, 50 schools were in teacher training, coaching, and parent involvement treatment conditions, respectively, and 80 schools in the comparison/business-as-usual condition. Twenty students within a school were randomly selected for assessment. Children's average age in the beginning of Grade 1 was 6.47 years ($SD = .70$, minimum = 4.42, maximum = 10.08). The large range in the children's age is not atypical in the South African context. Children's literacy skills were assessed at four time points: Time 1 at the beginning of Grade 1, Time 2 at the end of Grade 1, Time 3 at the end of Grade 2, and Time 4 at the end of Grade 4.

There were four conditions: (1) a teacher training intervention (3 years), (2) an on-site training and coaching intervention (3 years), (3) a parental involvement intervention (2 years), and (4) a business-as-usual control condition. Literacy instruction

in all conditions was provided in Setswana in Grades 1 to 3 (with English as a first additional language as a subject), followed by a year of English as a language of instruction in Grade 4. Teachers in both intervention 1 (i.e. training) and intervention 2 (i.e. coaching) received scripted daily lesson plans aligned to the South African Foundation Phase Curriculum and Assessment Policy Statement, learning and teaching support materials which were integrated into the lesson plans (e.g. the Department of Basic Education workbooks, graded reading booklets, flashcards, etc.), as well as teacher training on the use of lesson plans and materials in the classroom (centralized training for two days twice per year for the training intervention; cluster training for one day four times per year for the coaching intervention). Teachers in the coaching condition received ongoing on-site coaching monthly visits, in addition to occasional needs-based trainings. The parental involvement condition did not involve teacher training or lesson materials but involved weekly parent meetings where information was shared on early grade reading and ways for parents to be involved in their child's literacy development. These sessions were led by Community Reading Coaches, who were identified from each school's community with support from the school principal. In-school instruction remained the same as the business-as-usual control condition. Since the parental involvement condition was not found to be effective in improving learning outcomes by the end of Grade 2, the intervention was stopped after 2 years. The control condition was a business-as-usual condition. Instruction under this condition was intended to align with the South African Foundation Phase Curriculum and Assessment Policy Statement but did not include the structured support and instructional materials provided to teachers under the training and coaching conditions. However, more than half of the teachers in this condition reported receiving some form professional development support on Setswana literacy instruction (not the explicit and systematic phonological awareness and phonics instruction in the treatment condition), while all teachers were also expected to receive support visits from district level subject advisors.

As noted above, treatment conditions (1) to (3) were implemented in Grade 1 and Grade 2, and the treatment conditions (1) and (2) continued in Grade 3. There was no treatment in Grade 4. In the present study, children in the conditions (1) and (2), and those in the conditions (3) and (4) were combined, respectively, because previous analysis showed no effect of the parental involvement intervention (condition 3) such that children's performance in conditions (3) and (4) did not differ whereas there were positive effects of conditions (1) and (2) (Taylor et al., 2019). Therefore, conditions (1) and (2), and conditions (3) and (4) were considered as the treatment condition and the comparison condition, respectively, in the present study. Table 1 shows the number of children in different conditions in the original study and in the present data analysis.

Implementation fidelity and quality were measured in two ways: the first was surveys administered to all schools; the second was classroom observations of randomly selected 20 schools per treatment conditions. Of the 20 schools in each condition, six were urban schools, five were high-performing schools and five were low-performing schools in midline assessment, and four schools had high learning gains between the baseline and midline assessments. The classroom observation study was conducted in the fourth term in October 2016, which was the second year of

Table 1 Sample sizes for different conditions in the original evaluation study and in the present analysis (total N = 4538)

Original conditions	*n*	Conditions in the present study	*n*
1. Training	983	Treatment	1964
2. Coaching	981	Treatment	
3. Parents	999	Comparison	2574
4. Control	1575	Comparison	

implementation. Observations were conducted in grade 2, the grade of direct implementation in that year. Appendix 1 provides a summary of key fidelity findings (see Cilliers et al., 2019 for details).

Measures

Assessments were developed and adapted to be appropriate for the grade. All instruments were piloted and adjusted through several iterations. For example, the length of reading passages and comprehension questions were adjusted based on a pilot study. Whereas some tasks such as letter sound identification and word reading were measured consistently across the times, other measures changed slightly over time considering and reflecting developmental changes. For example, phonological awareness is a key precursor skill of an early reading skill, word reading, and therefore was measured in Times 1, 2, and 3 (Grades 1 and 2) but not in Time 4 (end of Grade 4). Similarly, children's oral reading fluency and passage reading comprehension are higher order reading skills, and were measured beginning in Time 2 (end of Grade 1). Measures in Setswana were administered in all time points whereas measures in English were administered for Times 3 and 4, in order to measure the spillover effects of Setswana instruction on English in later grades. The number of items in each task is shown in Table 2. All items were scored dichotomously (1 = correct; 0 = incorrect).

Time 1 (beginning of grade 1)

Measures included phonological awareness, letter sound knowledge, word reading, sentence reading, and sentence comprehension in Setswana. In the phonological awareness task, the child was asked to segment words into phonemes, and to provide a word that starts with the same syllable (e.g., sega; seba) and ends with the same syllable (e.g., yona; bana). Cronbach's alpha was .90. In the letter sound knowledge task, the child was shown a series of randomly ordered alphabet letters, and was asked to provide the sound that each letter represents within a minute. In the word reading task, the child was shown a list of words that were composed of single syllable, two-syllable, and three-syllable words—the vast majority of items were monosyllabic and disyllabic words—and they were asked to read aloud each word accurately and rapidly within a minute. In the sentence reading and sentence comprehension tasks, the child was shown three short sentences and was asked to

Table 2 Descriptive statistics

		Comparison condition						Treatment condition					
Variable**	# of Items	*N*	M	SD	Max	Skewness	Kurtosis	*N*	M	SD	Max	Skewness	Kurtosis
Time 1													
Phonological awareness	12	2574	2.33	3.19	12.00	1.53	1.56	1964	1.96	2.99	12.00	1.73	2.31
Letter sound identification**	110	2574	5.15	10.40	94.00	4.40	24.60	1964	4.99	8.88	99.00	3.82	21.75
Word reading**	50	2574	2.02	5.53	50.00	5.00	28.70	1964	1.75	4.82	50.00	5.66	40.09
Sentence reading	3+	2574	1.24	3.52	15.00	3.22	9.23	1964	1.19	3.19	15.00	3.48	11.75
Sentence comprehension	3	2574	0.67	1.20	3.00	1.32	−0.15	1964	0.81	1.29	3.00	1.03	−0.86
Time 2													
Phonological awareness	6	2345	0.63	1.13	4.00	1.72	1.74	1798	0.80	1.23	4.00	1.34	0.43
Letter sound identification**	110	2345	21.96	22.14	110.00	1.04	0.51	1798	23.61	21.22	110.00	0.78	−0.03
Word reading**	50	2345	6.84	10.04	50.00	2.00	3.63	1798	6.97	9.66	50.00	1.91	3.36
Nonword reading**	50	2345	4.24	7.98	50.00	2.01	3.56	1798	4.73	8.23	50.00	1.91	3.41
Sentence reading	2+	2345	3.92	4.56	11.00	0.55	−1.43	1798	4.32	4.61	11.00	0.37	−1.59
Oral reading fluency**	NA	2345	7.70	14.18	64.00	2.03	3.42	1799	8.30	14.01	62.00	1.85	2.63
Reading comprehension	6	2345	0.97	1.65	6.00	1.57	1.14	1798	1.01	1.67	6.00	1.54	1.11
Dictation	12	2345	5.66	3.36	12.00	0.01	−0.84	1798	6.17	3.43	12.00	−0.16	−0.78
Time 3													
Phonological awareness	3	2140	1.81	1.07	3.00	−0.36	−1.16	1641	1.85	1.08	3.00	−0.41	−1.15
Letter sound identification**	110	2140	38.91	26.92	110.00	0.20	−0.85	1641	40.30	25.64	110.00	0.04	−0.80
Word reading**	50	2140	18.57	16.92	50.00	0.47	−1.19	1641	20.54	16.96	50.00	0.27	−1.33
Nonword reading**	50	2140	13.57	13.78	50.00	0.51	−1.08	1641	15.45	13.75	50.00	0.28	−1.23
Oral reading fluency**	NA	2140	24.16	24.68	66.00	0.43	−1.38	1641	27.45	24.46	66.00	0.19	−1.50
Reading comprehension	4	2140	1.21	1.34	4.00	0.60	−1.04	1641	1.36	1.34	4.00	0.42	−1.21
Dictation	9	2140	5.90	2.32	9.00	−0.45	−0.47	1641	6.06	2.42	9.00	−0.68	−0.30
English word reading	8	2140	2.99	3.15	8.00	0.49	−1.45	1641	3.33	3.16	8.00	0.28	−1.58

Table 2 (continued)

Variable**	# of Items	Comparison condition						Treatment condition					
		N	M	SD	Max	Skewness	Kurtosis	*N*	M	SD	Max	Skewness	Kurtosis
Time 4													
Letter sound identification**	110	1846	40.39	20.21	105.00	0.10	−0.17	1455	41.91	19.72	104.00	0.04	0.02
Word reading**	70	1846	29.36	17.92	70.00	−0.23	−1.00	1455	31.93	17.25	70.00	−0.38	−0.76
Oral reading fluency 1**	NA	1846	46.56	33.56	159.00	0.37	−0.18	1455	51.92	33.09	159.00	0.23	−0.19
Oral reading fluency 2**	NA	1846	54.63	40.46	220.00	0.56	0.53	1455	58.74	38.48	220.00	0.36	0.21
Reading comprehension	8	1846	2.35	1.82	8.00	0.41	−0.28	1455	2.70	1.78	8.00	0.23	−0.12
English word reading**	104	1846	28.87	24.74	102.00	0.53	−0.69	1455	31.35	24.22	102.00	0.34	−0.81
English oral reading fluency**	NA	1846	38.01	37.38	142.00	0.74	−0.44	1455	40.52	36.03	142.00	0.56	−0.64
English reading comprehension	8	1846	1.25	1.82	8.00	1.53	1.48	1455	1.41	1.87	8.00	1.38	1.04

Minimum value was 0 for all variables

*Unless otherwise noted, measures were in Setswana. +There were three sentences: At Time 1, the three sentences were composed of 15 words and therefore total maximum possible score was 15 for each of the words. At Time 2, the two sentences were composed of 11 words and therefore total maximum possible score was 11

**indicates 1-min timed task; those without *are not timed tasks

read them aloud and was asked three comprehension questions. The score for sentence reading was the number of words read correctly, and comprehension score was the number of correct responses to comprehension questions.

Time 2 (end of grade 1)

Measures included phonological awareness, letter sound knowledge, word reading, sentence reading, nonword reading, text (oral) reading fluency, reading comprehension, and dictation in Setswana. The letter sound knowledge, and word reading, tasks were identical to Time 1. Sentence reading had the same format as Time 1 but it was composed of two sentences with a total of 11 words. Phonological awareness was measured by asking students to break down 6 words into their component parts ($\alpha = .80$). The nonword reading, text (oral) reading fluency, reading comprehension, and dictation measures were new in Time 2. In the nonword reading task, the child was shown a list of pseudowords, and was asked to read them aloud accurately and rapidly in a minute. In the text reading fluency task, the child was shown a passage and was asked to read it aloud as accurately and rapidly as possible. The number of words read correctly within a minute was the child's (fluency) score. After reading the passage, the child was asked comprehension questions ($\alpha = .80$). The dictation task had three parts ($\alpha = .74$): In the first part, the child heard the sound associated with a letter and was asked to write the letter (i.e., letter dictation), and heard a word and asked to write the heard word (word dictation); in the second part, the child was shown a single sentence with an accompanying illustration that had one missing word and was asked to fill in the blank (i.e., cloze); and in the last part, the child was a shown a four-word sentence, and was asked to correct the sentence using writing conventions (i.e., capitalization and a period).

Time 3 (end of grade 2)

Measures included phonological awareness, letter sound knowledge, word reading, nonword reading, sentence reading, text (oral) reading fluency, reading comprehension, and dictation in Setswana. In addition, English word reading skill was measured. Letter sound knowledge task, word reading, and nonword reading tasks were identical to Time 2. The procedures for text reading fluency and reading comprehension were identical to Time 2, but and the same text with slight modifications was used. In the phonological awareness task, the child was asked to blend syllables (Cronbach's alpha = .58). In the dictation task, the procedures were identical to Time 2 but used different items. In the English reading task, the child was asked to read aloud words.

Time 4 (end of grade 4)

The following were measured in Setswana: letter sound knowledge, word reading, text (oral) reading fluency, and reading comprehension. The format of the tasks in Setswana was identical to Time 3 with minor modifications to the letter sound task with the inclusion of digraphs and trigraphs. Words in the word reading task

changed, text reading fluency was measured by two tasks, and reading comprehension was measured for the first text reading fluency task only (α = .74). In English, word reading, text (oral) reading fluency, and reading comprehension were measured. The format of these tasks was identical to those in Setswana. For English reading comprehension, Cronbach's alphabet was estimated to be .81.

Procedures

The assessments were administered individually. An exception was in Time 4 when reading comprehension assessments were conducted by class. There were 40 to 60 fieldworkers engaged across the assessment time points, all of whom had some postgraduate qualification. The duration of field worker training ranged from two days (Time 1) to five days (Time 3 and Time 4). Training included content of assessments, administration procedures, practices in pairs and groups, and logistics for data collection. As part of the quality assurance mechanisms, random quality assurance spot-checks were conducted in randomly selected 10% of schools.

Data analytic strategies

Primary data analytic strategies were multigroup confirmatory factor analysis and structural equation modeling, using Mplus 8.6 (Muthén & Muthén, 1998–2018). Maximum likelihood estimates with robust standard errors (Satorra-Bentler Scaled Chi-square and standard errors) were used due to floor effects in some variables (see Table 3 for details). Confirmatory factor analysis was conducted to create a latent variable of literacy skill in Setswana across the four time points and a latent variable of literacy skill in English at Time 4 (see Fig. 1). Note that English reading skill at Time 3 was measured by a single task and therefore, was not included in the confirmatory factor analysis.

Measurement invariance was examined across the treatment and comparison conditions. Latent variables of literacy skills, instead of using the observed variables, were created for two reasons. First, as noted above in the Measures section, various reading precursor/emergent reading skills and reading skills were measured at different time points considering developmental phase of reading development, and therefore, examining the relations across these various multiple measures would be unnecessarily too complicated and has issues (e.g., multicollinearity) and was not necessary for addressing the research questions. Second, latent variables are superior and preferred over observed variables, as long as models have good fit and observed variables have adequate loadings, because latent variables have reduced measurement error. In the confirmatory factor analysis of Setswana skills, we proceeded with a single latent variable per assessment wave instead of considering alternative structures. This is based on theory, prior evidence, data, and the primary goal of the present study. Theory and prior evidence suggested that reading subskills (word reading, text reading fluency, reading comprehension) and reading precursors are moderately and strongly related particularly in the beginning phase of reading development (e.g., see Malda et al., 2014; Probert, 2019 for evidence in Setswana).

Table 3 Bivariate correlations between skills within each time (comparison/control condition below the diagonal and treatment condition above the diagonal)

Time 1 (Beginning of Grade 1)	1	2	3	4	5			
1. Phonological awareness	–	.38	.45	.42	.27			
2. Letter sound identification	.32	–	.40	.25	.11			
3. Word reading	.46	.60	–	.48	.29			
4. Sentence reading	.49	.22	.43	–	.55			
5. Sentence comprehension	.47	.24	.41	.52	–			
Time 2 (End of Grade 1)	1	2	3	4	5	6	7	8
1. Phonological awareness	–	.55	.64	.64	.62	.65	.67	.59
2. Letter sound identification	.53	–	.69	.67	.66	.65	.62	.62
3. Word reading	.60	.71	–	.93	.74	.89	.85	.62
4. Nonword reading	.59	.67	.91	–	.73	.90	.85	.59
5. Sentence reading	.58	.63	.72	.74	–	.74	.79	.67
6. Text (Oral) reading fluency	.60	.65	.89	.89	.73	–	.88	.61
7. Reading comprehension	.62	.64	.84	.86	.81	.88	–	.61
8. Dictation	.52	.62	.60	.57	.66	.59	.62	–
Time 3 (End of Grade 2)	1	2	3	4	5	6	7	8
1. Phonological awareness	–	.41	.49	.49	.49	.48	.46	.48
2. Letter sound identification	.40	–	.72	.71	.69	.61	.58	.61
3. Word reading	.47	.77	–	.94	.94	.82	.65	.85
4. Nonword reading	.47	.73	.93	–	.92	.80	.63	.83
5. Text (Oral) reading fluency	.47	.73	.93	.92	–	.83	.65	.86
6. Reading comprehension	.45	.63	.82	.81	.85	–	.62	.76
7. Dictation	.45	.63	.69	.65	.68	.63	–	.62
8. English test	.46	.66	.88	.85	.87	.80	.65	–
Time 4 (End of Grade 4)	1	2	3	4	5	6	7	8
1. Letter sound identification	–	.66	.61	.59	.55	.57	.54	.41
2. Word reading	.67	–	.91	.87	.75	.84	.82	.61
3. Text (Oral) reading fluency 1	.62	.90	–	.89	.80	.83	.86	.63
4. Text (Oral) reading fluency 2	.58	.87	.90	–	.74	.81	.83	.61
5. Reading comprehension	.56	.76	.80	.73	–	.69	.70	.62
6. English word reading	.58	.84	.84	.82	.72	–	.89	.71
7. English oral reading fluency	.53	.81	.84	.81	.72	.89	–	.76
8. English reading comprehension	.41	.59	.63	.59	.62	.72	.74	–

All values are statistically significant at $p < .001$ level

In addition, bivariate correlations in the present study showed moderate to strong relations among the measured skills with a few exceptions of weak relations that are attributed to floor effects (see Tables 1 and 2). In addition, the loadings were all moderate to strong (see Fig. 1). Lastly, our primary goal was to investigate the nature of the relation between Setswana literacy skill and English reading skill by instructional context, not exploring an alternative factor structure of Setswana literacy skill.

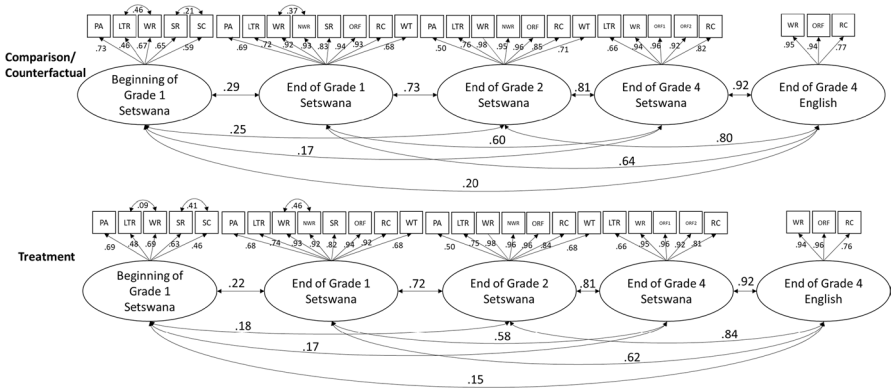

Fig. 1 Standardized loadings and correlations between latent variables (literacy skills at different time points) for children in the business-as-usual comparison condition and treatment condition. *Note* The indicators shown here for each latent variable are the variables in the order shown in Table 2. PA, phonological awareness; LTR, letter sound knowledge; WR, word reading; SR, sentence reading; SC, sentence comprehension; NWR, nonword reading; ORF, text (oral) reading fluency; RC, reading comprehension; DIC, dictation

Confirmatory factor analysis was conducted to create latent variables for literacy skills at each time point. Given that children in the present analysis were in two different conditions, comparison and treatment (see Table 1), measurement invariance was tested by fitting configural, metric, and scalar models (see Brown, 2015). In the configural model, structural relations are hypothesized to be the same across the groups (comparison and treatment); in the metric model, loadings are fixed to be the same across the groups; and in the scalar model, intercepts are additionally fixed to be identical across the groups.

The research questions were addressed by a structural equation model shown in Fig. 2. In this model, children's literacy performance in Setswana in each time point predicted their literacy performance in the subsequent times (Time 1 → Time 2 → Time 3 → Time 4). Children's literacy skills in Setswana predicted concurrent literacy skills in English in Times 3 and 4. Furthermore, to examine longitudinal crosslinguistic relations, children's Setswana literacy skills in Times 1 and 2 were hypothesized to predict subsequent English reading skill in Time 3, and literacy skills in Setswana and English in Time 3 were hypothesized to crosslinguistically predict literacy skills in Time 4 (see Fig. 2). Children's age was included as a control variable when examining structural relations shown in Fig. 2.

Model fit was determined by multiple indices: the root mean squared error of approximation (RMSEA) and its associated confidence interval, where values under .08 are preferred (Kline, 2016); and the confirmatory fit index (CFI), for which values above .90 are considered adequate, and values above .95 are considered excellent (Hu & Bentler, 1999). To compare model fits for nested models in measurement invariance models, the Satorra-Bentler chi-square tests of model fits were conducted (Muthén & Muthén, 1998–2018).

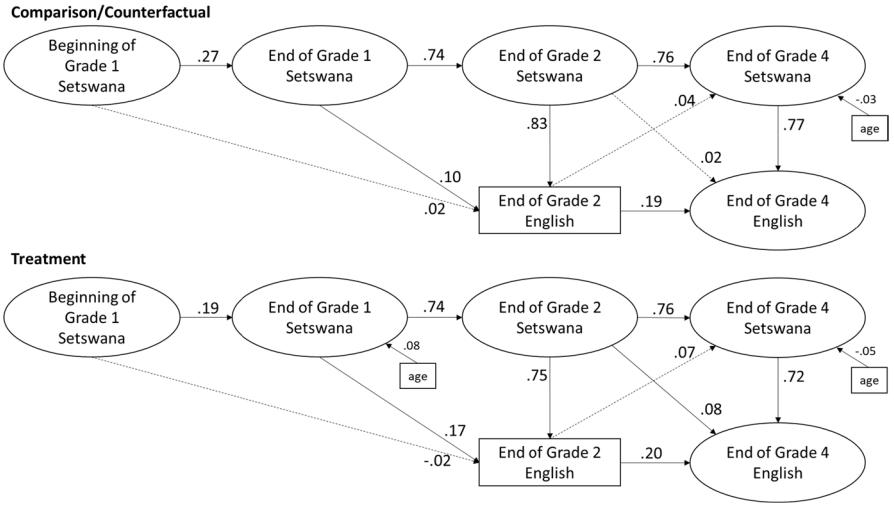

Fig. 2 Standardized coefficients of literacy skills at different time points for children in the comparison and treatment conditions. *Note*. Solid lines represent statistically significant relations whereas dotted lines represent statistically nonsignificant relations. Loadings of indicators for latent variables are presented in Appendix 3. Age was included as a control variable at all the time times and outcomes, but only statistically significant ones are shown

Results

Descriptive statistics and preliminary analysis

Attrition rate from Time 1 (beginning of Grade 1) to Time 4 (end of Grade 4) was 27% overall, and by treatment conditions it was 27.6% in the comparison condition and 26% in the treatment condition. Table 2 shows mean, standard deviation, minimum and maximum, skewness, and kurtosis in the tasks. Not surprisingly children's mean performances increased over time. An exception is children's phonological awareness in Time 2, which was due to a change in the nature of tasks from Time 1 to Time 2 (see above for description). Distributional properties as examined by skewness and kurtosis were adequate except for a few measures in Time 1. Specifically, children's mean performances on the letter sound knowledge, word reading, and sentence reading tasks had severe floor effects, resulting in high skewness and kurtosis values. Floor effects were also found in Time 2 and Time 3 in Setswana, and English reading skills in Time 3 and Time 4, but it was the most severe in Setswana in Time 1. In subsequent confirmatory factor analysis and structural equation modeling, maximum likelihood estimates with robust standard errors (Satorra-Bentler Scaled Chi-square and standard errors) were used to address nonnormal distributions.

Bivariate correlations by time points and by treatment conditions are presented in Table 3. Correlations across times are found in Supplemental Materials. Essentially all the literacy skills within each time point were moderately to very strongly related to each other ($.32 \leq rs \leq .92$) except for a couple of weak relations in Time 1 (letter

sound knowledge with sentence reading [.22 ≤ *r*s ≤ .25] and sentence comprehension [.11 ≤ *r*s ≤ .24]).

When conducting confirmatory factor analysis to create latent variables for literacy skills at each time point for comparison and treatment conditions, residual covariances were allowed for the following pairs based on modification indices: letter knowledge and word reading, sentence reading and sentence comprehension, and word reading and nonword reading in both conditions in the configural and metric models. Models that did not allow these residual covariances did not converge; and therefore, partial configural model, partial metric model, and scalar model were fitted. The model fit information for these models is reported in Appendix 2. Satorra-Bentler Chi-square test results showed that there is no difference between the partial configural model and partial metric model ($\Delta\chi^2 = 36.63$, $\Delta df = 23$, $p > .10$). Given that the metric model is more parsimonious, the metric model was preferred over the configural model. When the partial metric model and scalar model were compared, the metric model was superior ($\Delta\chi^2 = 492.70$, $\Delta df = 27$, $p < .001$). The superiority of the partial metric model over the scalar model may not be surprising considering the treatment effect reported (Taylor et al., 2019). In other words, because there was a treatment effect, differences in intercepts should not be unexpected, and the scalar model, which constrains intercepts to be equal across both conditions, did not have as good a model fit as the metric model. Therefore, the metric model was chosen as the final model and was used in the subsequent latent regression model. Figure 1 shows standardized loadings and correlations between latent variables from the metric model by treatment condition. Loadings were adequate, ranging from moderate (.46) to very strong (.98, *p*s < .001).

Relations of L1 Setswana literacy skill and L3 English reading skill by treatment conditions

Multigroup structural equation models in Fig. 2 were fit to the data and the model fit was good: $\chi^2 = 4177.37$, $df = 952$, $p < .001$, scaling factor = 1.17, RMSEA = .054 [.052, .056], CFI = .94, SRMR = .06. As noted above, children's age was included as a control variable. Factor loadings for the latent variables are reported in Appendix 3. Standardized coefficients are presented in Fig. 2. Not surprisingly, in both conditions, children's performance in Setswana in each time was related to their subsequent performance such that children's literacy skill in Time 1 (beginning of Grade 1) was weakly related to their literacy skill in Time 2 (end of Grade 1; .27 for comparison and .19 for treatment condition, *p*s < .001), which was strongly related to literacy skill in Time 3 (end of Grade 2; .74 for both conditions, *p*s < .001), which, in turn, was also strongly related to literacy skill in Time 4 (end of Grade 4; .76 for both conditions, *p*s < .001).

When it comes to crosslinguistic relations, children's Setswana literacy skill in Time 3 strongly predicted English reading in Time 3 (.83 for comparison condition; .75 for treatment condition, *p*s < .001). Children's Setswana literacy skill in Time 4 also strongly predicted their English reading skill in Time 4 (.77 for comparison condition; .72 for treatment condition, *p*s < .001). When it comes to crosslinguistic

longitudinal relations, children's Setswana literacy skill in Time 2 was also positively, albeit weakly, related to English literacy skills in Time 3 in both conditions (.10 for comparison condition; .17 for treatment condition, $ps < .001$). English reading skill in Time 3 did not predict Setswana literacy skill in Time 4 after accounting for the other skills in the model ($ps \geq .10$). Interestingly, for the treatment condition, Setswana literacy skill in Time 3 weakly but independently predicted English reading skill in Time 4 (.08, $p = .01$) after accounting for children's English literacy skill in Time 3 and Setswana literacy skill in Time 4. This was not the case for children in the comparison condition (.02, $p = .60$).

Discussion

In the present study, we examined the relations of L1 Setswana literacy skills to L2 English reading skill, using large-scale longitudinal data from children who participated in a randomized control trial on early literacy instruction in South Africa. We were particularly interested in whether the nature of relations varies as a function of instructional contexts. Overall, the results support our hypothesis that L1 literacy skill predicted L2 English reading skill, and instructional contexts influenced the pattern of relations.

As shown in Fig. 2, children's Setswana literacy skills were strong predictors of their concurrent English literacy skills across the instructional contexts. That is, children who had strong literacy skill in Setswana also had a strong reading skill in English regardless of instructional contexts when examined concurrently. These results are in line with the developmental interdependence hypothesis (Cummins, 1979) and previous findings (Baker et al., 2011; Kim & Piper, 2019; Manis et al., 2004; Proctor et al., 2006; Skutnabb-Kangass & Toukomaa, 1976; Wang et al., 2006), and expands L1–L2 relations to the Setswana-English pair in the South African context.

A unique and interesting finding of the present study is that the relations of prior Setswana literacy skill in Grade 2 to later English reading skill in Grade 4 differed by instructional contexts. Specifically, for those who received explicit and systematic literacy instruction in Setswana, their Setswana literacy skill at the end of Grade 2 longitudinally and directly predicted English reading skills at the end of Grade 4 in addition to its indirect effects via English reading skill at the end of Grade 2 and Setswana literacy skill at the end of Grade 4. This was not found for children in the comparison condition. These results lend support to our hypothesis that explicit and systematic instruction on literacy skills and underlying competences such as metalinguistic awareness in L1 Setswana enhances children's understanding of these skills in L1 Setswana, and children use and capitalize on these resources when learning to read in L2 English. Note though that the differential pattern was found from Grade 2 to Grade 4, but not from Grade 1 to Grade 2 during which earlier Setswana literacy skill predicted English reading skill across the treatment and comparison conditions. The reasons for the divergent findings between different time points are not clear. One potential explanation includes floor effects. As shown in Table 1, there were

floor effects in English reading skills in Times 3 and 4, but it was more severe in Time 3; and associated reduced variance might have limited potential differential relations across treatment conditions between Time 2 and Time 3.

It is also of note that crosslinguistic relations were not bidirectional. As shown in Fig. 2, the relation was unidirectional from L1 Setswana to L2 English. These results are divergent from Kim and Piper's (2019) study which showed bidirectional relations for children in Kenya who were learning to read in Kiswahili and English. An important difference that might explain the discrepant findings is instructional context: In the present study, explicit and systematic reading instruction was provided only in L1 Setswana whereas in Kim and Piper's (2019) study, it was provided for both Kiswahili *and* English reading. Because exposure to direct and systematic instruction in reading only occurred in L1 in the present study, children would have developed their skills in L1, which then would lead to the unidirectional relation from L1 Setswana to L2 English skill.

The results overall indicate that literacy skill in L1 facilitates reading acquisition in L2, and the transfer is more likely when literacy instruction is explicit and systematic in underlying skills that contribute to reading. L1 instruction that explicitly targets letter-sound relations, phonological awareness, and reading improves children's metalinguistic awareness and knowledge, which, in turn, facilitates reading acquisition in L2. Children's learning of the general mapping principle that applies to learning to read in any language (Perfetti, 2003), such as mapping of sounds to graphic symbols, facilitates the learning process of reading in a new language (Koda, 2007). These findings, together with a large body of studies on the effect of explicit and systematic instruction on literacy acquisition (e.g., Graham & Kelly, 2019; Kim et al., 2020; National Institute of Child Health and Human Development, 2000), indicate a need for explicit and systematic instruction for reading precursor and reading skills in L1 to support children's L1 reading development *and* their L2 literacy acquisition.

Although not our primary research question, precursor skills and literacy skills in Setswana were related to one another within each time point (Table 3), and these are in line with earlier studies in Setswana (Malda et al., 2014; Probert, 2019). Furthermore, literacy skills in Setswana in different developmental time points were related. In general, the relation was strong such that children's earlier Setswana literacy skills are an important predictor of later Setswana literacy skills (e.g., end of Grade 1 skill strongly predicted end of Grade 2 skill). This is not surprising, and indicates high stability of literacy skills in Setswana over time; and this pattern has been observed in previous studies (e.g., Hulslander et al., 2010). An exception was weak relations from Time 1 to Time 2 (see Fig. 2), and this is likely due to measurement issues. As noted above, there were severe floor effects in some of the skills in Time 1. Although this is informative and reflects the level of children's literacy skills in the beginning of Grade 1, floor effects reduce variance, which influences covariance with other skills. Similarly weak relations were observed between English reading skills at Time 3 and Time 4, and these may also be related to floor effects (see Table 1).

Limitations, future directions, and conclusion

As is the case for any studies, generalizability of the findings is limited to the population from which the sample is drawn. Therefore, the present findings are likely generalizable to primary grade children in South Africa with similar demographic characteristics: elementary grade children learning to read in Setswana and English and from low socioeconomic backgrounds in rural areas of South Africa. Previous studies found that linguistic distance, degree of (dis)similarity of structural features, is related to the strength of crosslinguistic relations (see Koda, 2007). Although Setswana and English have vastly different linguistic features, both of them employ the alphabetic writing system, and uses the Roman alphabet letters. Therefore, the present findings are generalizable to languages with similar linguistic and orthographic features that were examined in the present study.

Measures across the four time points differed to reflect developmental changes, and therefore, results should be interpreted with this in mind. In addition, we acknowledge that there are other statistically equivalent models to the model fit in Fig. 2 (see Muthén & Asparouhov, 2023 for a discussion). The nature of relations hypothesized in Fig. 2 is based on theory and prior evidence: Literacy skills acquired earlier (Setswana) predict literacy skills acquire later (English) and this includes cross-linguistic relations. We also recognize the complexity of inferring causality using cross-lagged panel data (e.g., Zyphur et al., 2020). However, note that the causal inference is enhanced by a randomized controlled trial design employed in the present study.

As noted above, there were floor effects in the included measures. Floor effects in reading skills reflect low reading skills for children in the study. Although the measures in the study were developmentally appropriate words and texts, the floor effects would have likely impacted the findings due to reduced variance. Future replications with longer developmental span can shed light on the nature of relations that might have been impacted by floor effects such as the bidirectional relations between Setswana and English literacy skills.

Another limitation is that residual covariances were allowed for both conditions and the current results should be interpreted with this in mind. Additionally, differences across the 230 schools were not modeled and fidelity was not taken into account in the structural relations. Lastly, it would have been ideal to have reliability estimates for all measures in the present sample, rather than only for some measures. The tasks in the present study were developed based on widely used established measures in the field such as Early Grade Reading Assessment (EGRA), and underwent a pilot study and revision prior to the use in the study. EGRA has been widely used in more than 70 countries and 120 languages (Ecalle et al., 2019) with accumulated evidence of reliability and validity (Kim et al., 2016; Stern et al., 2018). For example, many studies using oral reading fluency in EGRA have reported high reliability (e.g., Piper & Korda, 2011; Piper et al., 2014). Nonetheless, reliability information for all measures in the present study would have been ideal and future work addressing this gap is needed.

Our goal in the present study was to expand our understanding of the nature of L1 and L2 literacy skills, and the role of instructional contexts in the relation. While the findings are informative, they also indicate a need for future work. Although L1-L2 relations have been widely supported, empirical investigations on mechanisms of transfer between L1 and L2 skills and the role of instruction are still limited. Future work is warranted.

Appendix 1: Implementation fidelity and quality

Teacher survey items & observation	Teacher Training Condition	Coaching Condition	Parent Involvement Condition
Teacher received a high quality of support in teaching Setswana Home Language	45%	66%	N/A
Books are available in Setswana in the classroom	90%	90%	N/A
Teacher implementation of group guided reading	70%	85%	N/A
Teacher access to lesson plans	78%	96%	N/A
Teacher received training over the three years	94%	94%	N/A
Teacher regularly meets with people who provide mentoring and curriculum support	57%	84%	45%
Parent attendance of meetings	N/A	N/A	50%

Appendix 2: Model fit for alternative models for measurement invariance

Model	χ^2 (df)	Scaling Factor	RMSEA (CI)	CFI	TLI	SRMR
Partial configural model	4976.317 (674)	1.282	.053 [.052, .054]	.94	.93	.063
Partial metric model	5029.940 (697)	1.288	.052 [.051, .054]	.93	.93	.064
Scalar model	5701.21 (670)	1.285	.058 [.056, .059]	.92	.92	.068

Appendix 3: Standardized Factor Loadings for the Latent Variables in Fig. 2

Variables/indicators	Comparison condition		Treatment condition	
	Standardized loading	S.E	Standardized Loading	S.E
Time 1 Setswana				

Variables/indicators	Comparison condition		Treatment condition	
	Standardized loading	S.E	Standardized Loading	S.E
Phonological awareness	.736	.027	.681	.036
Letter identification	.501	.047	.536	.051
Word reading	.707	.032	.711	.055
Sentence reading	.645	.036	.663	.047
Sentence comprehension	.601	.024	.384	.035
Time 2 Setswana				
Phonological awareness	.657	.023	.709	.023
Letter identification	.746	.018	.741	.020
Word reading	.914	.008	.925	.009
Nonword reading	.917	.009	.922	.008
Sentence reading	.833	.008	.831	.008
Oral reading fluency	.923	.010	.937	.011
Reading comprehension	.931	.007	.922	.007
Dictation	.678	.015	.696	.016
Time 3 Setswana				
Phonological awareness	.484	.021	.496	.024
Letter identification	.760	.013	.721	.018
Word reading	.976	.002	.975	.003
Nonword reading	.953	.004	.950	.005
Oral reading fluency	.959	.005	.955	.007
Reading comprehension	.870	.008	.847	.012
Dictation	.676	.017	.660	.021
Time 4 Setswana				
Letter identification	.668	.018	.664	.019
Word reading	.934	.010	.952	.006
Oral reading fluency 1	.960	.011	.973	.004
Oral reading fluency 2	.936	.015	.951	.013
Reading comprehension	.820	.011	.805	.013
Time 4 English				
English word reading	.951	.012	.957	.012
English oral reading fluency	.941	.012	.972	.007
English reading comprehension	.770	.011	.770	.012
Residual covariance	correlation	S. E	correlation	S. E
Time 1 word reading and letter knowledge	.294	.056	.049	.094
Time 1 sentence reading and sentence comprehension	.240	.041	.431	.031
Time 2 word reading and nonword reading	.386	.059	.486	.057

All loadings are statistically significant at .001 level

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s11145-023-10508-1.

Declarations

Conflict of interest Authors report no conflict of interest.

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