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EMPIRICAL ARTICLE

CHILD DEVELOPMENT

Language-specific phonological skills and the relationship with reading accuracy in Sylheti-English sequential bilinguals

Kathleen M. McCarthy[1] | **Katrin Skoruppa**[2]

[1]Department of Linguistics, Queen Mary University of London, London, UK

[2]Institut des sciences logopédiques, Maison des sciences du language et de la communication, Université de Neuchâtel, Neuchâtel, Switzerland

Correspondence
Kathleen M. McCarthy, Department of Linguistics, Queen Mary University of London, London, UK.
Email: k.mccarthy@qmul.ac.uk

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Abstract
This study investigated the influence of first language (L1) phonology on second language (L2) early reading skills in Sylheti-English bilinguals (N = 58; 48% girls; British Bangladeshi) and their monolingual-English peers (N = 43; 45% girls; 96% White British, 4% multiethnic British) in a diaspora context. Language-specific phonological awareness and nonword repetition were tested at two time points (6;2–7;8 years-old). At Time 1, the bilinguals had lower productive accuracy for phonological sequences that violated their L1 phonology (d = .56; .84), and these skills accounted for a significant amount of variance in their reading accuracy. At Time 2, the language-specific effects were no longer present. These findings highlight the importance of considering language structure in multilingual early literacy development.

Early literacy development lays the foundation for later literacy abilities, as well as academic and societal success (Ritchie & Bates, 2013). The predictive relationship between early reading skills such as phonological awareness (the ability to manipulate sound sequences e.g., *say cat without the /k/ sound*) and reading accuracy is well-established for monolingual children (e.g., Hulme & Snowling, 2013), and the growing body of research on bilingual children shows similar predictive patterns for bilingual populations (see e.g. Gottardo et al., 2021 for a recent review). Bilingual early reading research, however, is yet to fully capture the intricate characteristics of different types of bilinguals, especially for children who grow up in dense diaspora communities. Research on oral language acquisition shows that bilinguals are a highly heterogenous group, with outcomes depending on sociocultural background, exposure patterns across the lifespan, as well as the structure of the languages being acquired (Nicoladis & Montanari, 2016). With regard to the latter, this line of research has revealed specific patterns of interplay between bilinguals' languages, with facilitatory effects for structural elements that are shared by both languages, and interference effects for unique or contradictory elements (see, for instance, Hambly et al., 2013, for a review in the domain of phonology). Such effects are yet to be thoroughly researched in bilingual early literacy, which, for the time being, has focused largely on the relation between global differences between languages and positive transfer effects, by measuring overall correlations between skills (e.g., phonological awareness) in both languages (e.g., Gottardo et al., 2021; Saiegh-Haddad, 2019). However, understanding how specific structural differences between languages may lead to interference effects in phonological processing tasks, and in turn modulate early literacy outcomes, is not only crucial for understanding bilingual reading acquisition but also for informing educational practice.

In the current study, we track the impact of bilinguals' unique language environment on their phonological processing and early reading skills. Specifically, we focus on bilingual children who grow up in a dense diaspora community and are primarily (though not exclusively) exposed to their heritage language (L1), before starting formal education in the majority language (L2). These

Abbreviations: CI, confidence interval; CTOPP-2, Comprehensive Test of Phonological Processing—second edition; RAN, rapid automatized naming; RI, relative importance.

children are often referred to as "sequential" bilinguals (e.g., Gottardo et al., 2021, p. S372). We use a series of tailored tasks to investigate how phonological differences between the L1 and L2 modulate early literacy skills, and the changes that occur with increased language and literacy experience in school. To our knowledge, only one study has examined how language-specific phonological knowledge modulates phonological awareness and in turn influences reading, in an L2 immersion context (Wade-Woolley & Geva, 2000). Our study investigates such interrelations in a diaspora context and explores how they change over time. Finally, a unique feature of the Sylheti-English community under investigation is that children are exposed to their heritage language in a purely oral form since its script has fallen out of use. This might make a difference because bilingual research has suggested that learning to read in both languages can modulate early reading outcomes in bilinguals (see e.g., Schwartz et al., 2005).

The sections to follow provide an overview of the previous research on the importance of phonological processing in early reading development in monolinguals and bilinguals, and how, in turn, language-specific differences can impact bilingual phonological processing.

The role of phonology in early reading development

Successful reading depends on both decoding and oral language skills (Gough & Tunmer, 1986), with phonological skills underpinning decoding (converting strings of letters to sounds), and oral language skills such as vocabulary and grammatical knowledge underpinning reading comprehension. Accurate decoding is an essential pre-requisite for reading comprehension, especially in the early stages of literacy acquisition (Castles et al., 2018). Later on, as children master decoding, oral language skills are thought to become more predictive of reading comprehension (e.g., Gough et al., 1996).

When children start to read, they use their underlying phonological representations and phonological processing abilities to decode the written form, and in turn access the word in their lexicon (Hulme & Snowling, 2013). As such, children who start out with poorly specified phonological representations display poorer reading accuracy later on (Peterson & Pennington, 2012). Moreover, the relationship between phonological skills and reading seems to be bidirectional, with longitudinal studies showing reading accuracy is both predicted by and predicts phonological skills (Cunningham et al., 2021; Wagner et al., 1994). In particular, phonological awareness (the ability to consciously process and manipulate sound sequences e.g., *say cat without the /k/ sound*) and phonological short-term memory (often indexed by nonword repetition tasks), are key predictors for early reading accuracy (Cunningham et al., 2021; Hulme & Snowling, 2013).

More specifically, phonological awareness is thought to reflect the quality of the phonological representations as well as phonological processing efficiency (Hulme & Snowling, 2013 for review). Depending on the specifics of the task, children are required to pull apart and reassemble the phonological structure of spoken words. In particular, children's awareness of individual phonemes, versus larger units, is thought to play a major role in decoding skills in alphabetic languages (Hulme et al., 2002). Longitudinal and cross-sectional studies with monolingual children have shown that phonological awareness prior to or at the onset of reading is positively related to reading accuracy and later reading outcomes (Cunningham et al., 2021; Muter et al., 2004).

Phonological memory, as indexed by nonword repetition, is also related to reading accuracy. It is thought that phonological memory predicts reading accuracy via shared variance with phoneme awareness. The idea being that they both rely on the quality of underlying phonological representations, rather than solely the ability to remember sequences (Melby-Lervåg et al., 2012). The specifics of the phonological memory task, for example, serial recall task versus nonword repetition, however, will determine the specific level of processing that is being assessed (see e.g., Cunningham et al., 2021; Gathercole, 2006; Metsala, 1999). In terms of the relationship with reading accuracy, a recent large-scale 5-year longitudinal study from age 5 to 9 years-old, found that nonword repetition predicted word reading from age 5 to 6, and indirectly via phonological awareness in the later years (Cunningham et al., 2021; but see Nation & Hulme, 2011). That is, the relationship was found to be partly mediated by the development of phonological awareness (see Melby-Lervåg et al., 2012 for meta-analysis data showing a similar effect).

It is important to note that other skills, some of which are thought to be related to phonological processing, namely rapid automatized naming (RAN), and letter knowledge have also been found to be strong predictors of reading accuracy (Hulme & Snowling, 2014). RAN tests the ability to name familiar symbols such as letters or numbers as quickly as possible and draws on a range of cognitive and perceptual processes, including phonology (Lervåg & Hulme, 2009; Yeung, 2016). Its precise relationship with reading is still under debate, but it is widely thought to reflect the speed of access and integration of lexical, orthographic, and phonological representations (see Kirby et al., 2010 for a review). Additionally, earlier acquired speech perception skills such as phoneme identification and categorical perception, have also been found to be related to later phonological awareness (Erskine et al., 2020; but see Snowling et al., 2019) and later reading accuracy, though somewhat weaker than the previously discussed measures.

The growing body of bilingual early literacy research confirms that phonological skills are an important predictor for early reading in this population as well. Studies have shown bilinguals to develop strong decoding skills, but weak reading comprehension, which is thought to be due to poorer oral language skills (e.g., Burgoyne et al., 2011). Bilinguals, however, are a highly heterogeneous population and this diversity has been reflected in meta-analyses that found large variations in the predictive strength of the relationship between L1 and L2 early reading skills (Melby-Lervåg & Lervåg, 2014). Studies on bilingual phonological awareness have primarily focused on transfer of L1 and L2 skills, that is, correlational relationship between L1 phonological awareness skills and their L2 skills (see Gottardo et al., 2021, for a thorough review of this literature). Many of these studies have shown that phonological awareness in the L1 is highly correlated with phonological awareness abilities in the L2 (Gottardo et al., 2021; Melby-Lervåg & Lervåg, 2011). Furthermore, studies that have directly compared monolinguals and bilinguals have shown bilinguals to display an "advantage" over their monolingual peers in phonological awareness tasks, possibly due to the cognitive demands of acquiring two languages (see e.g., Adesope et al., 2010 for a review).

In an attempt to pull apart the causal factors that drive the variability observed in bilinguals, a growing body of research has explored how differing exposure patterns and age of acquisition impact on phonological awareness and early reading skills (see e.g., Jasińska & Petitto, 2018; Loizou & Stuart, 2003). Studies to date suggest that phonological awareness skills are modulated by language exposure patterns, task type, as well as non-linguistic factors such as socioeconomic status (Kovelman et al., 2008). In terms of language exposure, Jasińska and Petitto (2018) found that 6- to 7-year-old French-English early bilinguals who were exposed to their two languages before 3 years, outperformed their monolingual English peers on English phonological awareness tasks. In contrast, sequential bilingual children who were immersed in English at the start of school at around 4–6 years old, performed worse than monolinguals and early bilinguals. Furthermore, English phonological awareness skills predicted reading accuracy in the French-English early bilinguals, but not for the sequential bilinguals. These effects changed over time, with the gap between the sequential bilinguals and monolinguals closing by 9–10 years old.

Some bilingual studies have suggested that typological features in the languages being learned can influence transfer effects found in phonological awareness skills: For example, using a longitudinal design, Bruck and Genesee (1995) investigated the phonological awareness skills of English-speaking first graders who attended either an English-speaking school (monolinguals) or French-immersion school (bilinguals). The children who were attending the French-immersion school outperformed their monolingual peers on syllable-awareness tasks. The authors attributed these findings to the salience of syllables in French. Likewise, Loizou and Stuart (2003) found a bilingual advantage effect in phonological awareness for English-Greek bilinguals, but not for Greek-English bilinguals. Although not explored directly, the authors attribute these findings to the relative phonological complexity of the children's languages, in this case the less complex L1 (Greek) was thought to not facilitate phonological awareness skills in a more phonologically complex L2 (English). The above studies, however, have not directly tested how differences in the complexity of the phonological structure modulate phonological awareness. That is, how children perform on a phonological awareness task when the test items themselves violate or align with the phonological structure of children's languages. In the following section, we provide an overview of the bilingual phonological processing research that often sits separately from early literacy research, yet this body of research highlights a more detailed approach to phonological processing may explain some of the cross-linguistic patterns found in early literacy research to date.

The role of phonotactics in phonological processing

Cross-linguistic differences in phonological processing can concern various levels: individual sound categories, sound sequences (phonotactics), and suprasegmental features such as intonation patterns. Previous research has shown that early phonetic and phonological processing in bilinguals is influenced by their language environment, resulting in L2 patterns that align with the children's L1 (Darcy & Krüger, 2012; Khattab, 2000; Kirkham & McCarthy, 2021; Mayr & Siddika, 2018; McCarthy et al., 2014). Less is known about the long-term influence of these language-specific processing patterns; furthermore, if they manifest in other aspects of phonological processing, such as those related to early reading decoding.

The current study focuses on bilingual children's developing phonological skills, specifically phonotactic processing during tasks that have been shown to be important predictors of reading accuracy. Phonotactics refers to the sound sequencing structure in a given language, the language-specific sound sequencing rules. At the most basic level, sound sequences can either be legal (attested in a given language) or illegal (impossible to occur given the language-specific rules). For example, the word initial consonant cluster /bl/ is legal in English (e.g., "blue") and German (e.g., "blau"), however, the cluster /pfl/ is only legal in German (e.g., "pflaume"), but illegal in English. This patterning can be further refined when we consider *phonotactic probability*, a term used to refer to the frequency of a sound sequence in a given language:

high-probability phonotactics are regularly occurring, whereas low-probability sequences rarely occur.

A wealth of research has shown that phonotactic sensitivity is present across the lifespan and plays a key role in language acquisition. Monolingual infants are sensitive to the language-specific phonotactic regularities of their native language, with 9-month-olds showing a preference for phonotactically legal versus illegal sound sequences and nonwords (e.g., Jusczyk et al., 1993), and the ability to distinguish between high- and low-probability sequences in their native language (Jusczyk et al., 1994). In children, phonotactic probability effects have also been found in production, most notably in nonword repetition tasks, such that children have greater production accuracy for nonwords that are high probability than low probability, with some studies finding developmental changes with age (e.g., Coady & Aslin, 2004; Edwards et al., 2004).

Research on children learning more than one language suggests that phonotactic sensitivity is modulated by language exposure patterns, with children showing greater sensitivity to the phonotactic patterns (and also greater production accuracy) in their first (Messer et al., 2010, 2015 for Turkish-Dutch bilingual 4-year-olds) or dominant language (Sharp & Gathercole, 2013 for Welsh-English bilingual 4- to 5-year-olds). Not all studies, however, have shown bilinguals to have difficulties, and this seems to be driven by the cross-linguistic differences in the phonotactics of the languages being learned (e.g., Tamburelli et al., 2015; Vender et al., 2020). For example, Tamburelli et al. (2015) found Polish-English bilinguals showed greater accuracy than their monolingual peers on an English-based nonword repetition task. The authors suggest that these patterns may be driven by the phonological complexity of Polish, compared to English, giving the Polish-English bilinguals an advantage for complex phoneme sequences.

To our knowledge, only four studies have directly attempted to test the impact of cross-linguistic structural differences on phonological awareness skills (Chen et al., 2004; Kuo & Anderson, 2010; Kuo et al., 2016; Wade-Woolley & Geva, 2000). Kuo and Anderson (2010) and Kuo et al. (2016) tested phonological awareness using an odd-man-out syllable perception task that was designed to include syllables that were either shared in both languages of the bilinguals, or only existed in the L2 of the bilingual children. They found language-specific effects, such that bilingual first and second-graders outperformed the L2 monolinguals for trials where the syllable structured conformed to both their languages (shared condition; see also Chen et al., 2004 for similar effects). As far as we are aware, only Wade-Woolley and Geva (2000) explored the relation between a phonological interference effect and early L2 reading accuracy in English-speaking bilingual children in a Hebrew school. The authors found that poorer perceptual accuracy on a contrast that is phonemic in L2 Hebrew (/ts/ vs. /s/) but phonotactically constrained in L1 English, was correlated with lower reading accuracy in L2 Hebrew. However, this study did not allow for group-level analyses or the control for other factors such as vocabulary, further, its cross-sectional design does not allow conclusions regarding the direction of the effect, or the children's developmental trajectories. Furthermore, its L2 immersion context is very different from the typical immigrant diaspora context, where the L2 is the country's majority language and L1 literacy often remains underdeveloped, or, as in the current study, not in use.

The current study

It is widely agreed that phonological skills play a key role in the decoding aspect of reading, however, to our knowledge, only a few studies have explored how knowledge of language-specific phonological structures (i.e., phonotactic probability and legality) modulates phonological awareness, with none investigating how these skills change over time longitudinally, and if language-specific phonological processing impacts on reading accuracy. In the case of sequential bilinguals, their more robust L1 phonological representations may mismatch with the phonotactic constraints of the L2. In such a scenario, these children may display difficulties with tasks that rely on the quality of L2 phonological representations, such as phonological awareness. As discussed, phonological skills play an important role in early reading and predict later reading skills, thus any L2 phonological processing difficulties may have a knock-on effect on the children's L2 reading accuracy.

In the current study, we focused on Sylheti-English bilinguals from the East London Bangladeshi community, UK. All children in this study were predominately exposed to their heritage language, Sylheti, as an oral language, before starting full-time formal education. We tested the children at two time points, in UK school Year 1 (6 years old), when early literacy skills are a main focus in the classroom, and again 20 months later when they were in UK school Year 3. We test the hypothesis that bilinguals' existing and developing L1 phonological representations will influence their L2 phonological processing skills—that is, we expect weaker performance for L2 phonological sequences that do not exist in their L1. Based on previous research, we know that the quality of children's phonological representations is a strong predictor of reading accuracy. Thus, a second aim of the study is to test if language-specific phonological processing accounts for a significant amount of variance in L2 reading accuracy. Specifically, if our bilinguals show a language-specific pattern in the L2 phonological awareness and memory tasks (i.e., lower accuracy with words that contain sound sequences that do not exist in the L1), do these skills differentially predict their L2 reading accuracy?

We explored the following predictions: that the bilinguals' L2 phonological processing (nonword repetition and phoneme elision) is influenced by L1 phonotactic knowledge. This would mean lower production accuracy for L2 sequences that are phototactically illegal in their L1. Furthermore, as shown in previous phonotactic acquisition research, we expect a probability effect: monolingual and bilingual children to show greater accuracy for sequences that are high probability versus low probability. At Time 2, the children have increased English experience, and also regular reading in English, we therefore, predicted that L2 phonological skills would improve, in particular for the illegal sequences for the bilinguals. Given previous research has shown that phonological skills are related to reading accuracy, we predicted that phonological skills would account for a significant amount of variance in the children's reading accuracy, when we accounted for other factors which are known to be strong predictors of reading accuracy. More specifically, we predicted that the language-specific phonological skills (i.e., the children's phonological processing performance with items that do not exist in their L1), would differentially predict reading accuracy in the bilinguals but be equally predictive for the monolinguals, who would not be subject to such non-native phonological influences.

Sylheti and the London Bangladeshi community

The bilingual children in this study are Sylheti-English bilinguals from the Bangladeshi community in East London UK, where Bangladeshis are the largest ethnic group (Tower Hamlets Council, 2013). The children attended primary schools in East London where 80%–95% of the classroom were of Bangladeshi heritage.

Sylheti is an Indo-Aryan language, originating from Sylhet, a north-east district in Bangladesh, and is spoken widely in diaspora in large cities around the world. The Sylheti script, "Siloti Nagri," fell out of use in the mid to late 20th century. While it is recently being revived for linguistic research purposes (see, e.g., the SOAS Camden Sylheti Project), speakers in the London Bangladeshi community only use the spoken form of Sylheti, and children will therefore have no experience with reading in Sylheti script (McCarthy, 2013). Sylheti provides an interesting comparison with English, in particular in terms of syllable structure (i.e., consonant cluster sequences) and phonemic inventory (see e.g., McCarthy et al., 2013). In terms of syllable structure, Sylheti permits word-initial consonants and deviates from the canonical CV structure to allow word-medial and word-final codas (Eden, 2020). Unlike English, however, Sylheti hardly permits consonant cluster sequences (i.e., complex onsets or codas). See Supplementary Material A for a more detailed comparison.

TIME 1

Participants

One hundred and one children took part in the study: 58 Sylheti-English bilinguals from four primary schools in the London Borough of Tower Hamlets UK, and 43 monolingual English children from four primary schools in the London Borough of Islington. At Time 1, the children were in Year 1 in UK primary school (monolinguals: $\underline{x}_{age}$ = 6;3, female = 20, bilinguals: $\underline{x}_{age}$ = 6;2, female = 28).

To be included in the study, children had to have (a) no identified speech, language, or cognitive difficulties, or reported family history of dyslexia, (b) normal hearing thresholds, and no recent history of hearing infection. All participants had to pass three screens: a hearing screen for the audiometric frequencies 0.5, 1.0, 2.0, and 4.0 kHz presented at 25 dB HL over audiometric headphones; an articulation screen using the diagnostic screen from Diagnostic Evaluation of Articulatory Phonology (Dodd et al., 2002); and non-verbal IQ (NVIQ)—within 2 SD from the mean for the Matrices subtest from the Wide Range Intelligence Test (Glutting et al., 2000).

To be considered sequential bilingual, a child needed to have a minimum of 80% exposure to Sylheti from their main caregivers from birth to entering full-time education (as in McCarthy et al., 2014). Language exposure patterns were recorded using an interview-based home language environment questionnaire (an adapted version of McCarthy et al., 2014), administered by a trained Sylheti-speaking research assistant in the school or family home. The questionnaire indexed main caregiver Sylheti exposure patterns before starting full-time education (retrospectively), and their current exposure patterns in Year 1 (Time 1), as an estimation of the proportion of time (number of wake hours per day) spent with the main caregivers (parents, grandparents) and the languages used. Prior to starting full-time education, Sylheti was the dominant language for all bilinguals ($\underline{x}$ = 87%; SD = 6). The onset of full-time education in English (6 h per day, 5 days a week), which was on average 4;0 years old, saw a decrease in Sylheti exposure ($\underline{x}$ = 48%; SD = 7).

Demographic and socioeconomic information

Caregiver demographic information was collected during the interviews, such as place of birth, age of arrival in the UK, level of education (Bangladesh and UK). In all, 90% of families responded to questions regarding the demographic information. For all bilinguals, the main caregiver was born in Bangladesh and migrated to the UK in adulthood. In total, 88% of the caregivers were born in Sylhet, Bangladesh. For the remaining 12%, the caregiver was born in London, UK. Additionally, 38% of the children had a Bangladeshi-born grandparent living in the home. Where possible children were matched for socioeconomic status based on maternal and paternal level of education (Bradley & Corwyn, 2002). Level of education was classified based on the Regulated Qualifications Framework (Ofqual, 2015) or the Bangladesh equivalent (based on UK ENIC). Most caregivers had A-levels or an equivalent college level (bilingual: 42%, monolingual: 44%), followed by GCSE level (b: 24%, m: 20%), bachelor's degree (b: 20%, m: 24%), primary school (b: 13%, m: 9%), and postgraduate degree (b: 1%, m: 3%).

Materials and procedure

Children completed the test battery individually in a quiet room in their school over three 20- to 25-min sessions, for an average of 70 min in total per child, including short breaks between tasks.

Nonword repetition

Phonological memory was assessed using a computer game-style nonword repetition task.

Stimuli

The aim of this task was to investigate the interplay between Sylheti and English phonotactics in the repetition performance in English, therefore all nonwords had to be pronounceable in English. Given the lack of a written Sylheti corpus, Sylheti phonotactics could only be incorporated at a broad level, that is, whether a syllable sequence is legal or illegal in Sylheti, rather than specific probability counts (i.e., high vs. low probability in Sylheti).

We selected 54 English-based monomorphemic nonwords ranging from two to three syllables in length from the PseudoLex database (Needle et al., 2022), an English nonword database developed using statistical phonotactic models and acceptability ratings. To fully capture English syllable structure, we selected the high- and low-probability nonwords based on triphone probabilities (Coleman & Pierrehumbert, 1997; Hay et al., 2004). To incorporate Sylheti phonotactic legality, we used the Nidaba phonological comparison tool (Eden, 2018, 2020), which has both an English and Sylheti lexicon (phonetic transcriptions from dictionaries). We compared the English and Sylheti syllable structure and segmental patterns to select the nonwords that respected (legal) versus violated (illegal) Sylheti phonotactics. In total, we selected 14 nonwords for each of the four nonword types: (1) high English probability, that would be legal in Sylheti (high-legal), for example, *cadaw*, (2) high English probability, that violate Sylheti segmental structure (high-illegal), for example, *twager*, (3) low English probability, that would be legal in Sylheti (low-legal), for example, *zompab*, (4) low English probability, that violate Sylheti syllable structure (low-illegal), for example, *thanfer*. Additionally, we controlled for phoneme length and wordlikeness using PseudoLex acceptability ratings, across the four phonotactic nonword types. The final wordlist contained 48 disyllabic nonwords and eight trisyllabic nonwords. The wordlist and accompanying details can be found in Supplementary Material B.

To ensure that the nonwords were not real Sylheti or English words, they were checked against dictionaries and by two native Sylheti speakers. The nonwords were digitally recorded by a trained phonetician, female Southern British English speaker, and piloted on three monolingual English adults, to ensure they could produce all words.

Procedure

The task was developed as computer "alien language" game and presented on a laptop. The nonwords were presented in pairs from the same phonotactic nonword type (28 trials, 56 words in total) in two pseudorandomized lists. The pairing was based on previous nonword repetition studies that have shown two-word trials are suitable for the attention span of children within the current study's age range and tap into phonological processing (e.g., Edwards et al., 2004). The stimuli were presented at 68 dB SPL over Sennheiser HD 25-1 II Headphones (Wedemark). Children were instructed to listen to a Space Apple character and "say each word exactly how you hear it." For motivational purposes, the children were awarded a point on screen for each trial regardless of their accuracy, and a reward screen with a spinning Space Apple and an increased level counter appeared after every seven trials. The children's responses were audio recorded using a H2 Zoom recorder (Chiyoda-ku) with a sampling rate of 44.1 kHz 16-bit resolution.

Scoring and analysis

Accuracy was initially scored online by the researcher, at a per trial level using a mouse button click (i.e., any production error in either word was scored as 0, both words correct scored as 1). All words were subsequently phonetically transcribed offline and coded for accuracy by two trained phoneticians unaware of the focus of this study. A nonword was considered as incorrect when at least one segment was deleted or replaced, with the exception of regional dialectal variations, for example, "l" vocalization, glottalization, "th" fronting. A random sample of 20% of the tokens was coded for accuracy (from the audio recordings) by the first author and yielded a 94% inter-rater agreement rate.

Phoneme elision

English phonological awareness was assessed using the phoneme elision subtest of the CTOPP-2 (Wagner et al., 2013). The task required children to delete a word, syllable, or phoneme and subsequently recombine the remaining segments to form a new word. For example, *say toothbrush without "tooth,"* or at the single phoneme level *say bold without the "b" sound*. All children completed the first 24 items, so that we had a comparable set of items across all children. To explore the influence of Sylheti phonotactics, in our analysis we spilt the items by Sylheti phonotactic legality. In the 24 items, 11 items contained phoneme sequences that are illegal in Sylheti (bold), for example, ***wint****er*, and 13 items that did not violate Sylheti phonotactics, for example, *powder*. The item administration followed the order in the standardized test and was administered by the research assistant (i.e., live voice, Southern British English accent).

Language and literacy measures

The following standardized tests were administered following the standardized procedure, and raw scores were calculated for all children. Receptive vocabulary was assessed using British Picture Vocabulary Scale—third edition (Dunn et al., 2009). Letter-sound correspondence was assessed using the Letter Sound Knowledge subject from the York Assessment of Reading Comprehension (Hulme et al., 2009). Rapid-automatized naming was assessed using the letter and digit RAN subtests of the Comprehensive Test of Phonological Processing—Second Edition (CTOPP-2; Wagner et al., 2013). Digit recall was assessed using the Memory for Digits subtest of the CTOPP-2 (Wagner et al., 2013). Finally, to assess word reading accuracy, children completed the Single Word Reading Test (Foster, 2007). In this task, the child is presented with a sheet of 60 written words, grouped into blocks of 10 words. The child is instructed to read aloud a list of words (per block) that increase in difficulty.

Results

For the language and cognitive measures, all children were no more than 2 SD from the mean and did not differ from a normal distribution. See Table 1 for a summary.

Phonological skills

To evaluate the influence of language experience on the children's phonological skills, a series of mixed model analyses were conducted with production accuracy as the dependent variable, language group (monolingual, bilingual), and phonotactic nonword type (specified for each task below) as categorical fixed factors, and by-subject random intercepts. All analyses were conducted in R (R Core Team, 2020) using the lmer function in the R package lme4 (Bates et al., 2015), with reported significance values from a type-II analysis-of-variance table calculated using the CAR package (Fox & Weisberg, 2019). Post hoc Tukey-adjusted group comparisons were conducted using the emmeans package (Lenth, 2019). All analyses were confirmatory.

Nonword repetition

Recall, there are four phonotactic nonword types in this task, diverging with respect to English probability (high vs. low), as well as Sylheti legality (legal vs. illegal). In this analysis, the dependent variable was accuracy per word. In addition to subject, word order was entered as a random factor in the model, given we had two words per trial.

Figure 1 (left) displays the children's nonword repetition accuracy spilt by the four phonotactic nonword types at Time 1. The mixed model analysis revealed a main effect of language group ($\chi^2(1) = 17.40$, $p < .001$), English probability ($\chi^2(1) = 314.76$, $p < .001$), Sylheti legality ($\chi^2(1) = 73.37$, $p < .001$), and a significant interaction between language group and English probability ($\chi^2(1) = 4.68$, $p < .05$), and language group and Sylheti legality ($\chi^2(1) = 45.29$, $p < .001$). Post hoc group comparisons revealed no significant language group difference for the Sylheti legal items, ($p > .05$), but the bilinguals had significantly lower production accuracy for the Sylheti illegal items than the monolinguals ($p < .001$). Furthermore, the bilinguals had significantly lower accuracy for the Sylheti illegal items than for the Sylheti legal items ($p < .001$), whereas the monolinguals did not (all $p > .05$). Both language groups had significantly lower accuracy for English low probability items than for English high probability items ($p < .001$), the difference between the probability groups was larger for the monolinguals. See Supplementary Material C for R formulae, full-comparison tables, and effect sizes.

Phonological awareness: Phoneme elision

Figure 2 (left) displays the children's phoneme elision accuracy at Time 1, with raw score split by Sylheti legality (*legal*, *illegal*). The mixed effects model revealed a main effect of language group ($\chi^2(1) = 6.89$, $p < .01$), Sylheti legality ($\chi^2(1) = 221.17$, $p < .001$), and a significant interaction between language group and Sylheti legality ($\chi^2(1) = 8.33$, $p < .01$). Overall, the bilinguals and monolinguals had lower accuracy for the Sylheti illegal items than the Sylheti legal items (both $p < .05$). The bilinguals, however, had lower accuracy scores than the monolinguals for the Sylheti illegal items ($p < .05$), but there was no language group difference for the Sylheti legal items ($p > .05$). See Supplementary Material D for R formulae, full-comparison tables, and effect sizes.

TABLE 1 Descriptive statistics (total raw scores) for the variables measured at Time 1 and 2, including the effect size and p value for comparisons for each measure at both time points

Measure	Monolinguals M (SD)		Time comparison effect size (Cohen's d[a]) and p value	Bilinguals M (SD)		Time comparison effect size (Cohen's d[a]) and p value	Group comparison effect size (Cohen's d[a]) and p value	
	Time 1 ($n = 43$)	Time 2 ($n = 39$)		Time 1 ($n = 58$)	Time 2 ($n = 50$)		Time 1	Time 2
Language and cognitive								
WRIT NVIQ[b]	21 (6.18)	—	—	19 (4.61)	—	—	0.25	—
CTOPP memory for digits	15 (2.04)	19 (2.75)	−1.22***	15 (2.04)	18 (3.03)	−1.11***	0.09	0.31
BPVS receptive vocabulary	93 (12.60)	109 (13.92)	−1.31***	80 (8.39)	96 (11.52)	−1.34***	1.23**	1.13***
Phonology								
CTOPP phoneme elision	19 (3.11)	21 (3.14)	0.63*	16 (4.50)	20 (3.66)	−0.91***	3.38**	0.26
Nonword repetition	37 (6.10)	40 (8.22)	−0.57***	30 (2.49)	42 (5.76)	−1.63***	0.82**	0.28
Reading								
YARC letter sound knowledge[b]	31 (2.49)	—	—	31 (1.28)	—	—	−0.21	—
CTOPP RAN digits (milliseconds taken)	25 (5.36)	20 (4.86)	0.96***	27 (5.41)	18 (3.52)	1.72***	−0.38*	0.33
CTOPP RAN letters (milliseconds taken)	30 (11.85)	22 (4.83)	0.79**	36 (16.17)	22 (6.02)	1.40***	−0.49**	−0.01
SWRT reading accuracy	27 (9.83)	40 (8.53)	−1.33***	24 (10.16)	36 (9.35)	−1.90***	0.26	0.41

Abbreviations: BPVS, British Picture Vocabulary Scale; CTOPP, Comprehensive Test of Phonological Processing; RAN, rapid automatized naming; SWRT, Single Word Reading Test; WRIT, Wide Range Intelligence Test; YARC, York Assessment of Reading Comprehension.

[a]Cohen's d effect size reflects the size of the group differences in the measurements at each time point. See Supplementary Material C for full group comparison table.

[b]Time 1 only.

*$p > .05$; **$p > .01$; ***$p > .001$.

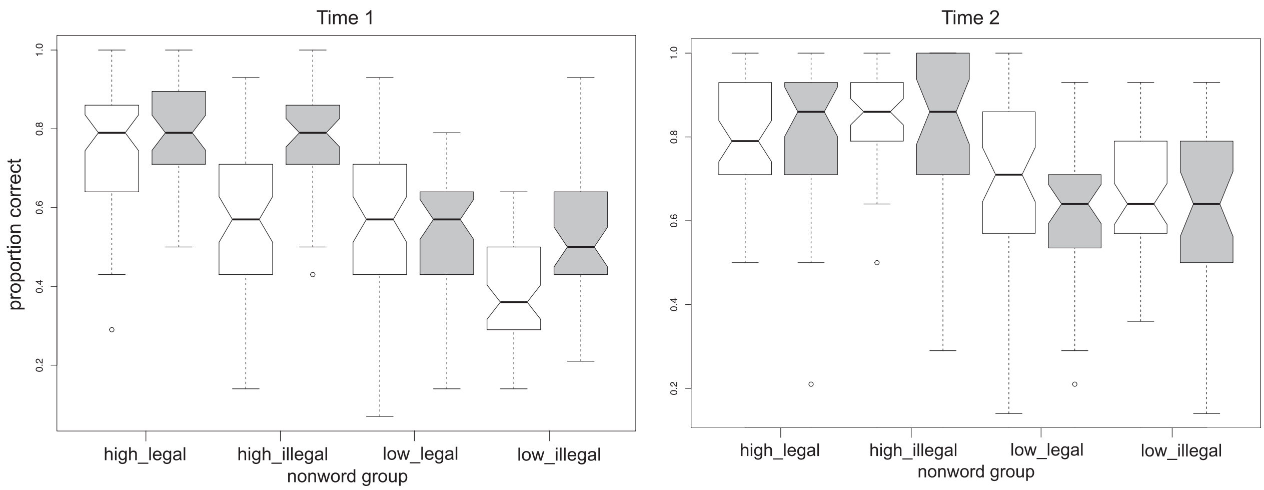

FIGURE 1 Boxplots of bilingual (white) and monolingual (grey) children's production accuracy for the nonword repetition task at Time 1 and Time 2. Items are split by English probability (high, low) and Sylheti legality (legal, illegal). The notches represent 95% confidence intervals.

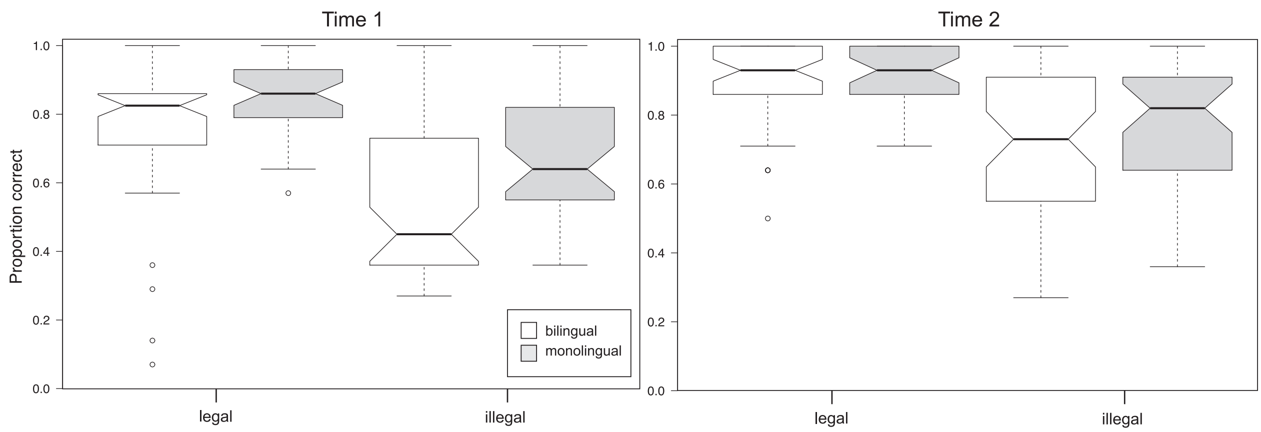

FIGURE 2 Boxplots of bilingual (white) and monolingual (grey) children's production accuracy for the CTOPP-II phoneme elision task at Time 1 and Time 2. Items are split by Sylheti legality (legal, illegal). The notches represent 95% confidence intervals.

Language and literacy measures

A series of t-tests revealed significant language group differences for vocabulary and RAN letters and digits (all $p < .05$). The bilinguals had lower scores than the monolinguals for these measures. There was no significant difference between the language groups for NVIQ, digit recall, letter sound knowledge, and single word reading accuracy (all $p > .05$). All children were at ceiling for letter sound knowledge, this measure was therefore not used in any further analysis. See Table 1 for a summary, and Supplementary Material E for the full-comparison table. Correlation analyses revealed that RAN digits and letters were correlated (r = .29, $p < .01$), we therefore computed a composite RAN score for subsequent analysis, by summing z-scores for digits and letters (see also Lervåg & Hulme, 2009 for findings on the longitudinal relationship between these measures).

The relationship between language-specific phonological skills and reading accuracy

The aim of this section is to explore the relationship between the phonological skills outlined above and reading accuracy. We conducted a hierarchical regression analysis (HLM) to explore how much of the variance in the children's reading accuracy can be accounted for by the bilingual's language-specific phonological skills, once we control for other measures that account for variance in early reading accuracy (Lervåg & Hulme, 2009). We ran separate HLMs for the bilinguals and monolinguals, to explore how each variable accounted the individual variance in reading accuracy for each group separately.

We created a composite phonology score for the regression analysis, because both phoneme elision and nonword repetition revealed legality effects, and both measures were correlated with each other and reading accuracy (all $p < .05$, see Supplementary Material F for the correlation table). Furthermore, this ensured that we had a suitable number of predictor variables given our sample size (Raudenbush & Bryk, 2002). The composite score was computed by summing z-scores for the measures, resulting in two measures of phonology: 1. phonology legal, and 2. phonology illegal. The results of the Pearson correlations between the phonology composite scores and reading accuracy reflected the same pattern as the individual measures (*phonology legal*, monolingual: $r(42) = .50$, $p = .001$, bilingual: $r(56) = .54$, $p < .001$; *phonology illegal*, monolingual: $r(42) = .50$, $p = .001$, bilingual: $r(56) = .60$, $p = .001$).

Prior to conducting the analyses, the relevant regression assumptions were tested, including normal distributed residuals, collinearity (i.e., variance inflation factor values ≤2 and correlation between independent variables $r < .8$), and homoscedasticity (Gelman & Hill, 2007). All analyses were conducted in R (R Core Team, 2020) using the lm() and anova() functions to compute the R^2 and adjusted R^2 for each model, as well as the *beta* statistics, standard error and p values for each independent predictor variable. Standardized beta statistics were computed using the *QuantPsyc* package (Fletcher, 2012).

We also calculated the relative importance (RI; contribution to the R^2) of the predictors in the models. Here, RI takes into account that variable's correlation with reading accuracy, and its effect on reading accuracy after accounting for all other variables included in the model. The RI of the predictors in the final model was calculated using the *relaimpo* package (Grömping, 2006). We extracted normalized *lmg* values (sum of 1.00) for each variable, with each value representing the proportionate contribution to R^2. We also extract their 95% confidence intervals (CI) derived from bootstrapped samples.

We conducted separate hierarchical regression analyses using a three-step fixed-entry model. Step 1 included vocabulary to control for the individual differences in the children's general English language skills, we also included RAN in the initial step, as previous research has shown RAN to be a strong predictor of reading accuracy (Lervåg & Hulme, 2009), and this measure was significantly correlated with reading accuracy for both groups. In step 2, we entered the legal phonology measure, that is, the children's accuracy for items that would be phototactically legal in both English and Sylheti. This was entered in the second step because our previous analysis showed that the bilinguals were more accurate with phonotactic sequences that were legal in their L1, than the Sylheti illegal items. It was therefore thought that both groups would have similar phonological representations for the legal phonology measure. The final step included the illegal phonology measure, to see how much additional variance in the children's reading accuracy is accounted for, once the measure of legal phonology and all other measures were controlled.

As shown in Table 2, vocabulary and RAN significantly predicted reading accuracy, for both groups. This initial step accounted for 30% of unique variance for the monolinguals and 47% for the bilinguals. The inclusion of the legal phonology measure was significant for both groups. This step explained an additional 5% of unique variance for both groups, and the change in R^2 was significant. Finally, the addition of the illegal phonology measure explained an additional 4% of unique variance for the bilinguals, and this change in R^2 was significant. The addition of the illegal phonology measure did not result in a significant change for the monolinguals. Together, the measures accounted for 33% of unique variance for the monolinguals and 56% for the bilinguals. See Supplementary Material F for R formulae.

Inspection of the RI values for the monolingual model indicated minimal difference between the variables, with vocabulary accounting for most of the R^2 (RI = .306, 95% CI [.0707, .5611]), followed by the phonology measures, with no difference in Sylheti legality (*legal* RI = .259, 95% CI [.0440, .533]; *illegal* RI = .230, 95% CI [.069, .485]), and finally RAN (RI = .204, 95% CI [.0210, .6237]). For the bilinguals, RAN accounted for the majority of the R^2 (RI = .447, 95% CI [.251, .625]), followed by Sylheti illegal phonology (RI = .269, 95% CI [.132, .388]), then Sylheti legal phonology (RI = .183, 95% CI [.080, .342]), and vocabulary (RI = .099, 95% CI [.013, .297]).

Discussion: Time 1

The Time 1 results showed that the bilinguals' L2 phonological processing skills were modulated by their L1, Sylheti, phonotactics. The bilinguals produced more errors for words and nonwords that violated Sylheti phonotactics versus those that aligned with the Sylheti syllable structure. This resulted in lower accuracy scores for the bilinguals than monolinguals, driven by the bilinguals' lower accuracy on the illegal-Sylheti items. Specifically, we found a significant difference between the bilinguals and monolinguals for the Sylheti illegal items, but not for the Sylheti legal items in both tasks. These results highlight that, in addition to well-reported overall cross-language transfer effects (e.g., Gottardo et al., 2021), specific structural discrepancies between languages can also impact phonological processing (as in Chen et al., 2004; Kuo & Anderson, 2010; Kuo et al., 2016, Saiegh-Haddad, 2019; Wade-Woolley & Geva, 2000). It is important to note that for phoneme elision task, the monolinguals were also less accurate for the Sylheti illegal items than the Sylheti legal items (albeit still more accurate than the bilinguals). This is possibly because as a standardized measure, unlike our nonword repetition task, it lacks control of other aspects of word structure

TABLE 2 Hierarchical regression analyses of the Time 1 measure predicting time 1 word reading accuracy for the monolinguals and bilinguals

Time 1: reading accuracy

	Monolingual			Bilingual		
	***n* = 43**			***n* = 57**		
Time 1: predictors	***B***	**SE**	***β***	***B***	**SE**	***β***
Step 1						
BPVS vocabulary	0.32	0.10	.41**	0.27	0.10	.26*
CTOPP RAN composite	−2.30	0.91	−.33*	−3.74	0.63	−.59***
R^2	.30			.47		
F	9.90**			26.11***		
Step 2						
BPVS vocabulary	0.26	0.10	.40**	0.19	0.10	.19*
CTOPP RAN composite	−1.61	0.94	−.21	−3.15	0.64	−.50***
Phonology legal	1.77	0.88	.34*	1.63	0.67	.26*
R^2	.35			.52		
ΔR^2	.05* (F = 9.90, p = .03)			.05* (F = 26.11, p = .03)		
F	8.45***			20.97***		
Step 3						
BPVS vocabulary	0.24	0.11	.31*	0.12	0.10	.12
CTOPP RAN composite	−1.53	0.97	−.22	−2.93	0.63	−.46***
Phonology legal	1.49	1.05	.24	0.64	0.80	.10
Phonology illegal	0.58	1.16	.10	1.83	0.87	.28*
R^2	.33			.56		
ΔR^2	.003 (F = .25, p = .62)			.04* (F = 4.47, p = .03)		
F	6.27***			17.84***		

Note: NVIQ was previously included in step 1 of the model but was not significant nor did it change the R^2 statistic.
Abbreviations: ΔR^2, change in R^2; β, standardized beta coefficient; B,unstandardized beta coefficient; BPVS, British Picture Vocabulary Scale; CTOPP, Comprehensive Test of Phonological Processing; R^2, adjusted R^2; RAN, rapid automatized naming; SE, standard error, F, statistic is provided for the model.
*p > .05; **p > .01; ***p > .001.

(e.g., word frequency, phoneme length, probability), simply because the task was not originally designed to explore Sylheti phonotactic legality, unlike our tailored nonword repetition task.

The second aim was to see if these language-specific patterns in phonological processing differentially predicted the bilinguals' English single-word reading accuracy. The motivation for looking at predictors of reading accuracy was to see if language-specific phonological skills predicted bilinguals' reading accuracy skills once we controlled for factors that previous research has shown to be important predictors for reading accuracy (Hulme & Snowling, 2013). We predicted that the language-specific phonological skills would differentially predict reading accuracy in the bilinguals but be equally predictive for the monolinguals, who should not be subject to such L1-L2 phonological influences. Note that there was no significant difference between the monolinguals and bilinguals in their reading accuracy scores.

As predicted, based on previous research, both RAN and vocabulary accounted for large proportion of variance in the monolinguals' and bilinguals' reading accuracy. For the monolingual and bilingual model, the addition of legal phonology in the next step was significant, resulting in a significant increase in the proportion of variance being accounted for by the model. In the final step, we added the illegal phonology measure. For the monolingual model, this made no difference in terms of how much of the variance in reading was accounted for by the model. This is not surprising given the monolinguals' performance our phonology task showed no difference between the two Sylheti legality groups. In contrast, the bilingual model demonstrated a significant increase in R^2 when the illegal phonology measure was added in the final step of the regression analysis, with illegal phonology being a significant predictor. What this shows is the bilinguals' performance on our illegal phonology measure accounts for an additional amount of variance in the children's reading accuracy, above what is accounted for by the legal phonology measure alone. As in the L2 immersion context studied by Wade-Woolley and Geva (2000), these findings show a distinct influence of our bilinguals' first language phonology on their L2 reading accuracy, crucially once we control for other factors that are known to be strong predictors of reading accuracy.

The relative importance analyses showed that receptive vocabulary accounted for the largest proportion of variance in the monolingual model, however, there was no significant difference in the relative weight of all the variables in the model. For the bilingual model, RAN accounted for largest proportion of variance, followed by illegal phonology.

In sum, at Time 1, we found language-specific effects in the bilinguals phonological processing. Our hierarchical regression analyses found that this language-specific phonological processing accounted for a significant amount of variance in the bilinguals' reading accuracy, even when we control for other factors that are known to drive bilingual reading accuracy (RAN and vocabulary). To understand how this changes with increased experience with literacy, we followed the children up 20 months later, Time 2.

TIME 2

Participants

Children were tested again approximately 20 months later, when they were in Year 3 (monolinguals: $\underline{x}_{age}$ = 7;8, n = 38; bilinguals: $\underline{x}_{age}$ = 7;8, n = 51). The attrition rate was 11%, with 12 children not being available to test at Time 2 because they had moved schools or left the U.K. At Time 2, we checked with teachers and caregivers that the children had passed any in-school hearing tests, and that they did not have a recent history of ear infection, or recently identified speech and language difficulty.

Materials and procedure

Children completed the same test battery as Time 1, except the screens and Letter Sound Knowledge. As at Time 1, children were tested individually in a quiet room in their school over three 20- to 25-min sessions, for an average of 70 min in total per child, including short breaks between tasks.

Results

For the Time 2 measures, all children were no more than 2 SD from the mean and did not differ from the normal distribution. See Table 1 for a summary. All analyses were conducted in R (R Core Team, 2020) using the same functions and packages reported at Time 1.

Phonological skills

As for Time 1, a series of mixed model analyses were conducted with production accuracy as the dependent variable, language group (monolingual, bilingual) and phonotactics (specified for each task as before) as categorical fixed factors, and by-subject random intercepts. Following this, to evaluate changes over time, we ran mixed models with time (Time 1, Time 2) added as a fixed factor, in addition to the factors listed above.

Nonword repetition

Recall that in this task, there were four phonotactic nonword types, diverging with respect to English probability (high vs. low) and Sylheti legality (legal vs. illegal). The mixed effects model only revealed a main effect of English probability ($\chi^2(1)$ = 191.42, p < .001). As can be seen in Figure 1 (right), all children had lower accuracy for the English low-probability nonwords than the English high-probability nonwords. All other main effects and interactions were not significant (all p > .05).

To explore changes between Time 1 and Time 2 (Figure 1 left vs. right), we ran a similar model including all data and added time as a fixed factor. This model showed main effects of language group ($\chi^2(1)$ = 3.85, p = .05), time ($\chi^2(1)$ = 285.14, p < .001), English probability ($\chi^2(1)$ = 515.70, p < .001) and Sylheti legality ($\chi^2(1)$ = 37.17, p < .001): Monolingual children outperformed bilingual children in general, production accuracy increased between Time 1 and Time 2, and English high-probability items were being solved more accurately than English low-probability items, ditto for Sylheti legal versus Sylheti illegal items. There also was a significant three-way interaction between language group, Sylheti legality, and time ($\chi^2(3)$ = 17.99, p < .001): The language group differences with respect to Sylheti legality that were found at Time 1 (bilingual children being affected by Sylheti legality, while monolingual children were not) were no longer present at Time 2. See Supplementary Material C for R formulae, full-comparison tables, and effect sizes.

Phonological awareness: Phoneme elision

Recall that for this task, only two nonword types, differing in Sylheti legality (legal vs. illegal), were distinguished. At Time 2 (Figure 2, right), the mixed effects model revealed a main effect of language group ($\chi^2(1)$ = 4.97, p < .05) and Sylheti legality ($\chi^2(1)$ = 187.88, p < .001), and a significant interaction between language group and Sylheti legality ($\chi^2(1)$ = 4.25, p < .05). Overall, the bilinguals and monolinguals had lower accuracy for the Sylheti illegal items than the Sylheti legal items (both $p < .05$). There was a significant language group difference for the Sylheti illegal items ($p < .05$), but not for the Sylheti legal items ($p > .05$).

Changes from Time 1 to Time 2 (Figure 2 left vs. right) were analyzed using a similar mixed effects model including time as a fixed effect. It revealed a main effect of language group ($\chi^2(1) = 5.68$, $p = .02$), Sylheti legality ($\chi^2(1) = 238.04$, $p < .001$), and time ($\chi^2(1) = 55.57$, $p < .001$), with both groups displaying a significant increase in accuracy from Time 1 to Time 2. As for the individual time point analyses, we also found a significant interaction between language group and Sylheti legality ($\chi^2(1) = 5.73$, $p = .02$): with the bilinguals showing a lower accuracy for the Sylheti illegal items than the monolinguals ($p < .05$), but not for the Sylheti legal items ($p > .05$). See Supplementary Material D for R formulae, full-comparison tables, and effect sizes.

Language and literacy measures

Group comparisons revealed that the bilinguals had significantly lower scores than the monolinguals for vocabulary ($p < .05$), but there were no significant differences between the groups for all other measures. We also found a significant improvement from Time 1 to Time 2 for all measures ($p < .05$). Table 1 provides a summary of the descriptive statistics for each measure, see Supplementary Material E for full comparison tables.

Our smaller sample size was deemed insufficient for the hierarchical regression analysis conducted at Time 1 (Raudenbush & Bryk, 2002). We were therefore not able to explore the relationship between the children's phonological skills and reading accuracy at Time 2.

Discussion: Time 2

At Time 2, the language-specific effects and group differences were no longer present in our nonword repetition task, which was tailored to explore English-Sylheti phonotactic interactions. At this time, we did not find any Sylheti-specific effects, we only found that all children performed better for nonwords with high phonotactic probability in English than for low probability nonwords, confirming a well-established effect (Coady & Aslin, 2004; Edwards et al., 2004; Messer et al., 2010, 2015). Differences with respect to Sylheti legality were still present for bilinguals in the phoneme elision task—but given that even monolinguals also showed such differences at Time 1, and the monolinguals at Time 2 were close to ceiling, the interpretation of these effects and interactions is not straightforward. Furthermore, as already discussed using a standardized measure meant we were unable to control for other word structure factors such as probability, like we did for our nonword task.

These findings add to that growing body of research showing how bilinguals' phonological knowledge may change with increased L2 experience (see also, Jasińska & Petitto, 2018; Messer et al., 2015). This could be explained by the children's accumulated English experience from Time 1 to Time 2, potentially combined with the onset of reading (see e.g., Nation & Hulme, 2011). As a result, what we see is a refinement in the bilinguals' L2 phonological representations, in particular their phonotactic knowledge for patterns that do not exist in their previously dominant L1.

As we found at Time 1, the high English probability nonwords were recalled more accurately than low probability nonwords in both groups. To our knowledge, this study is one of few to explore how this develops longitudinally (see also Messer et al., 2015). We found that over time, our bilinguals showed an improvement in their production accuracy of the high and low probability nonwords (both Sylheti legal and Sylheti illegal). The monolinguals also improved in their production, but this was only significant for the low-probability nonwords, likely because they were already at a high accuracy rate for our high probability at Time 1.

For reading accuracy, all children improved and as with Time 1, we found no significant difference between the monolinguals and bilinguals. Our attrition rate meant that our Time 2 smaller sample size was insufficient for the hierarchical regression analyses we ran at Time 1, but we also did not find clear signs of language-specific phonological processing at Time 2, making this analysis no longer as meaningful.

GENERAL DISCUSSION

This study investigated the influence of bilinguals' first language (Sylheti) phonology on the development of their L2 (English) phonological skills, and the relationship between phonological skills and L2 reading accuracy, in comparison with a matched English monolingual control group. Specifically, we investigated how Sylheti-English bilinguals perform on tasks that include phonological structures that are shared in Sylheti and English (*Sylheti legal*), and those that are not shared (*Sylheti illegal*). We investigated the influence of L1 phonotactic knowledge on our bilinguals' performance on two production tasks: phonological awareness (phoneme elision) and nonword repetition (NWR), both of which have been shown to be strong predictors of early decoding (Cunningham et al., 2021).

Both tasks showed a language-specific effect at Time 1, that is, group differences for the Sylheti illegal items, but not for the Sylheti legal items. For the phoneme elision task, the monolinguals were also less accurate for the Sylheti illegal items than the Sylheti legal items (albeit still more accurate than the bilinguals). As already discussed, a possible explanation for these findings is, as a standardized measure, phoneme elision measure lacks control of other aspects of word structure such as probability. The NWR task was more carefully controlled and designed to incorporate Sylheti phonology, such that half the items violated Sylheti phonotactics, while also accounting for English phonotactic probability. Here, we found distinct group differences for Sylheti legality, that is, unlike the bilinguals, the monolinguals did not display a Sylheti legality effect.

What is interesting is that previous research also found language-specific effects in sequential bilinguals, but in the acoustic-phonetic domain (voice onset time, vowel formants) at slighter younger age, that is, 4-years-old, 7 months after being immersed in English-speaking school (McCarthy, 2013; McCarthy et al., 2014). Already by 5–6 years old, with more experience in English-speaking full-time education, these effects were mostly no longer present (but see Kirkham & McCarthy, 2021). In the current study, we found language-specific effects for tasks that tap into more complex phonological structures, suggesting that cross-linguistic differences may continue to influence higher-level phonological processing beyond individual segments, even when earlier acoustic-phonetic L1 patterns may no longer present. This adds to the previous research that has shown how structural differences can modulate phonological processing (Chen et al., 2004; Kuo & Anderson, 2010; Kuo et al., 2016; Saiegh-Haddad, 2019; Wade-Woolley & Geva, 2000). Our findings expand on this work by showing that language-specific structural differences can impact bilingual children's productive accuracy in tasks that have been shown to be important predictors of early word reading, beyond phoneme discrimination or identification.

At Time 1, we were able to explore how the children's language-specific phonological processing patterns differentially predict their reading accuracy, once we controlled for factors that previous research has shown to be important predictors for reading accuracy (Gottardo et al., 2021; Hulme & Snowling, 2013). It is important to note that the bilinguals and monolinguals in this study did not differ in terms of their overall single-word reading accuracy. The aim here was to test if a language-specific approach to phonological processing can explain the variance in reading accuracy in this population. Indeed, for the bilingual participants, phonotactic legality explained a significant part of the variance even once we controlled for other linguistic abilities, such as vocabulary and RAN.

The distinct importance of phonology and RAN, over vocabulary in the bilingual model warrants some discussion. In this study, receptive vocabulary was used as an index of general language abilities. In terms of its predictive role in the bilinguals' Time 1 reading accuracy, vocabulary may have been less relied on by the bilinguals because bilinguals' L2 vocabulary tends to be less developed and more heterogeneous than monolinguals, and strongly influenced by language exposure patterns (e.g., Hoff et al., 2012). Thus, bilinguals may be less able to rely on consistent oral word knowledge during early reading. Instead, phonology and RAN accounted for most of the variance in reading accuracy. This aligns with studies that have shown both RAN and phonology play a predictive role in reading accuracy, in particular in the earliest stages of learning to read an alphabetic language (e.g., Powell & Atkinson, 2021; Yeung, 2016).

Finally, we were able to follow up the majority of the children 20 months later, at age 7;8, in Year 3. By that time, their performance on all phonological processing tasks had improved, and the phonotactic legality of the sequences did not significantly influence performance anymore (except for the phoneme elision task, where this effect was also shown by monolingual participants). Due to a 11% drop out rate, we were not able to assess the role of phonotactic legality in reading accuracy via hierarchical regressions at this second-time point, but the lack of significant language-specific influences on our Sylheti phonology measures during this later stage of development no longer justified a differential analysis of legality for the two language groups. The finding that bilinguals showed similar patterns to the monolinguals with more English exposure mirrors the results found by earlier studies in the acoustic-phonetic domain (McCarthy, 2013; McCarthy et al., 2014), but at an older age and after the beginning of formal reading instruction.

At Time 1, the bilinguals performed worse than the monolinguals for RAN (letters and digits), but this was not significant at Time 2. This may be due to the fact that the RAN was run in their L2, in which lexical access may not have been as efficient as in their L1. At both time points, the bilinguals had lower receptive vocabulary scores than the monolinguals, thus replicating the well-known vocabulary effect found in many other childhood L2 studies (Hoff et al., 2012). Finally, we found no difference between the groups for our measure of general cognitive ability (NVIQ and digit recall).

To sum up, at Time 1 we found a distinct influence of the bilinguals' first language phonology on their L2 reading accuracy. The bilinguals' performance on our illegal phonology measure accounted for an additional amount of variance in the children's reading accuracy, above what is accounted for by the legal phonology measure alone. While there is strong evidence for the importance of phonological skills for early reading accuracy in general, our findings suggest that bilinguals' L2 reading accuracy is modulated by their first language phonology. Although we cannot make direct statistical comparisons between the monolingual and bilingual models, our findings suggest that the mechanisms driving L2 reading accuracy in sequential bilinguals, in particular the role of phonology, may be different from monolinguals and influenced by their overall (L1 and L2) phonological representations.

One clear limitation of our study was our inability to assess the predictors of reading skills via a comprehensive model at Time 2. Likewise, it would be interesting to further explore the predictive role of initial phonological skills on later reading comprehension, as well as different reading strategies, in monolingual and bilingual children, while accounting for other potential linguistic differences between the groups, that is, in oral vocabulary and morphosyntax, which are crucial for reading comprehension and often contribute to poor reading performance (Cain & Oakhill, 2011). Moreover, our study assessed only one particular L1-L2 language pair—further research is also needed to establish whether similar patterns are found in bilinguals acquiring other languages, with different degrees of phonotactic overlap with English, and also with children who also learn to read in their L1, like the children in the immersion context studied by Bruck and Genesee (1995). Likewise, our study does not reveal how increased L2 experience and the onset of L2 literacy impacts the children's L1 phonological skills. Tracking both languages, both phonology and phonological related tasks such as RAN, would provide a more complete picture of their developing phonological system.

Despite these limitations, the current findings already have both theoretical and practical implications. As far as theories of phonological acquisition are concerned, our study shows how sequential bilinguals' L2 phonological processing can be affected by L1 properties long after initial difficulties at the phonetic level (e.g., McCarthy et al., 2014) may have resolved, and how these processing differences have a knock-on effect on early reading. Even if overall reading accuracy did not differ between monolinguals and bilinguals, our regression analysis suggests that bilinguals' reliance on phonological skills may be more prolonged than monolinguals during these early stages of reading. Monolinguals, in contrast, already show greater effects of vocabulary, which may signal the beginning of a stronger application of reading strategies for comprehension.

The fact that sequential bilinguals' initial difficulties with L2 phonotactics influences their reading accuracy also raises suggestions for educational practice. Even if these problems seem to be only transient and do not lead to bilinguals' overall reading accuracy scores being poorer than monolinguals, they may contribute to initial difficulties with reading certain words, and the impact of this on later reading and academic achievements should not be underestimated. Reading acquisition seems to be heavily affected by the "Matthew effect," creating rich-get-richer and poor-get-poorer patterns of reading achievement (Stanovich, 1986) through reciprocal relationships between different facets of reading abilities (decoding and phonological awareness, vocabulary, and comprehension) and reading practice and motivation. For instance, first-grade reading ability is a strong predictor of 11th-grade reading abilities, which suggests that "rapid acquisition of reading ability might well help develop the lifetime habit of reading, irrespective of the ultimate level of reading comprehension ability that the individual attains" (Cunningham & Stanovich, 1997). Thus, it seems crucial to tailor our provisions to eliminate any possible obstacles to early reading success, such as the phonotactic difficulties that have been presented in this study. Future research could investigate if bilingual children benefit from tailored assessment and early reading skills programs, for example, Phonics in the UK, where programs target-specific sound sequences based on the child's home language. So far, the majority of these specific intervention reading programs for bilinguals have focussed on the well-known vocabulary weaknesses in these populations (e.g., Murphy & Unthiah, 2015).

To conclude, this study investigated the influence of L1 phonotactics on the phonological skills of Sylheti-English sequential bilinguals, and how these skills differentially predict their reading accuracy. Our study is particularly unique because it combines a very specific cross-linguistic approach to the L2 phonology phenomena with a broader assessment of reading accuracy. We show that a detailed and specific assessment of L1 phonological transfer effects has an important role to play in explaining bilinguals' success at skills that have been shown to be key for early reading accuracy. Our findings highlight the importance of taking into account home language structure in literacy education for bilingual children who grow up similar diaspora communities in large urban centers, to ensure adequate support in the earliest stages of their academic journey.

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ORCID

Kathleen M. McCarthy https://orcid.org/0000-0003-0011-246X
Katrin Skoruppa https://orcid.org/0000-0002-5675-5993

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