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Title: A preliminary report on the English phonology of typically developing English–Mandarin bilingual preschool Singaporean children

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ABSTRACT

Background

There are no published data on typical phonological development for Singaporean children. There is therefore the risk that children's speech in Singapore may be misdiagnosed or that clinicians may set goals erroneously.

Aims

This paper reports a preliminary study on the English phonology of typically developing 4;0-4;5 year old Chinese Singaporean children who speak English and Mandarin.

Method and Procedures

70 children were recruited throughout Singapore and speech samples were collected in English using the Phonology Assessment of the Diagnostic Evaluation of Articulation and Phonology (DEAP). The participants were divided equally into two groups – English-dominant and Mandarin-dominant. Their speech samples were compared with British English targets (BT) and Singapore English targets (ST) in terms of phonological accuracy and types of phonological processes used.

Outcomes and Results

The results showed that Singaporean children's phonological accuracy scores increased significantly when scored against ST instead of BT. When scored against ST, English-dominant children were found to perform similarly to their DEAP counterparts. However, Mandarin-dominant children had significantly less accurate consonant production in English and exhibited more interference effects from Mandarin phonology than English-dominant children.

Conclusions and Implications

In this preliminary study, the results highlight the importance of speech and language therapists using local dialect pronunciations to be the target of speech assessments so as to provide appropriate assessment and intervention. It is also essential to account for the language background and language dominance of the children. More local normative data are needed for the typical acquisition of Singapore English in children, especially for children whose dominant language is not English.

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

What this paper adds

What is already known on this subject?

The dialect of English in Singapore varies from the target pronunciations of words used in the published standardised speech and language assessments for English-speaking children. Little is known about the phonological development of Singaporean children and many, if not all, are brought up in a bilingual environment. Hence, it is difficult for professionals to accurately determine the presence and severity of a phonological impairment.

What this study adds

The phonological features of Singapore English markedly differ from those of British English and other Standard Englishes. Professionals who are not familiar with these features are highly likely to misdiagnose children with phonological impairments. When dialectal features are accounted for, English-dominant bilingual children appear to have similar phonological systems to monolingual English-speaking children. However, children whose dominant language is not English have dissimilar phonological development and further study is needed in this area to facilitate accurate differential diagnosis of speech impairment.

INTRODUCTION

Most speech acquisition studies and normative samples of standardised phonological assessments have focused on speakers of British Standard English (BSE) and General American English (GAE). However, there has been a growing interest in varieties of English, in particular how speech sound systems differ across languages and dialects (Wee, 2008). In this preliminary study, we examined the phonology of Singapore English (SgE) in typically developing English-Mandarin bilingual 4;0-4;5 year old children and the issues surrounding the development of relevant normative data for this population. We will first consider the Singapore context and an analysis of Singapore English and Mandarin, followed by bilingualism and language dominance to outline the significance of this study.

The Singapore Context

Singapore has a multi-ethnic population of 5.08 million people, of which 3.77 million people are residents. The Singaporean authorities and people classify the ethnicity of residents as: Chinese (74%), Malay (13%) and subcontinental Indian (9%) (Singapore Department of Statistics, 2010). Besides the four official languages, English, Mandarin, Malay and Tamil, a variety of other languages are also spoken (e.g. Chinese dialects such as Hokkien, Teochew and Cantonese, other Indian languages like Hindi and Malayalam). Mandarin is currently the most commonly used language for the Chinese population; however, census data show that the preference for English increases as educational qualifications rise and as income rises (as reflected by type of dwelling). Also, English is increasingly the more commonly used language for younger Singaporeans (Singapore Department of Statistics, 2010).

While there are several publications of data on SgE, to date there are none on the speech acquisition of children in Singapore. In Singapore, many speech and language therapists (SLTs) are non-Singaporeans and most practising clinicians were trained overseas. Paediatric therapy is carried out mostly in English and formal assessments are used in clinical environments (Cruz-Ferreira & Ng, 2010). However, due to the lack of local normative data, content and linguistic bias in the assessments, even SLTs who are native speakers of SgE may have difficulties making accurate judgments. International studies have shown that the absence of normative data increases the likelihood of undesirable outcomes such as an over/under diagnosis of cases, misjudged severity and/or inappropriate intervention goals (Yavas, 2007; De Lamo White & Jin, 2011; Hambly, Wren, McLeod & Roulstone, 2013). Thus, relevant norms for speech acquisition of local languages are required.

Local dialects in Singapore

Due to years of language contact and multilingualism, local dialects of languages have developed in Singapore (Gupta, 1998), of which SgE and Singapore Mandarin (SgM) are relevant to this study. SgE has been examined in relation to BSE and SgM in relation to Putonghua (also known as Modern Standard Mandarin). Phonological features that differentiate the Singapore variety from either BSE or Putonghua are labelled as dialect features.

Singapore English

Variation exists within SgE due to factors like educational level, socio-economic background and ethnicity of the speakers as well as the formality of the context (Gupta, 1998, Poedjosoedarmo, 2000). Singapore Standard English (SSE) is used in formal situations such as education and politics. Singapore Colloquial English (SCE) or 'Singlish' is used mainly at home and in casual situations (Cruz-Ferreira & Ng, 2010).

The term 'SgE' in this study incorporates both SSE and SCE since both varieties mostly share the same phonological features. Tables 1 and 2 summarise the dialect features involving consonant and vowel production respectively, which differentiate SgE from BSE (Hung, 1995; Bao, 2003; Deterding, 2007; Wee, 2008). It is important to note that while the following features have been observed, not all speakers utilise all the features or use them in every context.

Insert Table 1 about here

Insert Table 2 about here

Dialect features of SgE that could have arisen due to cross-linguistic influences between English and Mandarin[1] include:

- Dental fricatives – /θ, ð/ may not be spoken by Singapore speakers as they neither occur in Mandarin nor Malay (Deterding, 2010);
- Final consonant cluster reduction - the reduction of maximum number of consonants in the syllable-final position in SgE could be due to the influence of Mandarin which does not have clusters. Cluster reduction could also be associated with the lack of inflectional morphemes in Mandarin; hence final consonants or syllables associated with morphological suffixes such as plural {s}, {es} or present progressive {ing} may be omitted (Lin & Johnson, 2010);
- Final obstruent devoicing – voicing is not a distinctive feature in Mandarin; hence Mandarin speakers may overlook voicing distinctions between English consonants accounting for the devoicing of final consonants in SgE. This feature has also been observed in Lin and Johnson's (2010) study;
- Lack of vowel length contrast – Deterding (2010) reported that this could be because neither Mandarin nor Malay (another commonly spoken language in Singapore) have contrasting vowel lengths;

[1] The terms 'English' and 'Mandarin' in this section do not denote reference to any specific dialects.

- Reduced vowels – English-Mandarin bilingual children in Taiwan were also found to substitute the schwa with another vowel in certain words. This was attributed to unfamiliarity of vowel reduction patterns in English (Lin & Johnson, 2010).

To emphasise the variability of SgE, Poedjosoedarmo (2000) found that educated Singaporeans appear to be aware of some dialect features of SgE (e.g. the lack of dental fricatives) and try to avoid them in formal speech but not in less formal speech. However, for other features like length distinction of vowels, there is less deviation between formal and less formal speech. Wee (2008) also found that unlike BSE and GAE, there is a presence of tone within words in SgE. This affects the distribution of syllabic stress but does not differentiate word meaning as it would in tonal languages. However, because it is more difficult to analyse suprasegmental features into easily quantifiable units, this study focuses on the segmental features of SgE.

Singapore Mandarin

There have been few studies on SgM and its differences from Putonghua, and these have focused mainly on consonant substitutions. Table 3 lists the findings from Yau's (2008) study. Almost all of the substitutions involve replacing a consonant that is not found in English with a consonant that is. For example, the velar fricative /x/ is replaced with the glottal fricative [h], a sound that is not found in Putonghua.

Insert Table 3 about here

Contrast between Singapore English and Singapore Mandarin phonology

With the features of both SgE and SgM in mind, Table 4 shows a comparison between the two phonologies adapted from Zhu (2006). One main difference is syllable structure – SgE is able to accommodate up to three consonants before and after a vowel whereas the maximum for SgM is one. Furthermore, SgE has many consonants that can occur in syllable-final position while SgM only allows two - /n, ŋ/. Another key difference is the marking of voice-onset time (VOT) for plosives between the 2 languages: SgE contrasts voiced with unaspirated unvoiced plosives whilst SgM contrasts aspirated and unaspirated plosives.

Insert Table 4 about here

Bilingualism and language dominance

Most Singaporean children can be considered bilingual, in the sense that they have "knowledge present (to whatever degree) in more than one language" (Valdes & Figueroa, 1994 p.4, cited in Goldstein & Washington, 2001). This is because they are exposed to at least two languages when they enter school: English, the inter-racial lingua franca and another language determined by the State based on the child's race. Therefore, a child who is ethnic Chinese will also learn Mandarin, otherwise known as their Mother Tongue (Gupta, 1998).

Studies have found both quantitative (e.g. percentage phonemes correct) and qualitative differences (e.g. types of phonological processes) between the phonological development of bilinguals and monolinguals. This can be attributed to the interaction between the phonological systems of the two (or more) languages. In some instances, there is a positive transfer whereby one sees accelerated phonological development in bilinguals compared with monolinguals. A negative transfer sees a slower rate of development in bilinguals or where there is interference. Interference is said to occur when one language influences another (Goldstein & Bunta, 2012). For example, in the study by Goldstein and Washington (2001), twelve Spanish-English bilinguals were found to use phonological processes considered atypical in monolinguals. Compared with monolinguals of the respective languages, bilinguals were observed to have a higher percent consonants correct (PCC) for English but a lower PCC for Spanish. Some children were observed to use Spanish features during English production and vice versa. In Holm and Dodd's (2006) study, the phonological accuracy of forty Cantonese-English bilingual children was found to be similar to Cantonese monolinguals but lower than that of English monolinguals. They also used a combination of phonological processes that were age-appropriate, delayed or atypical for monolingual populations of each language. This was despite the fact that monolingual developments in both languages are very similar in terms of the sequence of phoneme acquisition and phonological processes (c.f. Dodd, Holm, Zhu & Crosbie, 2003; So & Leung, 2006).

Bilinguals are seldom equally proficient in both languages and the language which the bilingual person hears or uses more frequently is known as the dominant language (Yavas, 2007). Many bilingual studies overlook the impact of dominance but Law and So (2006) found that for one hundred Cantonese-Putonghua bilinguals, Cantonese-dominant children acquired Cantonese faster than Putonghua-dominant children, and Putonghua-dominant children acquired Putonghua faster than Cantonese-dominant children. The effect of interference is often seen as the dominant language affecting the non-dominant language but there are also examples of the reverse happening (Hambly, et al., 2013). For example, Cantonese-Putonghua bilinguals used Cantonese vowels when speaking Putonghua and vice versa. They also used phonological processes considered atypical for monolingual Cantonese and Putonghua children (So & Leung, 2006). In Taiwan, 25 Mandarin-dominant Mandarin-English bilinguals used English phonological processes that may have been influenced by Mandarin phonology but their Mandarin phonology did not appear to have any English influence. When compared with BSE monolinguals, these children had similar consonant accuracy but poorer vowel accuracy. However, their phonological accuracy was similar to age-matched Mandarin monolingual children from the same country (Lin & Johnson, 2010).

Singaporean Chinese children are mostly English-Mandarin bilinguals and there is only one study on English-Mandarin phonological acquisition so far (Lin & Johnson, 2010). This study was conducted with Taiwanese children, who were exposed to dialects of English and Mandarin that differ from those in Singapore. Therefore the data collected in the aforementioned study would not be directly applicable in Singapore. In fact, we predicted that the English phonology of English-Mandarin children in Singapore would be markedly different in comparison with the English phonology of any other bilingual populations. Furthermore, given the marked difference between SgE and BSE, taking dialect features into consideration could have a huge impact on the diagnosis of speech difficulties, especially in a context where standardised speech assessments developed outside of the Singapore are in regular use. Goldstein and Iglesias (2001) found that when dialect features were not taken into account for children who spoke Puerto Rican Spanish, dialect features were counted as errors, thereby artificially inflating the occurrence of identified consonant errors and phonological processes. In clinical terms, the same study showed that when dialect features were not taken into account, 74% of typically developing children would be misidentified as having an impairment and almost all children with a phonological impairment would have been classified more severely. This is why a study of Singaporean children's speech is vital, because in addition to the issue of language dominance, the impact of dialect features needs to be investigated as well.

Aims and hypotheses

This preliminary study aimed to examine the English phonology of typically developing Chinese Singaporean children bilingual in English and Mandarin for the 4;0-4;5 year old age group. The following hypotheses were made:

i) Accounting for dialect features of SgE would:

- Increase the percentage of phonemes correct (PPC) calculated for Singaporean children;
- Decrease the type and number of phonological processes identified as being present in the speech of Singaporean children;
- Affect the identification of phonological impairment in Singaporean children.

ii) Dominance would have an impact on speech acquisition such that:

- English-dominant children's speech production would have a higher percentage of phonemes produced correctly in English than Mandarin-dominant children;
- The English speech production of the Mandarin-dominant children would display more interference effects from Mandarin phonology than that of the English-dominant children.

METHOD

Participants

Chinese Singaporean children aged 4;0 to 4;5 years (mean 4;2 years) participated in this research and were divided into either English-dominant (ED) or Mandarin-dominant (MD) groups (see Table 5). At the time of data collection, a questionnaire to reliably determine dominant language for children was not available. Thus, the children were grouped based on their parents' written and teachers' verbal reports on the child's preferred language. If the reports did not concur, then the researcher probed further with regard to the main language(s) spoken to the child at home and the language that the child's main caregiver spoke to the child. Eighty-three children participated in the study with a total data set from 70 children after 13 were excluded for the following reasons. Ten children's data were excluded because their language dominance could not be determined. Three children whose main caregiver spoke a dialect that was neither SgE nor SgM were also excluded to prevent the possibility of other dialect features affecting the results.

To participate, children had to be in good health and without any history of speech difficulties or suspected speech difficulties, so that only samples of typically developing speech were obtained. Children who did not wish to participate or wished to discontinue participation were also eliminated from the study.

Insert Table 5 about here

The children were recruited from kindergartens and childcare centres across Singapore, to provide a cross-sectional sampling of the population that allowed for representation across socio-economic status. This was to ensure that the data were sensitive to sociolinguistic variation.

Materials

Given that this study's focus is on children's English phonology, a speech assessment was only conducted in English. The *Phonology Assessment* from the Diagnostic Evaluation of Articulation and Phonology (DEAP) (Dodd, Zhu, Crosbie, Holm and Ozanne, 2002) was used to assess the children's sound system. The DEAP was chosen because it has quantifiable data on the phonological acquisition of children in the United Kingdom (UK) and Australia, which could be used for comparison purposes.

Children were asked to name 50 colour pictures which sampled all consonants in syllable-initial and –final positions, as well as all vowels and diphthongs except for /ʊə/ as in *cure*. An error was defined as a difference between the child's and expected adult's realization(s) of the speech sounds in each word. The children's productions were compared with BSE targets (BT) from the DEAP and with SgE targets (ST) that are based on the dialect features of SgE summarised in Table 1 and 2. Appendix 1 includes BT and ST with its possible vowel variations as well as the phonological processes that would have been scored if dialect features were not accounted for. Some of the vowels and vowel variations listed for

ST are not found in Table 2 but are included based on the first author's discretion as a native speaker of SgE. The definitions and examples of the phonological processes (also known as error patterns in DEAP) that are used in this study (Dodd et al., 2002, p. 76-77) can be found in Appendix 2. Appendix 3 shows the distribution of phonological processes associated with dialect features of SgE in the Phonology Assessment.

Procedure

Each child was seen individually in a quiet area by the first author, who first established rapport with the child prior to testing. The child's responses during testing were transcribed online using the broad phonetic symbols from the International Phonetic Alphabet (IPA), with diacritic markings for vowel length, aspiration, labialization and lack of audible release used where appropriate. The responses were also audio recorded using an Olympus WS-311M digital voice recorder. The recordings were used to check the accuracy of the face-to-face transcriptions and make adjustments as well as for intra- and inter-rater reliability testing. Positive feedback was provided to encourage participation and appropriate cues as instructed in the DEAP were used to elicit test items (e.g., 'The boy gave the girl some flowers. What should she say?'). The child was asked to imitate the target word if cueing failed.

Measures and analyses

The following quantitative measures were calculated:

1. Percent consonants correct (PCC): the percentage of consonants pronounced correctly out of the total number of consonants to be elicited;
2. Percent vowels correct (PVC): the percentage of vowels pronounced correctly out of the total number of vowels to be elicited;
3. Percent phonemes correct (PPC): the percentage of phonemes (consonants and vowels) pronounced correctly out of the total number of phonemes to be elicited.

The samples were also analysed qualitatively for phonological processes. As stated in the DEAP (Dodd et al., 2002), a child was identified as using a phonological process when there were at least five occurrences of that error type, e.g. cluster reduction (twice in the case of weak syllable deletion due to the low frequency of occurrence in target words). This helped to prevent the over-identification of processes that were made from errors due to chance or developmental fluctuation. The DEAP uses the following classification for these processes:

- Age-appropriate: Phonological processes used by at least 10% of children in that age group in the normative sample;
- Delayed: Phonological processes not used by 10% of the children in that age group in the normative sample but used by more than 10% of younger children;
- Atypical: Phonological processes not used by at least 10% of children of any age in the normative sample.

Reliability

To examine intra-rater and inter-rater reliabilities, the audio recordings of seven children (10%) were transcribed again by the first and third author over a month after the assessment was done. Both authors used a broad transcription of the IPA (with the diacritic markings for vowel length, aspiration, labialization and lack of audible release). The number of speech sounds that were transcribed exactly the same were calculated as a percentage of the total number of speech sounds elicited for each child. Intra-rater reliability was 96.3% while inter-rater reliability was 94.8%. Most discrepancies were related to differences in the use of diacritics, vowel symbols and glottal stops but these were resolved by re-examination.

RESULTS

The results obtained provide criterion reference data and are presented in two sections. The first compared the scores of the children, regardless of language dominance, when their data were scored against BT and when scored against ST (i.e. when dialect features stated in Tables 1 and 2 were and were not taken into consideration). The second section looked into the effects of language dominance by comparing the data of ED children with the data of MD children when scored against ST only.

Using British Standard English targets versus Singapore English targets

Table 6 shows the mean scores and standard deviations (SD) of the measures of the children's phonological accuracy, when the data were scored against BT and when scored against ST. The mean PCC when scored against ST was greater than the mean PCC when scored against BT. A related-samples *t*-test showed significance: $t_{(69)} = 25.47$, $p = < .01$(two-tailed) with an effect size of $d = 3.07$. The mean PVC when scored against ST was also significantly greater than the same when scored against BT: $t_{(69)} = 34.83$, $p = < .01$(two-tailed) with an effect size of $d = 4.16$. Similarly, the difference in the mean PPC when scored against ST and when scored against BT was significant: $t_{(69)} = 34.43$, $p = < .01$(two-tailed), with an effect size of $d = 4.11$. Figure 1 shows the comparisons between the median scores of the DEAP sample population and the children in this study when their data were scored against BT and ST. In this figure, the DEAP (grey) and ST (red) lines almost completely overlap, illustrating clearly that the children in this study had phonological accuracy scores that are very similar to monolingual children when dialect features were accounted for in the representation of target pronunciations.

Insert Table 6 about here

Insert Figure 1 about here

The children's phonological accuracy scores were converted into percentile ranks according to Appendix B on p. 68 of the DEAP manual (Dodd et al., 2002). The number of children who fell into the "average and above" ($\geqslant 16^{th}$ percentile) or "delayed" ($< 16^{th}$ percentile) categories when scored against BT and when scored against ST are shown in Figure 2. Table 7 shows the number and percentage of children who were observed to use the processes associated with dialect features of SgE (see Appendix 1) in comparison with BT and ST. Phonological processes that were not affected by whether BT or ST were chosen will be presented in the next section in terms of their use according to language dominance.

Insert Figure 2 about here

Insert Table 7 about here

English-dominant versus Mandarin-dominant

The means and standard deviations of the ST phonological accuracy scores for the ED and MD groups are shown in Table 8. Results of independent *t*-tests showed that the ED group's mean PCC was significantly higher than those from the MD group: $t_{(52.7)} = -5.54$, $p = < .01$(two-tailed), with an effect size of $d = 1.27$. Likewise, the mean PPC of the ED group was significantly higher than those from the MD group: $t_{(51.9)} = -5.00$, $p = < .01$(two-tailed), with an effect size of $d = 1.20$. Both comparisons had a large effect. In contrast, the mean PVC of the ED group was not significantly different from the mean PVC of the MD group: $t_{(68)} = -1.69$, $p = > .05$ and a small effect size of $d = 0.40$. Since PPC scores are a combination of PVC and PCC scores, these results show that ED children had a more complete English consonant inventory than MD children while the vowel inventory was not affected by language dominance.

Insert Table 8 about here

Table 9 is a formulation of percentile ranks based on the raw scores of the three phonological accuracy measures for each dominant group and for all the children as a whole. The phonological processes that were used by each group after dialect features have been accounted for are listed in Table 10 in descending order.

Insert Table 9 about here

Insert Table 10 about here

DISCUSSION

The aim of this study was to study the English phonology of typically developing Chinese Singaporean children bilingual in English and Mandarin. The first half of the discussion considers the data as a whole to investigate the effect of dialect features being taken into account in word targets on phonological analyses, in terms of phonological accuracies and phonological processes. The second half discusses the effect of language dominance on the English phonological acquisition of Singaporean bilingual children by comparing the data of English and Mandarin-dominant groups.

Dialect target and phonological accuracy

Results clearly showed that PCC, PVC and PPC scores were higher when the point of reference was ST rather than BT, and the children's median scores became comparable to that of the monolingual participant sample in DEAP (Table 6 and Figure 1). A child whose percentile ranks fall in the “delayed” range is likely to be diagnosed as having an impairment. Therefore a high percentage of typically developing children who fell in the “delayed” range (see Figure 2) when BT were chosen (100% for PVC and 60% for PCC) meant that use of BT would likely to end up in an over-diagnosis of phonological impairment. These results were consistent with Goldstein and Iglesias (2001), who reported that 74% of typically developing children in their study would have been misdiagnosed as having an impairment if dialect features were not taken into account. PVC was more impacted than PCC because vowels are greatly dependent on the dialect of English spoken by a child (Bernthal, Bankson & Flipsen, 2012). Hence, SLTs who are unfamiliar with the dialect features of SgE, especially with regard to the vowels, are at high risk of over-diagnosing children.

The reason why some typically developing children still fell in the “delayed” range when dialect features have been accounted for, (see Figure 2) could be because the percentile rankings were formulated from data of typically developing monolingual children who acquired BSE and they may not be applicable to bilingual children. When compared with monolingual children, bilingual children are likely to have different developmental trajectories (De Lamo White & Jin, 2011) as well as speech accuracy measures (see Hambly, et al., 2013). As stated by Cruz-Ferreira and Ng (2001, p. 346), “monolingual instruments will find ‘impairment’ where there is only difference and multilingual children risk ending up classified as ‘deviant’ monolinguals”. Hence, the results also suggest the need for bilingual/multilingual populations to have separate percentile ranking systems from monolingual populations. This will be discussed further in later sections.

Dialect target and *phonological processes*

Both the number of phonological processes and number of children identified as using these processes decreased when ST were the point of reference instead of BT (see Table 7). When compared with BT, all the children were analysed as using voicing and glottalization and at least half were identified as using cluster reduction and final consonant deletion. A small percentage of the children (less than 20%) were also identified as using stopping. However, when ST were the reference point, none of the children could be identified as using the processes of voicing, final consonant deletion and glottalization. Only 17% of the children were described as using cluster reduction and less than 5% for stopping. According to the DEAP, amongst these phonological processes, only cluster reduction is considered age-appropriate for 4;0-4;5 year olds. Stopping, voicing and final consonant deletion would be considered delayed and glottalization would be considered an atypical process. Thus, if BT were the point of reference, all of the typically developing children would have been identified as using “delayed” or “atypical” phonological processes, when they were simply presenting features of their ambient dialect, SgE. If so, processes considered delayed or atypical for monolinguals, such as glottalization may then be unnecessarily targeted for intervention by SLTs who are unfamiliar with the spoken characteristics of SgE.

All the children in this study were identified as using voicing and glottalization when BT were the reference point but none were identified when ST were chosen. These phonological processes can be confused with two dialect features: syllable-final obstruent devoicing and syllable-final plosive glottalization. The contrast between these two results can be attributed to the frequency of these dialect features amongst the assessment's word targets – 11 times for obstruent devoicing and 18 for plosive glottalization (see Appendix 2). A child is identified by the DEAP criteria as having a phonological process only when there are five or more occurrences; hence processes that were the most affected by choice of target were those which are associated with dialect features that occur many times in the assessment. On the other hand, cluster reduction, which decreased by 65%, was the least affected by target choice possibly because the dialect feature associated with it only occurs thrice in the assessment.

In summary, taking dialect features into account can have marked effects on the assessment of children. Furthermore, since the population is also bilingual, we will now discuss how bilingualism and language dominance may impact on children's speech.

Language dominance and phonological accuracy

Similar to Law and So's (2006) study, consonant production was significantly more accurate in ED children than in MD children. A likely explanation may be that ED children have more exposure to English, and thus have more developed English sound systems. On the other hand, while the mean PVC score for ED children was higher than that of MD children, the difference was not statistically significant. This is consistent with the general observation that vowel development is usually more advanced than consonant development. For example, at age 4;0-4;5, the average monolingual children acquiring BSE would produce 99% of vowels correctly but only 88-92% of consonants accurately (Dodd et al., 2003). Children may therefore be expected to have fairly complete vowel inventories at this age, regardless of dominance. Still, it may be important clinically to note that MD children may make more vowel errors than ED children. This can be linked to findings that bilinguals could persist in vowel errors longer than monolingual children (So & Leung, 2006; Lin & Johnson, 2010). For example, German-Spanish bilingual children were delayed compared with German monolingual children in acquiring vowel length contrast, which is absent in Spanish. These children however were similar to Spanish monolingual children in Spanish vowel acquisition, which has a less marked vowel system (Kehoe, 2002).

When comparing phonological accuracy scores with another group of Mandarin-dominant English-Mandarin bilingual children (Lin & Johnson, 2010), Singaporean MD children had a lower PCC mean (84.25%) than their Taiwanese counterparts (89.7%) This difference may be a consequence of the maturational difference between the two groups, since the mean age of the children from that study was 5;0 years while the mean age in this study was 4;2 years. Conversely, Singaporean MD children had a higher mean for PVC (97.79%) than the Taiwanese children (91.2%). The children in Lin and Johnson's study were exposed to English from a native English (likely GAE) speaker, only in a limited context (i.e. school). Hence, their lower PVC scores were associated with unfamiliarity with English vowel reduction patterns and other vowels that are not found in Mandarin (Lin & Johnson, 2010). In comparison, the children in this study are exposed to SgE in a wider variety of contexts and the aforementioned factors have been assimilated into the dialect features of SgE and therefore not considered errors. This resulted in PVC scores that were comparable to those of their monolingual counterparts.

Clinical Implications

As suggested previously, the reference data for a language needs to be dialect and possibly ethnic group specific. However, if there is only one normative sample for all the Chinese Singaporean children, it would be biased against MD children, especially in terms of PCC and PPC, since a significant difference between the two dominant groups has been found for these measures. A method to remove this bias would be to formulate two sets of percentile ranks, one for each language dominant group as in Table 10.

With two sets of percentile ranks, a child's score would be consistent with his dominant language. For example, a child with a PCC of 86% would be placed around the 10th percentile if he was English-dominant, but at the 50th percentile if his dominant language was Mandarin. This may also mean a difference in diagnosis as the child would have fallen in the delayed range if he was in the ED group but not if he was in the MD group. If there was only one percentile ranking system (i.e. 'All' in Table 10), that same child would have been placed at the 25th percentile. While it certainly is less complicated and more convenient to have only one and not two percentile ranking systems, the drawback is that it has a higher likelihood of under-identification of ED children and over-identification of MD children for therapy. These sets of percentile ranks were formulated based on data only from children identified as being typically developing and were made for the purposes of comparison between the two groups. If samples from children with a history or suspected of speech difficulties had been sought for inclusion as was done in the development of the DEAP norms (Dodd et al., 2002), the distribution of percentile ranks would likely be different.

Besides language dominance, another factor that might have influenced the children's phonological accuracy is socio-economic status. In Singapore, those who are from more affluent backgrounds are more likely to be proficient in English than those from less affluent backgrounds (Gupta, 1998). Goldstein and colleagues (2010, cited in Hambly, et al., 2013) found that parental language input and language proficiency were significant predictors of speech sound accuracy in bilingual children. Thus, ED children who are more likely to come from more affluent backgrounds than MD children, could have better phonological accuracy because their parents were more proficient in English and have had more sustained exposure to it in the home.

Language dominance and phonological processes

Phonological processes considered typical for monolinguals may not necessarily be considered typical for bilinguals. Furthermore, whether or not a process is age-appropriate can also differ depending on language dominance. As reflected in Table 11, gliding (/r/ realised as [w]) was the only phonological process that was observed in both the ED and MD children. This process was reported to be also used by monolingual children up to the age of 6, possibly due to the complexity involved in the articulation of [r] (Bernthal et al., 2012). However, deaffrication which is also considered 'age-appropriate' for monolingual children according to DEAP norms, was not identified in any of the children in this study, even when BT were chosen. Likewise, So and Leung (2006) did not find any Cantonese-Mandarin bilingual who used retroflexion, although it was common in Mandarin monolingual children.

Another process that is considered 'age-appropriate' for monolinguals at this age is cluster reduction. However, amongst the Singaporean children, only MD children were identified as using cluster reduction when ST were chosen. This meant that MD children also reduced clusters that were not reduced in adults' speech, mostly in the beginning and middle of words, similar to that of younger monolingual children (e.g. *umbrella* → [ɑmbɛlə]; *spider* → [paɪdə]). Just as the lack of clusters in Mandarin has been linked to the decrease in maximum number of consonants in syllable-final position for SgE, the data suggest that the MD children have more difficulty than the ED children in mastering English consonant clusters. This could be because the MD children have less exposure to English and thus acquire clusters at a slower rate than the ED children. However, given that none of the ED children were found to use cluster reduction, it may also imply that bilingual and monolingual phonology are qualitatively different and need to be assessed with different criteria, without ignoring the impact of language dominance.

The other processes observed are considered 'delayed' or 'atypical' for monolinguals and they were observed only in MD children. This is possibly because interference effects are mainly associated with the dominant language, so the English phonology of ED children would be expected to exhibit less interference effects from Mandarin phonology than the English phonology of MD children (Yavas, 2007). We will discuss these processes, starting with the one used by the most number of Singaporean children to the least.

Four out of 35 MD children were observed to use backing, which is not a typically developing phonological process for English. However, it is one of the more frequently used processes by children acquiring Putonghua (Zhu, 2006). Although this study did not collect data on the children's Mandarin phonology, it is probable that backing was carried over from Mandarin into English. This finding is especially noteworthy because clinicians in Singapore currently do not view backing as a typically developing process for English because their reference point has been monolingual English speech development.

The other process that was seen in at least 10% of the MD children is the confusion of [r] and [l] (i.e. MD children use these two speech sounds interchangeably). These two English consonants are a distinction that Singaporean Chinese speakers struggle with especially compared with Malay or Indian speakers (Poedjosoedarmo, 2000). Monolingual children acquiring Putonghua have also been reported to replace [r] with [l] (Zhu, 2006).

The other processes that were used in less than 10% of the MD children sampled could also be accounted for by interference effects from Mandarin phonology. Zhu (2006) found that at least 10% of children above 4 years acquiring Putonghua used initial consonant deletion, fronting and stopping. Affrication was another process used by typically developing children in China, although only up till the age of 3;6 years. Still, phonological processes have been known to persist longer in bilingual development than monolingual development (So & Leung, 2006; Holm & Dodd, 2006). However, while it appears that the MD children's phonology experienced interference effects of Mandarin, these associations are at best hypotheses, because this study did not investigate the children's Mandarin phonology.

Furthermore, labels such as ‘delayed’ or ‘atypical’ can only be applied when more studies are done to see whether or not these processes are observed at younger ages in bilingual speakers.

Study limitations

The English phonology of Singaporean children was the focus of this study since it is the main language in which therapy is carried out and there is widespread clinical use of formal assessments of English without reference to appropriate normative data. However, for bilingual children, Yavas and Goldstein (1998, p. 50) recommended that the phonological skills in both languages are assessed and analysed so that one can “differentiate between true speech sound errors, developmental errors, atypical/disordered patterns, and second-language (L2) acquisition patterns”. Since we do not have knowledge of the Mandarin development in the same group children, we were unable to verify the cross-linguistic effects between English and Mandarin, which have been found in speakers of different dialects spoken in different countries and may not be fully applicable in Singapore’s context. Future studies are required to investigate the development of phonology in children of other ethnic groups in Singapore. Although, there are phonological features of SgE that are shared amongst all Singaporeans, there are certain features that are specific to ethnic groups, which may be due to influence from languages other than Mandarin (e.g. Malay or Tamil) (Poedjosoedarmo, 2000). It is therefore highly plausible that non-Chinese children’s speech development differs from Chinese children in Singapore, since the interference patterns will depend on what other language is being acquired. This will also allow us to have a more complete picture of how the phonological features of SgE vary across linguistic communities.

Research is needed for other age groups as well as the inclusion of children with a history or suspected of speech difficulties to determine which phonological processes are to be classified as ‘typical’, ‘delayed’ or ‘atypical’ for the bilingual development of Singaporean children. This study only examined the speech of typically developing children who are 4;0-4;5 years old. It has been documented that bilingual children’s speech becomes more similar to monolinguals’ with age, which implies that the effects of interference might be even more prominent in younger children (Holm & Dodd, 2006). Furthermore, given the small sample size in this preliminary study, a larger and more carefully constructed sample for both language dominant groups is needed to construct normative information that can be used clinically.

Clinical implications

SLTs working in multilingual communities such as Singapore, and with bilingual or multilingual children around the world, face numerous challenges, including having to be sensitive to a range of cultural and linguistic backgrounds. Regrettably, in relation to English, many dialects are not adequately researched and most standardised assessments only include the norms and features of BSE or GAE. SLTs whom are unfamiliar with the features of the dialect(s) of the population with which they work run the risk of misdiagnosing children and setting inappropriate intervention goals.

SLTs also need to consider the children's dominant language when dealing with a group of bilingual or multilingual children who have the same language combination. A child who is dominant in one language is likely to have a phonological system that is both qualitatively and quantitatively different from a child who is dominant in another language.

Nevertheless, while it is understood that SLTs need to carefully identify the background of languages spoken by their clients and choose the most suitable normative reference points, the diversity of bilingualism in a complex multilingual environment means that, with the current state of knowledge, a perfect match is almost impossible to achieve. In the absence of these appropriate reference points, clinicians need to be conversant with the current literature on bilingual speech development and second-language acquisition, so as to be able to make the necessary inferences for appropriate clinical practice.

CONCLUSION

This study documents two key issues in the assessment of Singaporean children's speech production. Firstly, it demonstrates the importance of taking dialect features into consideration when determining the differences between the expected pronunciation of words by an adult speaker of that dialect and what children say. Without doing so, it is likely that a child's speech abilities will be substantially underestimated and misinterpreted. Thus, using assessment tools designed for populations that speak other language and dialects of English will not yield valid and reliable results. Secondly, it highlights the effects of bilingualism and language dominance on speech development in multi-lingual communities like Singapore. When dialect features were taken into consideration, the ED children's English speech sound system was developmentally similar to that of age-matched monolingual children acquiring BSE. In contrast, the English speech sound system of children whose dominant language was not English (i.e. Mandarin) was significantly less developed and demonstrated interference effects from the Mandarin.

How can clinical services for Singaporean children with speech impairment be advanced? Clearly, assessment tools designed specifically for the Singaporean population are required. Given that this study only captured a small snapshot of Singaporean Chinese children's English speech development, such assessments need to be informed by further studies that provide information about development at earlier ages. In addition, with the current dearth of information, research into speech development in the other community languages spoken in Singapore is critical. What this study demonstrates is that these further studies need to take into account the impact of language dominance as these languages are acquired bilingually (e.g. English-Malay, English-Tamil).

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Table 1: Consonant production of SgE in relation to BSE (Hung, 1995; Bao, 2003; Deterding, 2007; Wee, 2008)

Dialect feature	Description
Dental fricatives substitution	Stopping in syllable-initial position for /θ, ð/ (e.g. *thin* [tin] and, *this* [dis]) and [f]-substitution in syllable-final position (e.g. *breathe* [brif]).
Syllable-final consonant cluster reduction	SgE has only 2-3 consonants in the syllable-final position, e.g. *texts* [tɛks]. The following patterns of deletion are: ▪ Voiceless plosives deleted when preceded by voiceless consonant, e.g. *ask* [ɑs] but not deleted when preceded by a voiced consonant, e.g. *aunt* [ɑnt]. ▪ Voiced plosives deleted if preceded by homorganic consonant, e.g. *friends* [frɛns]. ▪ Morpho-phonemic word endings are not consistently produced: Past tense {t, d}, singular {s} and plural markers {s, z}.
Syllable-final plosive glottalization	Syllable-final plosives replaced by glottal stops or unreleased and accompanied by glottal reinforcement, e.g. *put* [pʊʔ], *lap* [læʔp̚] when preceded by vowels. Glottal stops do not occur in other positions.
Syllable-final obstruent devoicing	Voiced plosives, fricatives and affricates may become voiceless (e.g. *bees* [bis]) in syllable-final position.

Cont’d

Dialect feature	Description
Syllable-final /l/ deletion/substitution	The dark (velarized) [ɫ] tends to be deleted after back vowels or after a schwa (e.g. *school* [sku]; *functional* [fʌŋʃənə]). After front vowels it is produced as a vowel, i.e. no actual contact between the tongue and roof of the mouth (e.g. *wheel* [wiu])
Syllable-initial plosive un-aspiration	Initial voiceless plosives /p, t, k/ tend to be un-aspirated.

Table 2: Vowel production of SgE in relation to BSE (Hung, 1995; Bao, 2003; Deterding, 2007; Wee, 2008)

Where there is a difference in vowel symbols used by the authors, the most widely used exemplars are chosen.

Dialect feature	Description
Vowel	Vowel length is not distinctive in SgE, so the pairs /iː, ɪ/, /uː, ʊ/, /ɔː, ɒ/, /ɑː, ʌ/ and /ɜː, ə/ are produced without contrast. E.g. [i] – beat, bit [ɑ]– cart, cut [ɔ] – court, cot [u]– pool , pull [ə] - bird, about
/ɛ/ and /æ/	The front mid /ɛ/ and front low /æ/ vowels are produced with overlapping vowel quality (e.g. *bet*, *bat* [bɛt]). However when /ɛ/ is followed by a voiced plosive (/b,d,g/), it may become [e] or [eᶦ], although this is not predictable. E.g. *egg* [eg] and *bed* [bed] but *peg* [pɛg], *fed* [fɛd].
Reduced vowels	Compared with other varieties of English, speakers of SgE are not inclined to use the reduced vowel in monosyllabic function words (e.g. *to*) and unstressed syllables of content words. When [ə] is used, it is most likely to be in open initial syllables (e.g. *abroad* [ə.brɔd]) while full vowels tend to be used in closed syllables (e.g. *absorb* [ɛb.zɔb]).
Diphthongs	The diphthongs /eɪ, oʊ, ɛə/ in BSE have less glide in SgE and can also be considered as the monophthongs /e, o, æ/. Hence, SgE produces five diphthongs: *price* [aɪ]; *mouth* [aʊ]; *choice* [ɔɪ]; *near* [ɪə]; *poor* [ʊə].
Tripthongs	Some tripthongs in BSE are pronounced as two syllables (e.g. *fire* [faɪjə], *hour* [aʊwə]) and some are produced monosyllabically in SgE, (e.g. *science* [saɪns]; *flour* [fla]).

Table 3: Consonant substitutions in Mandarin observed in Chinese Singaporean adults who are English-Mandarin bilinguals (Yau, 2008)

Type of substitution	Examples
Alveolo-palatal → Alveolar	• tɕ → ts • $tɕ^h$ → ts^h * • ɕ → s*
Retroflex → Alveolar	• $tʂ^h$ → ts^h • ʂ → s*
Retroflex →Palato-alveolar	• $tʂ^h$ → tʃ (/tʃ/ is not found in Putonghua)
Velar → Glottal	• x → h* (/h/ is not found in Putonghua)
Velar → Alveolar	• ŋ → n

**Substitutions observed in 100% of the speakers.*

Table 4: Comparison of the phonological structures of SgE and SgM *(speech sounds in brackets are not produced by all speakers)*

	SgE	SgM
Syllable-initial consonants	p, b, t, d, k, g	p, pʰ, t, tʰ, k, kʰ
	m, n	m, n
	f, v, s, z, ʃ, ʒ, h, w, j, (θ, ð)	f, s, (ɕ, x/h, ʂ)
	l, ɹ	l, ɹ
	tʃ, dʒ	ts, tsʰ, (tɕ, tɕʰ, tʂ, tʂʰ/ tʃ)
Syllable-final consonants	m, n, ŋ	n, ŋ
	p, t, k, (b, d, g)	
	f, s, ʃ, l, ɹ, tʃ, (θ, ð, v, z, ʒ, dʒ)	
Vowels	i, e, ɛ, ɑ, ɔ, o, u, ə	i, y, u, ɤ, o, a, ə, ɛ, ɚ
	aɪ, aʊ, ɔɪ, ɪə, ʊə	ae, ei, ao, ou, ia, iɛ, ua, uo, yɛ
		iao, iou, uae, uei
Syllable/word structure	$[C_{0\text{-}3}]$-V-$[C_{0\text{-}2/3}]$, polysyllabic	$[C_{0\text{-}1}]$-V-$[C_{0\text{-}1}]$ + tone

Table 5: Sample by language dominance

Language dominance	Total participants	Boys	Girls
English	35	17	18
Mandarin	35	17	18
Total	70	34	36

Table 6: Mean correct percentage (SD) on phonological accuracy measures when the children's data were compared with BT and ST (n = 70).

Dialect Target	PCC	PVC	PPC
BT	76.39(5.95)	77.56(4.97)	77.03(4.35)
ST	87.95(6.67)	98.12(2.11)	91.61(4.85)

Table 7: Number and percentage of children whose speech could be described as reflecting phonological processes which are also associated with dialect features of SgE.

Phonological process	**BT**	**ST**
Cluster reduction	35 (50.0%)	12 (17.1%)
Final consonant deletion	41 (58.6%)	0 (0.0%)
Glottalization	70 (100.0%)	0 (0. 0%)
Stopping	10 (14.3%)	1 (1.4%)
Voicing	70 (100.0%)	0 (0.0%)

Table 8: Mean correct percentage (SD) on phonological accuracy measures by language dominance

	ED	MD
PCC (ST)	91.64 (3.79)	84.25 (6.92)
PVC (ST)	98.56 (1.75)	97.79 (2.05)
PPC (ST)	94.11 (2.77)	89.14 (5.20)

Table 9: Raw scores and re-calibrated percentile ranks of each phonological accuracy measure for each language dominant group and all the typically developing children as a whole.

		Percentile						
		5	10	25	50	75	90	95
PCC(ST)	ED	84.5	85.5	89.4	92.9	95.0	96.0	97.0
	MD	67.4	74.2	80.1	85.8	89.4	92.9	93.0
	All	74.2	78.7	85.1	89.4	92.9	95.0	96.1
PVC(ST)	ED	93.6	95.6	98.7	98.7	100.0	100.0	100.0
	MD	93.3	94.9	97.4	97.4	100.0	100.0	100.0
	All	93.6	94.9	97.4	98.7	100.0	100.0	100.0
PPC(ST)	ED	88.5	89.3	92.7	95.0	96.3	97.3	97.8
	MD	77.0	81.9	84.9	90.4	93.2	95.2	95.8
	All	81.9	83.6	89.0	93.0	95.4	96.8	97.3

Table 10: Number and percentage of children using each phonological processes by language dominance when scored against ST

Phonological Process	No. of Children	
	English-dominant	Mandarin-dominant
Gliding	10 (28.6%)	12 (34.3%)
Cluster reduction	-	12 (34.3%)
Backing	-	4 (11.4%)
Confusion of [r] and [l]	-	4 (11.4%)
Fronting	-	3 (8.6%)
Initial consonant deletion	-	3 (8.6%)
Affrication	-	2 (5.7%)
Stopping	-	1 (2.9%)

Figure 1: Comparisons of median scores for 4;0-4;5 year old children from U.K. and Singapore, when data were scored against British Standard English targets (BT) and Singapore English targets (ST).

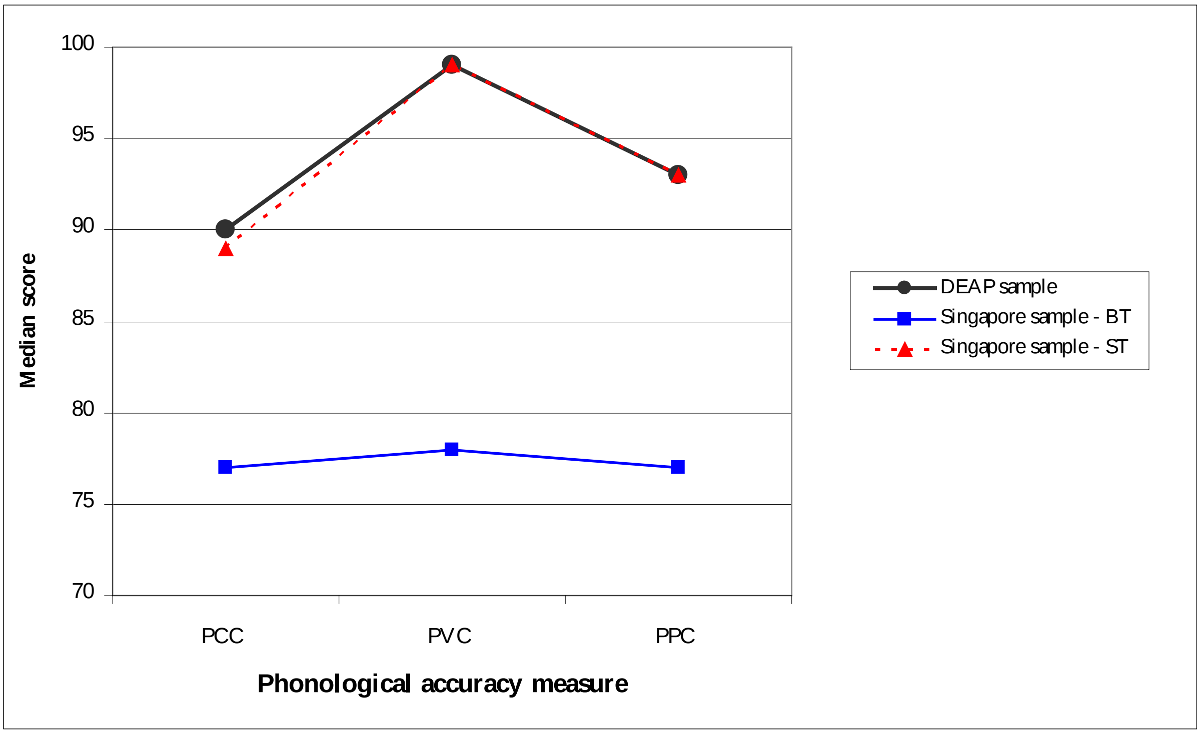
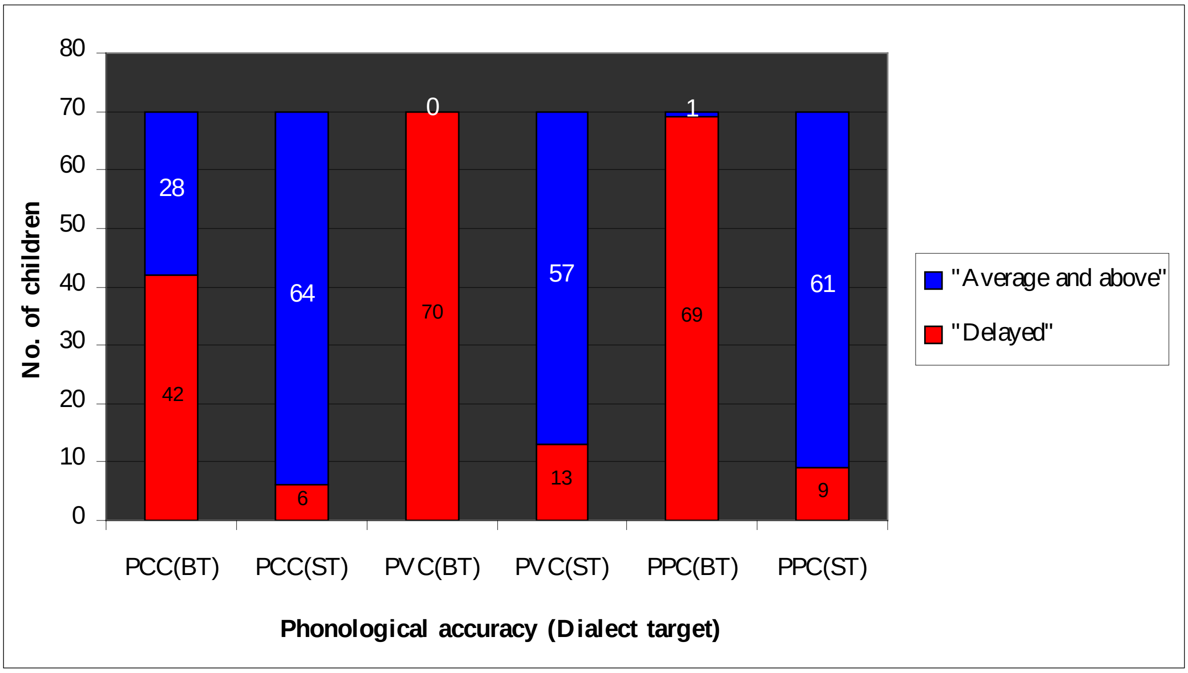


Figure 2: Number of children identified as 'average and above' or 'delayed' when compared with BT and ST, according to phonology accuracy measures (n= 70).



Appendix 1: List of British English targets (BT), Singapore English targets (ST), associated phonological processes and possible vowel variations

No.	Target	BT	ST			Phonological processes associated with SgE dialect features	Vowel variations	
							BT	ST
1	elephant	ɛləfənt	ɛlifənt	ɛlifən		CR, FCD, VC	[ə]	[i]
2	umbrella	ʌmbɹɛlə	ɑmbɹɛlə	ɑmbɹɛlɑ		VC	[ʌ] [ə]	[ɑ] [ɑ]
3	train	tɹeɪn	tɹeˡn	tɹen		VC	[eɪ]	[eˡ] or [e]
4	swing	swɪŋ	swiŋ			VC	[ɪ]	[i]
5	bread	bɹɛd	bɹɛʔt	bɹɛʔt˝	bɹɛʔ	Glottalization, Voicing	[ɛ]	[ɛ]
6	duck	dʌk	dɑʔk	d↨̱ɦ̮k˝	dɑʔ	Glottalization, VC	[ʌ]	[ɑ]
7	giraffe	ʤəɹɑf	ʤiɹɑf	ʤəɹɑf		VC	[ə]	[i]
8	five	faɪv	faɪv	faɪf		Voicing	[a]	[a]
9	teeth	tiθ	tiθ	tif		/θ/ → [f]	[i]	[i]
10	watch	wɒʧ	wɔʧ	wɔʔʃ		Glottalization, VC	[ɒ]	[ɔ]
11	orange	ɒɹɪnʤ	ɔɹinʤ ɔɹenʤ ɔɹeˡnʤ	ɔɹinʔʃ ɔɹenʔʃ ɔɹeˡnʔʃ	ɔɹinʧ ɔɹenʧ ɔɹeˡnʧ	Glottalization, Voicing, VC	[ɒ] [ɪ] [e]	[ɔ] [i] [eˡ]
12	school	skul	skul	sku		FCD	[u]	[u]
13	crab	kɹæb	kɹɛʔp	kɹɛʔp˝	kɹɛʔ	Glottalization, Voicing, VC	[æ]	[ɛ]
14	biscuits *	bɪskɪts	bɪskeʔt	bɪskeʔt˝	bɪskeʔ	CR, FCD, Glottalization, VC	[ɪ]	[e]
15	thank you	θæŋkju	θɛŋkju	tɛŋkju		Stopping, VC	[æ]	[ɛ]
16	helicopter	hɛlikɒptə	hɛlikɒʔptə	hɛlikɒʔtə		Glottalization	[ɒ]	[ɒ]

No.	Target	BT	ST			Phonological processes associated with SgE dialect features	Vowel variations BT	ST
17	egg	ɛg	eʔk	eʔk̚	eʔ	Glottalization, Voicing, VC	[ɛ] →	[e]
18	splash	splæʃ	splɛʃ			VC	[æ]	[ɛ]
19	square	skwɛə	skwɛ			VC	[ɛə]	[ɛ]
20	pig	pɪg	piʔk	piʔk̚	piʔ	Glottalization, Voicing, VC	[ɪ]	[i]
21	gloves *	glʌvz	glɑv gləf	glɑf	gləv	CR, FCD, Voicing, VC	[ʌ]	[ɑ], [ə]
22	queen	kwin	kwin				[i]	[i]
23	three	θɹi	θɹi	tɹi		Stopping	[i]	[i]
24	frog	fɹɒg	fɹɔʔk	fɹɔʔk̚	fɹɔʔ	Glottalization, Voicing, VC	[ɒ]	[ɔ]
25	yellow	jɛloʊ	jɛlo			VC	[oʊ]	[o]
26	strawberry	stɹɔbɹi	stɹɔbɛɹi	*(American pronunciation)*		Epenthesis	[ɔ]	[ɔ]
27	spider	spaɪdə	spaɪdə				[aɪ]	[aɪ]
28	web	wɛb	wɛʔp	wɛʔp̚	wɛʔ	Glottalization, Voicing	[ɛ]	[ɛ]
29	sheep	ʃip	ʃiʔp	ʃiʔp̚	ʃiʔ	Glottalization	[i]	[i]
30	snake	sneɪk	sneᶦʔk	sneᶦʔk̚	sneᶦʔ	Glottalization, VC	[eɪ]	[eᶦ], [e]
			sneʔk	sneʔk̚	sneʔ		[ɛ]	[ɛ]
31	pram	pɹæm	pɹɛm			VC	[æ]	[ɛ]
32	feather	fɛðə	fɛðə	fɛdə		Stopping	[ɛ]	[ɛ]
33	tomato	təmɑto	təmɑto təmeᶦto	tomɑto tomeᶦto		VC	[ə] [ɑ]	[o] [eᶦ]

No.	Target	BT	ST			Phonological processes associated with SgE dialect features	Vowel variations	
							BT	ST
				(American pronunciation)			[oʊ]	[o]
34	monkey	mʌŋki	mɑŋki			VC	[ʌ]	[ɑ]
35	toothbrush	tuθbɹʌʃ	tuθbɹɑʃ	tufbɹɑʃ		/θ/ → [f], VC	[ʌ]	[ɑ]
36	apple	æpəl	ɛpəl	ɛpə		FCD, VC	[æ]	[ɛ]
37	knife	naɪf	naɪf				[aɪ]	[aɪ]
38	van	væn	vɛn			VC	[æ]	[ɛ]
39	ear	ɪə	ɪə				[ə]	[ə]
40	this	ðɪs	ðis	dis		Stopping, VC	[ɪ]	[i]
41	scissors	sɪzəz	sizəs			Voicing, VC	[ɪ]	[i]
42	fishing	fɪʃɪŋ	fiʃiŋ			VC	[ɪ]	[i]
43	lighthouse	laɪthaʊs	laɪʔthaʊs	laɪʔhaʊs		Glottalization	[aɪ] [aʊ]	[aɪ] [aʊ]
44	zebra	zɛbɹə	zibɹə	zibɹɑ *(American pronunciation)*		VC	[ɛ] [ə]	[i] [ɑ]
45	kitchen	kɪʧən	kiʧən	kiʔʧən		Glottalization, VC	[ɪ]	[i]
46	sausage	sɒsɪʤ	sɔsiʔʧ sɔseʔʧ sɔseˈʔʧ	sɔsiʔʃ sɔseʔʃ sɔseˈʔʃ	sɔsiʔʤ sɔseʔʤ sɔseˈʔʤ	Glottalization, Voicing, VC	[ɪ] [e]	[i] [eˈ]
47	tiger	taɪgə	taɪgə				[aɪ]	[aɪ]

No.	Target	BT	ST			Phonological processes associated with SgE dialect features	Vowel variations BT	Vowel variations ST
48	rabbit	ɹæbɪt	ɹɛbiʔt	ɹɛbiʔt˝	ɹɛbiʔ	Glottalization, VC	[æ]	[ɛ]
49	book	bʊk	buʔk	buʔk˝	buʔ	Glottalization, VC	[ʊ]	[u]
50	boy	bɔɪ	bɔɪ				[ɔɪ]	[ɔɪ]

* Both singular and plural forms are acceptable because plural marking is optional in Singapore English.

Legend: CR – cluster reduction, FCD – final consonant deletion, VC – vowel change

Appendix 2: Definitions and examples of phonological processes mentioned in this study, taken from the DEAP manual (2002, p. 76-77)

Phonological Process	Definition	Examples
Affrication	Replacement of stops with fricatives or affricates	/dɒg/ → [zɒg]
Backing	Place if articulation is moved to a more posterior position	/tiθ/ → [kiθ] /faɪv/ → [saɪv]
Cluster reduction	Deletion of one consonant from the cluster	/spaɪdə/ → [paɪdə] /bɹɛd/ → [bɛd] /skwɛə/ → [swɛə] /ɛləfənt/ → [ɛləfən]
Deaffrication	Deletion or replacement of the stop feature with the retention of the fricative feature	/wɒʧ/ → [wɒʃ]
Final consonant deletion	Deletion of word final consonants	/dʌk/ → [dʌ]
Fronting	Place of articulation is moved to a more anterior position	/mʌŋki/ → [mʌŋti] /ɛg/ → [ɛd] /ʃip/ → [sip]
Gliding	Replacements of liquids /l, ɹ/ with glides [w, j]	/ɹabɪt/ → [wabɪt] /lam/ → [jam]
Initial consonant deletion	Deletion of word-initial consonant	/fɹɒg/ → [ɒg]
Stopping	Replacement of fricatives with stops	/van/ → [ban] /ðɪs/ → [dɪs] /zɛbɹə/ → [dɛbɹə]
Voicing	Prevocalic voicing and postvocalic devoicing	/pɹam/ → [bam] /pig/ → [pik]

Appendix 3: Frequency distribution of phonological processes associated with SgE dialect features in the Phonological Assessment of the DEAP

Phonological process	SgE dialect feature	Item no.	Frequency
Cluster Reduction	Syllable-final consonant cluster reduction	1, 14, 21	3
Final Consonant Deletion	Syllable-final consonant cluster reduction	1, 14, 21	3
	Syllable-final /l/ (deletion)	12, 36	2
Glottalization	Syllable-final plosive glottalization	5, 6, 10, 11, 13, 14, 16, 17, 20, 24, 28, 29, 30, 43, 45, 46, 48, 49	18
Stopping	Dental fricatives substitution (syllable-initial)	15, 23, 32, 40	4
Voicing	Syllable-final obstruent devoicing	5, 8, 11, 13, 17, 20, 21, 24, 28, 41, 46	11
Vowel Change	*See table 2 for all differences between BT and ST in terms of vowel production*	All except 5, 8, 9, 12, 16, 22, 23, 26-29, 32, 37, 39, 43, 47, 50	33
/θ/ → [f]	Dental fricatives substitution (syllable-final)	9, 35	2