An Exploratory Investigation of the /e/-/æ/ and /iː/-/ɪ/ Mergers and Durational Contrasts in Singapore English

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Abstract

This study explores the extent of merger between the vowels /e/ and /æ/, /iː/ and /ɪ/, and their durational contrasts, as produced by ten female and male speakers of Singapore English completing a wordlist task. The data were measured acoustically, including F1/F2 values and duration. The results reveal the most overlap for the vowels /iː/ and /ɪ/, followed by /e/-/æ/, /ɪ/-/e/, and /iː/-/e/. The findings also suggest durational differences for vowel pairs, especially among female speakers, whose productions show a greater degree of spectral overlap. This analysis lays the foundation for further investigation examining these vowel contrasts in Singapore English.

Index Terms: Singapore English, vowel merger, durational contrasts, gender differences

1. Introduction

The purpose of this study is to provide new sociophonetic insights into Singapore English (henceforth SgE), which is a variety of English spoken in a highly complex multilingual and multiethnic postcolonial context. The evolution of SgE has been against the backdrop of British colonisation and language contact with local languages such as Malay, Chinese dialects (e.g., Hokkien, Cantonese) and Tamil [1]. There are four official languages in Singapore: English, the interethnic lingua franca and the only medium of instruction in all government schools, and three 'mother tongue' languages (used to denote the speaker's ethnic belonging rather than their L1) — Mandarin, which is the assigned mother tongue for those identifying as ethnically Chinese, Malay for Malays, and Tamil for Indians. Although the 'mother tongues' may not necessarily be spoken at home [2], they have been offered as a single language subject in Singapore since 1987 [3, 4].

Over the years, research on SgE has identified it as an *endonormatively stabilised* postcolonial variety with its own linguistic standards [1, 5]. Such categorisation presupposes linguistic unity and homogeneity in SgE [1, 5]. However, previous work on the acoustic features of vowels in SgE [e.g., 6, 7, 8, 9, 10, 11, 12, 13, 14] suggests that the vowel system of SgE is still emergent, and relatively consistent and predictable pronunciations have yet to be fully established. In particular, there is a tendency for SgE speakers to reduce monophthong contrasts, such as those between front vowel pairs, e.g., /iː/ and /ɪ/, and /e/ and /æ/ [8, 9]. There is a growing body of work on mergers between /e/-/æ/ and /iː/-/ɪ/ in postcolonial "settler" varieties of English [15, 16, 17, 18], such as work on pre-lateral mergers in New Zealand English [17], and pre-lateral merger-in-progress in Australian English spoken in the state of Victoria [18]. However, limited attention has been given to Englishes that have developed as a result of contact with other, often indigenous, languages spoken alongside English (e.g., SgE, Indian English), with even less attention given to sociophonetic characteristics of vowel mergers [19]. Thus, the present study aims to address this gap and bring new insights into language variation in the multilingual, postcolonial society of Singapore.

Early studies on SgE have suggested an acoustic merger between /e/ and /æ/ (e.g., [12]). However, the degree of overlap between the vowels was reported to vary according to contexts, ranging from having a clear /e/-/æ/ contrast in formal contexts to almost no differentiation in casual speech [9, 11, 13]. It has also been noted that /e/ produced in citation form has a range of realisations such as the diphthongal FACE vowel, and anywhere on the continuum between the monophthongal TRAP and DRESS vowels [9, 11], as a result of highly variable F1 and F2 values, e.g., F2 values can vary from a more central position (e.g., 1800Hz) to a very fronted position (e.g., 3000Hz) in the speakers' vowel space [9]. The diphthongal change of /e/ for certain words (e.g., *egg* but not *peg*) was further suggested as evidence for the emergence of a new variety of English among young Singaporeans, whose productions were reported to have diphthongal pronunciation regardless of their ethnic background [9]. These findings suggest interaction between /e/ and other vowel classes with a potential 'redistribution' of vowels in the vowel space, which calls for the examination of co-variation and potential mergers not only for certain vowel pairs but also across the vowel classes.

Mergers between long and short vowels such as /iː/ and /ɪ/ (also tense-lax) have been reported for several postcolonial Englishes spoken in Asia [e.g., 20 for Malaysian English]. While distinctions based on vowel duration have attracted less attention in the literature, duration was suggested as a potential parameter to distinguish spectrally merged vowels such as /iː/ and /ɪ/ in SgE [9, 13], with little variation found in vowel formants for /iː/ and /ɪ/ in SgE across the ethnic groups (i.e., Chinese, Malays and Indians) and contexts [e.g., 7, 8, 9, 10, 11]. Furthermore, the /iː/-/ɪ/ merger in passage reading has been reported for SgE Malay speakers of both genders, with males having a greater degree of overlap as compared to female speakers [13]. However, in a more formal speech style, such as citation form, [13] found a significant difference in mean durational values between /iː/ and /ɪ/. Further, male Malay speakers exhibited a more compact vowel space as compared to female Malay speakers, suggesting possible gender-based differences in vowel productions and the degree of merger [13]. The findings discussed above emphasise the importance of considering the durational parameter in the investigation of vowel mergers [21]. As pointed out by [22], "it would be too premature […]to suggest that two vowel phonemes are merged just because they show overlapping distributions in a two-dimensional vowel space defined by F1 and F2".

1.1. Aims of the study

To date, there has been little examination of durational contrasts in /e/ and /æ/ and /i:/ and /ɪ/ in SgE with reference to gender, and none have explored the possible overlap within and across DRESS-TRAP and FLEECE-KIT vowel pairs. Based on the acoustic-phonetic analysis of the vowels /e, æ, i: ɪ/, this study aims to answer the following questions:

1. To what extent do DRESS and TRAP, and FLEECE and KIT vowels merge acoustically in SgE, i.e., /i:/and /ɪ/, /e/ and /æ/, /ɪ/ and /e/, /i:/ and /e/, /ɪ/ and /æ/, /i:/ and /æ/?
2. Do SgE speakers use duration to differentiate vowel classes in production when the vowel classes are spectrally merged?
3. Is there any effect of gender on the target vowel productions and possible vowel mergers?

2. Method and Materials

2.1. Materials and Procedures

The data analysed for this study were taken from the National Institute of Education Spoken Corpus of English in Asia (NIESCEA) [23] and were used with the approval of the researchers in charge of the corpus. All audio files were in .wav format and were produced by 10 native speakers of SgE: five females and five males. They were all undergraduate or graduate students, aged between 18 and 35 years at the time of the recording. The 10 audio files included 33 monosyllabic sample words that contained 11 monophthongs. All speakers were asked to read a list of words only once. In this study, two pairs of monosyllabic words were selected which included the front vowels /e, æ/ and /i:, ɪ/. The examined pairs were produced in /hVd/, /bVt/ and /bVd/ contexts with the words embedded in the carrier sentence ‘Please say ____ again’. The word set used in this study is included below, with the target words shown in bold font:

Please say **head** again. Please say **had** again.
Please say **bet** again. Please say **bat** again.
Please say **bed** again. Please say **bad** again.
Please say **heed** again. Please say **hid** again.
Please say **beat** again. Please say **bit** again.
Please say **bead** again. Please say **bid** again.

A total of 120 tokens were elicited from 12 citation words from 10 speakers. The words in their respective pairs formed minimal pairs, however, these minimal pairs were randomised and produced separately by all speakers during the recording [23]. The target vowels in their carrier phrases were extracted from the original audio files and saved separately in .wav format for each individual speaker.

2.2. Measurement and analysis procedure

All segmentations of the target vowels were annotated manually in Praat (version 6.1.40) [24]. The vowel duration (in ms) was measured from the left boundary to the right boundary of each vowel. The left boundary of each vowel was measured from the onset of clear formant energy, indicated by regular F1-F4 spectral energy of each vowel, while the right boundary was placed at the offset of spectral discontinuity of each vowel, indicated by a clear change in the overall shape of the vocal tract. A Praat script was used to extract durational values and F1/F2 values at vowel midpoints. Outliers caused by a formant tracking error, such as /i:, ɪ/ with low F2 values, were adjusted manually with reference to the wideband spectrograms, by placing the cursor at the temporal midpoint and in the middle of F1 and F2. The same principle of measurement was followed consistently throughout the measurements.

F1 and F2 characteristics (in Hz) were analysed using the *emuR* package in *R* (version 4.0.4) [25, 26]. *R* libraries such as *ggplot2* and *phonTools* were used to plot F1/F2 values of the target vowels with ellipses and duration in boxplots according to gender. F1/F2 values were normalised using Lobanov normalisation for comparison between the genders, given the effectiveness of this method in preserving the phonemic and the sociolinguistic variation while minimising the gender-related physiological variation [27]. The Pillai-Bartlett Trace, otherwise known as the Pillai score and as an output of a MANOVA, was calculated in *R* with the *tidyverse* package [28] to measure acoustic merger between six pairs of vowels, namely, /i:/and /ɪ/, /e/ and /æ/, /ɪ/ and /e/, /i:/ and /e/, /ɪ/ and /æ/, /i:/ and /æ/. The Pillai score was chosen due to its ability to compare between-speaker differences, capture the degree of overlap between vowel categories in the acoustic space, and conduct analysis on a small number of tokens [29]. The Pillai score values range from 0 to 1, with figures approaching 1 indicating a high level of distinction and values closer to 0 indicating a greater degree of overlap in the F1/F2 space. The significance values (Pr>(F)), as part of the output, were also extracted and presented in parenthesis with the Pillai scores. Mean duration, F1 and F2 values and their standard deviations were calculated according to the adjusted measurement values (the output of the Praat script) in Numbers (version 11.1) according to each vowel and gender category.

3. Results

3.1. Acoustic results

Table 1 presents descriptive statistics and summarises the results of the mean F1 and F2 values (in Hz) and mean duration of /e, æ, i: ɪ/ (in ms) for female and male speakers. For both gender groups, mean F1 values are higher for /æ/ (female - $\bar{x}$ 780Hz, σ 71Hz; male - $\bar{x}$ 615Hz, σ 43Hz), compared to /e/ (female - $\bar{x}$ 617, σ 155Hz; male - $\bar{x}$ 492Hz, σ 102Hz), and mean F2 values are lower for /æ/ (female - $\bar{x}$ 1708Hz, σ 412Hz; male - $\bar{x}$ 1880Hz, σ 93Hz), compared to /e/ (female - $\bar{x}$ 1905Hz, σ 364Hz; male - $\bar{x}$ 2027Hz, σ 185Hz).

Table 1. *Mean F1/F2 values for /e, æ, i: ɪ/ in Hz and mean vowel duration in ms with standard deviation in parenthesis for both female (F) and male (M) speakers.*

	Phoneme	F1 (Hz)	F2 (Hz)	Duration (ms)
F	æ	780(71)	1708(412)	166(101)
	e	617(155)	1905(364)	143(68)
	i:	428(48)	2590(540)	172(88)
	ɪ	467(65)	2172(606)	124(75)
M	æ	615(43)	1880(93)	139(43)
	e	492(102)	2027(185)	129(37)
	i:	320(40)	2214(196)	134(34)
	ɪ	359(40)	2078(109)	109(30)

The results also indicate that mean F1 values of /e/ and /æ/ produced by male speakers are lower than those produced by female speakers, but mean F2 values of /e/ and /æ/ produced by male speakers are higher than those produced by female speakers. The difference in mean F1 values between /e/ and /æ/

produced by male speakers is smaller than that produced by female speakers (123Hz versus 163Hz), and the difference in mean F2 values between /e/ and /æ/ produced by male speakers is also smaller than that of the female group (147Hz versus 197Hz).

Furthermore, for both female and male speakers, mean F1 values are higher for /ɪ/ (female - $\bar{x}$ 467Hz, σ 65Hz; male - $\bar{x}$ 359Hz, σ 40Hz), compared to /i:/ (female - $\bar{x}$ 428, σ 48Hz; male - $\bar{x}$ 320Hz, σ 40Hz), and mean F2 values are lower in /ɪ/ (female - $\bar{x}$ 2172Hz, σ 606Hz; male - $\bar{x}$ 2078Hz, σ 109Hz), compared to /i:/ (female - $\bar{x}$ 2590Hz, σ 540Hz; male - $\bar{x}$ 2214Hz, σ 196Hz). The results also indicate that both mean F1 and F2 values of /i:/ and /ɪ/ produced by male speakers are lower than those produced by female speakers. The difference in mean F1 values between /i:/ and /ɪ/ produced by male speakers is the same as that produced by female speakers (39Hz), while the difference in mean F2 values between /i:/ and /ɪ/ for male speakers is smaller than that for females (136Hz versus 418Hz).

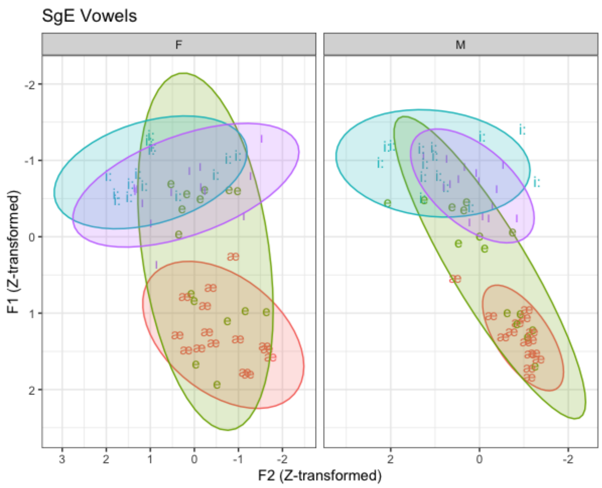

Figure 1: *First and second formant frequency (Lobanov-normalised) at midpoints of /e/ (green ellipsis), /æ/ (red ellipsis), /ɪ/ (purple ellipsis), /i:/ (blue ellipsis) according to gender (female - left, male - right).*

Figure 1 shows two Lobanov-normalised plots of F1 values (*y*-axis) against F2 values (*x*-axis) measured at the vowel midpoints, with ellipses over each vowel production, presented by gender (female speakers – left panel, male speakers – right panel). For both groups, F1 and F2 values for /e/ and /æ/, and /i:/ and /ɪ/ are indicative of the acoustic overlap between not only /e/ and /æ/, and /i:/ and /ɪ/, but also /e/ with both /i:/ and /ɪ/. Moreover, both female and male speaker groups show similar variation patterns, but with female speakers having a more dispersed vowel space than that of male speakers. Further, a closer look at the data shows that the raw F1 values for /e/ vary from 400Hz to 900 Hz for female speakers and 400HZ to 700Hz for male speakers. The raw F2 values for /i:/ vary the most, ranging from 1800Hz to 2500Hz among male speakers, while female speakers have the most variation in the productions of /ɪ/, ranging from 1000Hz to 3000Hz.

Pillai scores used to examine the extent of acoustic overlap between the two vowels in each pair are presented in Table 2, with significance values (Pr>(F)) included in parenthesis. The overall (averaged across all speakers) Pillai scores suggest overlap for a number of vowel pairs: /i:/and /ɪ/ (0.22), /e/ and /æ/ (0.25), /ɪ/ and /e/ (0.29), while vowel pairs such as /i:/ and /e/ (0.49), /ɪ/ and /æ/ (0.73), and /i:/ and /æ/ (0.81) indicate various degrees of distinction. Furthermore, *p*-values for all vowel pairs are below 0.001. When looking at the data combined across the speakers, the patterns suggest that SgE speakers are producing mergers for pairs /i:/ - /ɪ/, /e/ - /æ/, /ɪ/ - /e/ and are making better distinctions for vowel pairs /ɪ/-/æ/ and /i:/-/æ/, and most likely /i:/ - /e/.

Table 2. *Pillai scores for all possible vowel pairs, presented from the lowest to the highest score with significance values (Pr>(F)) in parenthesis.*

	Female	Male	Overall
/i:/&/ɪ/	0.32 (p<0.01)	0.27(p<0.05)	0.22 (p<0.001)
/e/&/æ/	0.33 (p<0.01)	0.43 (p<0.001)	0.25 (p<0.001)
/ɪ/&/e/	0.34 (p<0.01)	0.59 (p<0.001)	0.29 (p<0.001)
/i:/&/e/	0.55 (p<0.001)	0.57 (p<0.001)	0.49 (p<0.001)
/ɪ/&/æ/	0.86 (p<0.001)	0.92 (p<0.001)	0.73 (p<0.001)
/i:/&/æ/	0.91 (p<0.001)	0.93 (p<0.001)	0.81 (p<0.001)

When examined on the basis of gender, Pillai scores indicate that male speakers have a marginal difference in the degree of overlap between /i:/ and /ɪ/ (0.27) compared to female speakers (0.32). However, female speakers produce a greater amount of overlap between /e/ and /æ/ (0.33), as compared to male speakers who produced a more modest overlap in this pair (0.43). In addition, although the overlap between the vowels /ɪ/ and /e/, /i:/ and /e/ is more partial for both male and female speakers, female speakers tend to have greater amount of overlap for the /ɪ/ and /e/ vowel pair (0.34) compared to the /i:/ and /e/ vowel pair (0.55). This is in contrast to male speakers whose patterns show that /e/ overlapped more with /i:/ (0.57) and /ɪ/ (0.59). Lastly, the Pillai statistic results suggest that both gender groups make a distinction between /ɪ/ and /æ/, /i:/and /æ/, with the scores of 0.92 and 0.93 for male and 0.86 and 0.91 for female speakers. The distinction between /ɪ/ and /æ/, /i:/and /æ/ is also significant for both genders (p<0.001).

3.2. Duration results

Due to the small sample size, t-test results of durational contrasts did not show any significant differences between the examined vowel pairs (except for /i:/-/ɪ/ which has p<0.05), thus, *p*-values are not presented in this section. Figure 2 illustrates the durational values of vowels presented by gender, with the female group on the left and the male group on the right. Duration in ms is plotted on the y-axis and the target phonemes on the x-axis. For both female and male speaker groups, /æ/ is longer than /e/ and /i:/ is longer than /ɪ/, according to their median values as indicated by the horizontal line in each box. The durational differences between /e, æ, i: ɪ/ are very small, according to their median values. In general, male speakers produce slightly longer vowels across two pairs, as indicated by higher median values. Female speakers show greater variability in production than male speakers, as indicated by the shape of the boxes, more extended whiskers, and the presence of more outliers. /i:/ has the most variability in duration for female speakers (from 110ms to 210ms), but it is the least variable vowel for male speakers (from 110ms to 150ms). /e, æ, ɪ/ vary to almost the same degree for female speakers (80ms difference), but for male speakers, /æ/ (60ms difference) varies more than /e/ (50ms difference) which in turn, varies more than /ɪ/ (40ms difference).

Similarly, the mean duration values shown in Table 2 suggest that for both female and male speakers, /æ/ (female - $\bar{x}$ 166ms, σ 101ms; male - $\bar{x}$ 139ms, σ 43ms) is longer than /e/ (female - $\bar{x}$ 143ms, σ 68ms; male - $\bar{x}$ 129ms, σ 37ms) and /i:/

(female - $\bar{x}$ 172ms, σ 88ms; male - $\bar{x}$ 134ms, σ 34ms) is longer than /ɪ/ (female - $\bar{x}$ 124ms, σ 75ms; male - $\bar{x}$ 109ms, σ 30ms). However, in contrast to median values shown in Figure 2, the mean duration results indicate that females produced longer vowels for both pairs compared to male speakers. /i:/ is still the longest vowel produced by female speakers but not for male speakers, whose longest vowel is /æ/. Such a finding could be the result of averaging the amount of variability within the vowel classes where female speakers produce the most variation in /i:/ while male speakers have the most variation in /æ/, indicated by their standard deviations. Female speakers also produce larger durational differences in /e, æ/ (23ms), /i:, ɪ/ (48ms) and /i:, e/ (29ms) but smaller in /ɪ, e/ (19ms) than male speakers (10ms for /e, æ/; 25ms for /i:, ɪ/; 5ms for /i:, e/ and 20ms for /ɪ, e/).

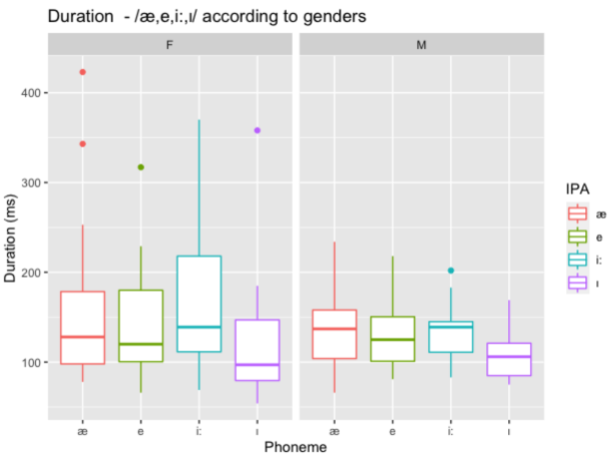

Figure 2: *Duration for /e, æ, ɪ, i:/ according to gender (female - left, male - right).*

We also observed that some speakers tend to have longer stops before target words (e.g., after *please say*), followed by a strong emphasis on the target words, resulting in exceptionally long vowel productions and hyperarticulation (e.g., one male and one female speaker were found to use 3s and 4s respectively to produce *hid* in the carrier phrase, as compared to 1s by most other speakers). As a consequence, some of the variation may be attributed to the nature of the task and the way some participants produced the vowels.

4. Discussion and conclusion

While the acoustic results indicate evidence of merger behaviour between /e/ and /æ/, and between /i:/ and /ɪ/, the patterns of such mergers are gradient for both female and male speakers. Such results, to some extent, corroborate findings reported in previous studies [8, 9, 11, 13] that these two vowel pairs tend to overlap and that there is indeterminate intra-speaker variation. However, the results of the present study suggest that such overlap for wordlist data is partial, especially for /e/ and /æ/ among male speakers. The findings also reveal that /ɪ/ and /e/ overlap for female speakers, but only partially so for male speakers; similarly, /i:/ and /e/ also overlap, although partially for both genders. Furthermore, the current results corroborate /e/-raising, suggested in previous work on SgE [e.g., 10, 11, 14].

In addition, the results of the current study show that there is greater internal variation and more dispersed productions among female speakers than among male speakers. This is consistent with the study by [13] and confirms their observations of overlap patterns based on gender, where female speakers have a greater degree of overlap for /e/ and /æ/, but smaller for /i:/ and /ɪ/. In contrast to the findings reported in other studies on SgE (e.g., [13]), we did not find a more fronted pronunciation of /æ/ as compared to /e/ among male speakers. Although /i:/ and /ɪ/ are the most overlapped pair for both genders, their durational difference is also the largest and highly perceivable for both genders (e.g., >20ms).

In general, female speakers have a greater degree of overlap for all pairs, except for /i:/ and /ɪ/; at the same time, female speakers produce greater and more contrastive and perceivable durational differences for all pairs (>20ms except for /ɪ, e/ of 19ms). In comparison, vowels produced by males overlap less and the durational contrasts are also smaller, with only two potentially perceivable pairs, /ɪ, e/ (20ms) and /i:, ɪ/ (25ms). Such observations suggest that there seems to be a complementary relationship between vowel quality and vowel duration. As such, it could be inferred that speakers of SgE, especially female speakers, may rely on durational differences to distinguish vowel differences in speech. However, as suggested in previous instrumental work (e.g., [12]), the quality of SgE vowels vary across contexts, with a greater likelihood of mergers in casual speech and greater distinctions in formal contexts. This study investigated vowels in citation form, which is a more formal and carefully controlled method as compared to casual conversations as well as the passage and the sentence reading tasks. Thus, it could be predicted that such durational contrasts might not appear in informal everyday conversations. Further studies with a larger sample and comparisons between groups and contexts are required for a more robust conclusion.

Furthermore, there is a lot of variation in the F2 values for the speakers in this study, consistent with other investigations of SgE [e.g., 9]. Careful inspection of the data indicate that one male speaker and one female speaker tended to produce more backed close vowels than other speakers. Hence, F2 values could have been affected by speaker-intrinsic variation in our sample. Moreover, each speaker was asked to read the words in citation form only once, limiting the number of tokens. Another possible reason for such variation in F2 could be due to the differences in pronunciation across the three ethnic groups in Singapore. Recall that the NIESCEA does not provide details about the speakers' linguistic, ethnic, and social background. As suggested in the literature [e.g., 9, 11, 13], Indian Singaporean speakers tend to maintain a clear /e/-/æ/ contrast whereas Malay Singaporeans produce the least distinction. Therefore, we emphasise the importance of collecting speakers' ethnic and language background details in future studies.

Given its exploratory nature and a small sample based on citation form data, the conclusions rendered in this study are tentative and subject to further investigation. Nonetheless, this exploratory study helps to address the gap in the recent literature on mergers in SgE. Our future work will include the collection of a large corpus of data based on present-day SgE speech, with a focus on different speech types (e.g., natural versus formal speech) and speakers' ethnic backgrounds. Further, a more nuanced approach to social factors such as gender will be taken where speakers can self-identify their gender in order to provide a more comprehensive picture of the vowel productions and mergers in SgE.

5. References

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