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Ethnicity and Tone Production on Singlish Particles

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Abstract: Recent research on Singlish, also known as Colloquial Singapore English, suggests that it is subject to ethnic variation across the three major ethnic groups in Singapore, namely Chinese, Malay, and Indian. Discourse particles, said to be one of the most distinctive features of the language, are nevertheless commonly used by bilinguals across all three ethnic groups. This study seeks to determine whether there are ethnic differences in the pitch contours of Singlish discourse particles produced by Singlish speakers. Four hundred and forty-four tokens of three Singlish particles, sia$_{24}$, meh$_{55}$, and what$_{21}$, produced by the three groups of English-speaking bilingual speakers were drawn from the National Speech Corpus, and the pitch contours extracted and normalized. Statistical analysis of the overall pitch contours, the three acoustic parameters of mean pitch, pitch range, and pitch movement, and the variability of these parameters showed that the effect of ethnicity on the three acoustic parameters was not statistically significant and that the pitch contours of each particle were generally similar across ethnic groups. The results of this study suggest that Singlish may be acquired as a first language by Singaporean speakers, pre-empting any ethnic differences in the production of the particles that might otherwise have resulted from the speakers' differing language repertoires.

Keywords: tone; language repertoire; singlish; discourse particles; ethnic variation

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1. Introduction

This study investigates how three different groups of English-speaking bilingual Singaporeans produce tones on Singlish particles, specifically how the ethnicity of these bilingual speakers affects the production of these tones. Although there has been extensive research on Singapore English showing ethnic differentiation in the production of segmental sounds (Tay 1982; Suzanna and Brown 2000; Kalaivanan et al. 2021) as well as suprasegmental features (Lim 1996, 2000; Tan 2002; Tan 2010), they focus on "standard" Singapore English. The term "Singapore English" refers to the standard, educated variety of English spoken in Singapore, whose syntax and lexicon are not distinctly different from other "standard" British, American or Australian varieties. No similar work has been done on Singlish, commonly known in the literature as "Colloquial Singapore English". Instead of using the term "Colloquial Singapore English", which brings with it close associations to English, we follow Tan (2017) and Wee (2018) in the adoption of the term *Singlish*. In recent years, there have been suggestions that speakers of different ethnic groups use specific ethnic varieties of Singlish. For example, Leimgruber et al. (2021) propose that ethnic differences in discourse particle usage are indicative of the emergence of sub-national ethnic varieties of Singlish, as expected under the differentiation stage of Schneider's (2007) Dynamic Model. Therefore, in this study, we focus on the English-Mandarin, English-Malay, and English-Tamil bilinguals' production of tones on Singlish discourse particles, as discourse particles have also been said to be one of the most distinctive Singlish features (Gupta 1992).

Bilingualism, and its relationship to a speaker's ability to produce tone, is particularly relevant in the context of Singapore, as Singapore's linguistic ecology comprises both tonal and non-tonal languages. Bao (2015) observes that the major languages that make up Singaporeans' linguistic repertoires "have been constant throughout the history of Singapore" (p. 34), and these languages include English, Malay, Chinese languages such as Mandarin, Hokkien, Cantonese, Indian languages such as Tamil, Hindi, and Malayalam, as well as contact languages like Singlish and Baba Malay. Of these, the tonal Chinese languages come from diverse language families such as Min and Yue. Non-tonal languages originating from multiple language families constitute the remainder of the list, such as English (Indo-European), Malay (Austronesian), Tamil (Dravidian), and Hindi (Indo-Aryan). The linguistic repertoires of Singaporean speakers are, therefore, especially varied as a result of this historically diverse linguistic ecology.

In addition, most Singaporeans are literate in at least two languages—74.3% of the population, according to Singapore's population census (Department of Statistics, 2021). Upon independence in 1965, Article 153A of the Singapore Constitution defined English, Malay, Mandarin, and Tamil as the nation's four official languages (Singapore Const. art. 153A 1965), with the latter three being designated as the official "mother tongues" of the Malay, Chinese, and Indian ethnic groups, respectively. These "mother tongues" are state-assigned and may not be one's ancestral or heritage languages as commonly understood (see Tan 2014 for a more extensive discussion). Long-standing language policies implemented by the government have thus resulted in a situation of widespread "English-knowing bilingualism" (Kachru 1982, p. 42), as all Singaporeans born after the nation's independence have had to learn both English and their designated mother tongues in schools following the implementation of the bilingual education policy. This means that the vast majority of Singaporeans are literate and proficient in both English and their state-assigned mother tongues.

The diversity of languages historically spoken in Singapore and the high rate of multilingualism among the population have also given rise to the emergence of contact languages. Chief among them is Singlish, which is mainly composed of elements from a variety of local languages, including English, Malay, Hokkien, Mandarin, and Cantonese (Tan 2017). According to Gupta (1998), who refers to Singlish as "Colloquial Singapore English", Standard English serves as the superstrate of Singlish while other local languages like Baba Malay, Bazaar Malay, Hokkien, Teochew, and Cantonese (among others) make up the substrate. Contact between these languages in the "turn-of-the-century period" (p. 125) before independence, when Singapore was an important regional trading post, has been attributed as the historical origin of Singlish. Today, supporters of Singlish argue that it serves as an important marker of Singaporean identity since it is used across all social classes, thus strengthening solidarity between speakers of different socioeconomic and educational backgrounds (Wee 2018). Although governmental efforts such as the Speak Good English Movement (SGEM) have attempted to eradicate it entirely, Singlish is still widely spoken in the community (Cavallaro and Ng 2009).

1.1. Ethnic Variation in Singlish Particle Use

Singlish contains many discourse particles, each used for different pragmatic purposes. Wong (2014) describes the language as "particle-rich" (p. 231), in contrast to English, and Gupta (1992) counts at least eleven different particles that are regularly used by speakers. Although Singlish speakers come from diverse ethnic backgrounds and acquire different languages in school depending on their assigned ethnic group, most studies on Singlish particles assume a uniformity in terms of their production, with little or no attention paid to how speakers of different backgrounds produce these particles. More recent literature on ethnic variation in the use of Singlish particles, however, mostly focusing on the frequency with which the main ethnic groups in Singapore (namely Chinese, Malay, and Indian) use the different particles, suggests an effect of ethnicity on particle use. Botha (2018) shows how ethnicity is an "important social variable" (p. 277) that results in differences in the frequency of particle usage and range of particles used among speakers of the three ethnic groups. The study found that Chinese speakers used significantly more particles than both Malay and Indian speakers and that they used the greatest range of particles while Indian speakers used the smallest range. Furthermore, almost all of the particles produced by Chinese speakers were of Cantonese origin, such as "hor" and "leh". Similarly, Leimgruber et al.'s (2021) study of written text messages in the Corpus of Singapore English Messages (CoSEM) found that Indian writers used significantly fewer particles than the other two ethnic groups, and Chinese writers used Cantonese-origin particles such as "hor", "leh", and "meh" significantly more often. Smakman and Wagenaar (2013) seem to present contrasting results, finding that "generally no ethnic clues could be derived from the number of particles produced by individuals" (p. 320), and that the relationship between the linguistic origins of Singlish particles and speakers' ethnicity remains unclear, as members of all three ethnic groups used roughly the same number of particles in conversation. However, this same study also shows how Cantonese-origin particles such as "hor" and "leh" are used almost exclusively by Chinese participants, which is congruent with Botha's (2018) findings. Could this possibly signal further differences in the production of these particles between speakers of different ethnic groups?

While previous studies focus on the speakers' choice of specific particles, the current study looks at *how* speakers of different ethnic groups produce these particles. This is because Singlish particles exhibit a significant amount of pitch variation, including both level and contour tones. An example of the former is meh$_{55}$, which maintains the same high pitch throughout, while an example of the latter is sia$_{24}$, whose pitch rises towards the end of the particle.[1] It is also possible for a single particle to have different tones corresponding to different pragmatic functions. This is seen in "lah", which Kwan-Terry (1992) argues conveys a sense of "gentle persuasion" when produced with a low level tone and a sense of "slight impatience or irritation" when produced with a mid-rising tone (pp. 64–65).

The question of whether or not discourse particles in Singlish possess lexical tone remains unresolved, which is further compounded by the fact that, as Botha (2018) observes, the majority of studies on Singlish particles have been concerned with their semantic and pragmatic functions. However, there have been strong arguments that the pitch contours of at least some discourse particles reflect lexical tone rather than intonation, for example, the particle "lah" described previously. Wong (2014) shows how different pitch contours convey different meanings on the same discourse particle, while in contrast, other particles such as "what" and "meh" can only be produced with one specific pitch contour, with any other pitch contour being impermissible in Singlish. Lee (2018) also concurs that "certain pragmatic functions seem to be strongly linked to the pitch contour of the particle even if the context is identical" (p. 262), and gives an example of how pronouncing "lah" with a high falling pitch contour (lah$_{51}$) rather than a low level pitch contour (lah$_{21}$) in the exact same situation can sound more natural.

In our study, we aim to answer the question of whether there are any ethnic differences in speakers' production of the particles' pitch contours, without assuming whether these particles are tonal in nature. Rather than attempting to cover the entire range of Singlish particles, three particles—meh$_{55}$, what$_{21,}$ and sia$_{24}$—were chosen from the existing inventory. We discuss the reasons that these three particles were specially curated in the following section.

1.2. Choice of Particles in the Study

As mentioned earlier, many Singlish particles are associated with more than one pitch contour, with each corresponding to a different meaning. The discourse context and intentions of the speaker, therefore, constitute additional factors besides ethnicity that affect how the speaker pronounces these particles. To limit the complexity of the study, we focused on the few particles that are associated with only one pitch contour and one corresponding pragmatic meaning, from which meh$_{55}$, what$_{21}$ (also transcribed as "wat$_{21}$"; see Lim 2007), and sia$_{24}$ were selected. In addition, all three particles only occur sentence-finally and each particle is acceptable in only one speech act—meh$_{55}$ is only acceptable in questions, while what$_{21}$ and sia$_{24}$ are only acceptable in declarative statements. This eliminates the effect of sentence-level prosody on the pitch contours of the particles.

The second consideration for selecting these three specific particles is that they also provide us with a wide range of tonal patterns for comparison in this study—meh$_{55}$ is pronounced with a high level tone, and what$_{21,}$ a low falling or low level tone (Lim 2007), while sia$_{24}$ is pronounced with a contour tone. The inclusion of contour tones also allows for the possibility of comparing the degree of pitch changes between speakers.

Thirdly, since Botha (2018) and Leimgruber et al. (2021) found that Chinese speakers and writers use more particles of Cantonese origin such as "hor" and "leh", we focused on particles that originated from languages associated with a given ethnic group in order to investigate if the effect of ethnicity on particle use extends to how speakers produce particles of different language origins—the particle meh$_{55}$ is chosen as it is thought to have been borrowed into Singlish from Cantonese (Lim 2007), while the particle sia$_{24}$ originates from Malay.

Finally, although the current study is agnostic about whether Singlish particles are tonal in nature, the origins of meh$_{55}$, what$_{21,}$ and sia$_{24}$ also span both tonal and non-tonal languages. Cantonese is a tonal language of the Yue branch of the Sinitic language family while Malay is a non-tonal Austronesian language. The language origin of the particle what$_{21}$ is unclear; while Lim (2007) raises the possibility that it may be a calque of the "ma" particle found in many Sinitic languages, which are generally tonal, Kuteva et al. (2018) argue that it is actually from English, a non-tonal language. The three particles, therefore, maximize the likelihood of there being both tonal particles (meh$_{55}$) and non-tonal particles (sia$_{24}$) in the study. If the results demonstrate that speaker variation in how meh$_{55}$ is pronounced differs from the other two particles in a way consistent with the hypothesis that meh$_{55}$ is a tonal particle, it will then provide preliminary support for the hypothesis, which we can build on in further research on the issue.

2. Materials and Methods

2.1. Selection of Tokens and Speakers

For this study, we made use of the National Speech Corpus (NSC), a corpus of more than 2000 h of Singapore English speech spearheaded by the Infocomm Media Development Authority of Singapore (Koh et al. 2019). Specifically, tokens were obtained from Part 3 of the NSC, which comprises roughly 1000 h of spontaneous conversational data. This part of the corpus contains conversations recorded in pairs performing two tasks. The first was a spot-the-difference task, in which each speaker received a picture handout and had to verbally communicate with their partner to identify all of the visual differences between both pictures without being able to see the other's handout. The second was a free conversation task, in which speakers were given a set of topic prompts but were free to discuss anything they liked.

Tokens of sia$_{24}$, meh$_{55,}$ and what$_{21}$ in the NSC transcripts were first extracted using a script in the R statistical environment (R Core Team 2021), from which we selected tokens for our dataset through random sampling. In order to maintain a sufficient basis for comparison across the selected tokens, we selected tokens only from speakers of a specific age group and gender, varying only in the ethnicity of the speaker. The NSC categorizes speakers into four ethnic groups: Chinese, Malay, Indian, and "Others", the last of which contains significant variation in ethnic background and languages spoken. We, therefore, restricted the language backgrounds of the speakers in our dataset by selecting only from the first three groups. All of the speakers in the corpus are Singaporean and, in the recording process, declared themselves to be bilingual in English and their designated mother tongues. Male speakers were chosen over female speakers as a count revealed that male speakers produced more tokens overall across the different ethnicities than female speakers. The age group of 20–39 was chosen as speaker metadata from the NSC indicated that they were the most numerous, comprising 62.6% of all Chinese, Malay, and Indian male participants in Part 3 of the NSC.

Within this pool of sia_{24}, $\text{meh}_{55,}$ and what_{21} tokens produced by the Chinese, Malay, and Indian speakers aged 20–39, 18 unique speakers from each ethnic group for each particle and 50 tokens from these 18 speakers were selected through random sampling using the R *sample* function.[2] However, two of the meh_{55} tokens from Indian speakers were subsequently removed as they were wrongly identified as meh_{55} in the NSC transcripts. This yielded 150 tokens per particle (with the exception of meh_{55}, which yielded only 148 tokens), divided equally among the three ethnic groups, and a total of 448 tokens across all particles. Table 1 shows the total number of tokens that were extracted and used for analysis:

Table 1. Number of tokens.

Ethnicity	Particle			Total
	$\textbf{sia}_{24}$	$\textbf{meh}_{55}$	$\textbf{what}_{21}$	
Chinese	50	50	50	150
Malay	50	50	50	150
Indian	50	48	50	148
Total	150	148	150	448

2.2. *Analysis of Selected Tokens*

We first identified the start and end times of the selected tokens in the corresponding audio recordings of the conversations, using them to extract the tokens' pitch contours using the software Praat (Boersma and Weenink 2021). The pitch contours were also inspected to ensure that there were no pitch tracking errors made by the software. Figure 1 shows an example of each particle indicating where the start and end times are located in relation to the particles' spectrograms in Praat, with the pitch contours marked out in blue. As can be seen in Figure 1, the start and end times for meh_{55} and what_{21} encompass the entire particle. However, unlike the other two particles, sia_{24} begins with a voiceless obstruent that does not carry pitch information, so the start times and end times for sia_{24} tokens encompass only the nucleus of the particle.

After extracting the pitch contours, the pitch values in the contours were then normalized using the ST-AvgF0 method described in Zhang (2018), which converts the pitch values in Hertz to a semitone scale using each speaker's average F0 value in their entire conversation as the reference pitch. The formula for the normalization is as follows:

$$\mathrm{F}_{\mathrm{ST-AvgF_0}} = \frac{12}{\log_{10} 2} \times \log_{10} \frac{x_i}{\mathrm{AvgF_0}}. \quad (1)$$

The ST-AvgF0 method was chosen instead of normalization methods that scale the pitch values of each speaker's tokens by the speaker's standard deviations in pitch in their entire conversation (e.g., z-score normalization) because differences in language background may be reflected in systematic differences in speakers' standard deviations. In addition, the logarithmic semitone scale "correctly capture[s] speakers' intuitions about equivalence of intonational span" (Nolan 2003, p. 771) in comparison to the linear Hertz scale.

The mean pitch of the particle tokens was used to identify outliers that are unreasonably high, given the range of our speakers' average F0 values from 104 Hz to 243 Hz, and eliminate them as unnatural or distorted tokens. As the distribution of mean pitch for all particle tokens is positively skewed, we identified and removed outliers using a boxplot formula that is adjusted for skewed distributions (Hubert and Vandervieren 2008), implemented in the *robustbase* package (Maechler et al. 2021) in R. Four outliers were removed through two iterations, until no further outliers were identified. Figure 2 shows the positive skew of the distribution.

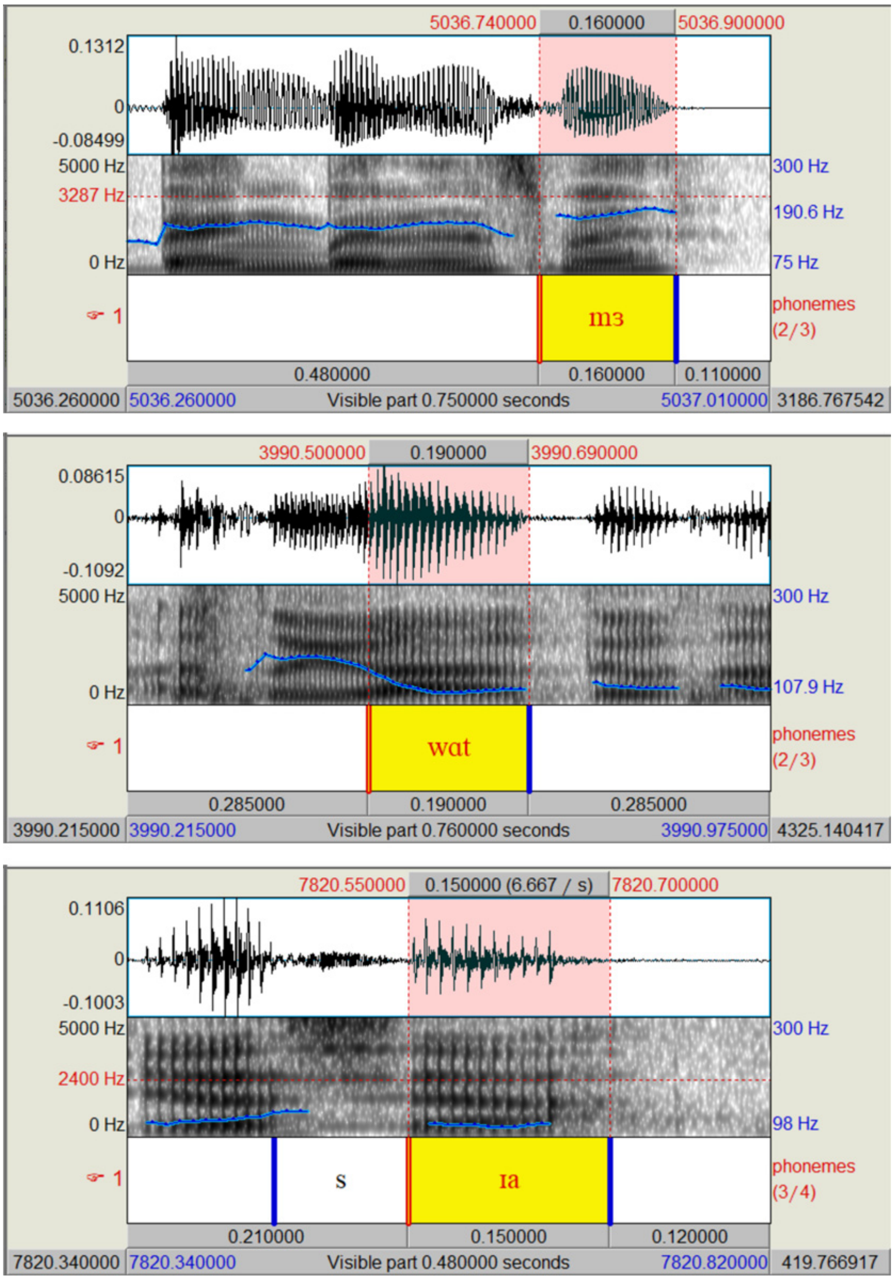

Figure 1. Start and end times for tokens of each particle in Praat.

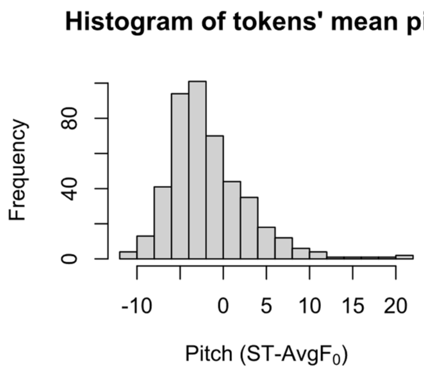

Figure 2. Distributions of tokens' mean pitch.

To identify general differences in the pitch contour of tokens across ethnicities, we used generalized additive mixed models (GAMMs), which fit non-linear curves or 'smooths' to time-series data such as pitch contours. In addition, GAMMs allow the inclusion of random effects such as speaker in the significance testing of main effects and interactions. To analyze the current dataset, we selected a model with the fixed effects of ethnicity, particle, and age group (as a controlling factor) as well as their interactions as parametric terms, a smooth fit at the reference level of the fixed effects, and difference smooths of ethnicity, particle, and age group. Random smooths of token and speaker were also included to account for the non-independence of data points within each token and across different tokens from the same speaker.[3] Models were fitted using the function *bam* in the R package *mgcv* (Wood 2021).

However, as one of our research aims is to determine if speakers of different ethnicities significantly differ in how consistent the pitch contours of tokens are for each particle, statistical analysis of the variances of the tokens' pitch contour is required. To describe the pitch contour of each token numerically, three acoustic parameters were calculated using the pitch contour of each token: the mean pitch, the pitch range (defined as the difference between the maximum and minimum pitch values), and the pitch movement (defined as the difference between the offset pitch and the onset pitch; both the onset pitch and offset pitch are obtained within the start and end times of the tokens identified previously). The mean pitch is meant to reflect the overall pitch height at which the particle in each token is pronounced, while the pitch range and pitch movement are meant to reflect the steepness and direction of the contour respectively.

To quantify the variance in each of the three parameters within each subgroup of ethnicity and particle (meh$_{55}$ tokens from Chinese speakers, meh$_{55}$ tokens from Malay speakers, what$_{21}$ tokens from Chinese speakers, etc.), we first transform the dependent variables following the Brown–Forsythe test (Brown and Forsythe 1974). The median values of each of the three acoustic parameters within each subgroup were identified, following which the absolute differences of the three parameters of each token from the median value of their respective subgroups were calculated. Three linear mixed-effects models were then fitted to the data[4] using the R package *lmerTest* (Kuznetsova et al. 2017), with speaker ethnicity and particle as fixed effects, an interaction between speaker ethnicity and particle, and the absolute differences of each of the three acoustic parameters from the group medians as the dependent variable. As with the GAMMs, age group is also included as a controlling factor, as well as a random effect of speaker to account for the fact that each speaker may contribute more than one token. In addition, since each speaker contributes tokens of all three particles, likelihood ratio tests were used to determine if a random slope of particle should be included in the model. As the tests did not indicate a significant difference between models with the random slope and models without, the random slope of particle is not included in these models. To identify specific interactions between speaker ethnicity and particle, pairwise comparisons of the estimated marginal means of the dependent variables were also conducted using the R package *emmeans* (Lenth 2021), with p-values adjusted using the Tukey method.

To supplement the general GAMM analyses, three additional linear mixed-effects models[5] were fitted to the data with each of the three acoustic parameters as the dependent variable. Age group is again included as a controlling factor, and speaker is included as a random effect to account for the fact that more than one token may come from a speaker. In addition, since each speaker contributes tokens of all three particles, likelihood ratio tests were used to determine if a random slope of particle should be included in the model, and the results indicate that the models with a random slope of particle included fit the data better, $\chi^2(5) = 21.68$, $p < 0.001$ for mean pitch; $\chi^2(5) = 16.24$, $p < 0.001$ for pitch range; and $\chi^2(5) = 12.20$, $p < 0.05$ for pitch movement. Again, pairwise comparisons of the estimated marginal means of the dependent variables were also conducted to identify specific interactions between speaker ethnicity and particle.

3. Results

With the outliers removed, the distributions of the three acoustic parameters are shown in the boxplots, seen in Figure 3, separated by speaker ethnicity:

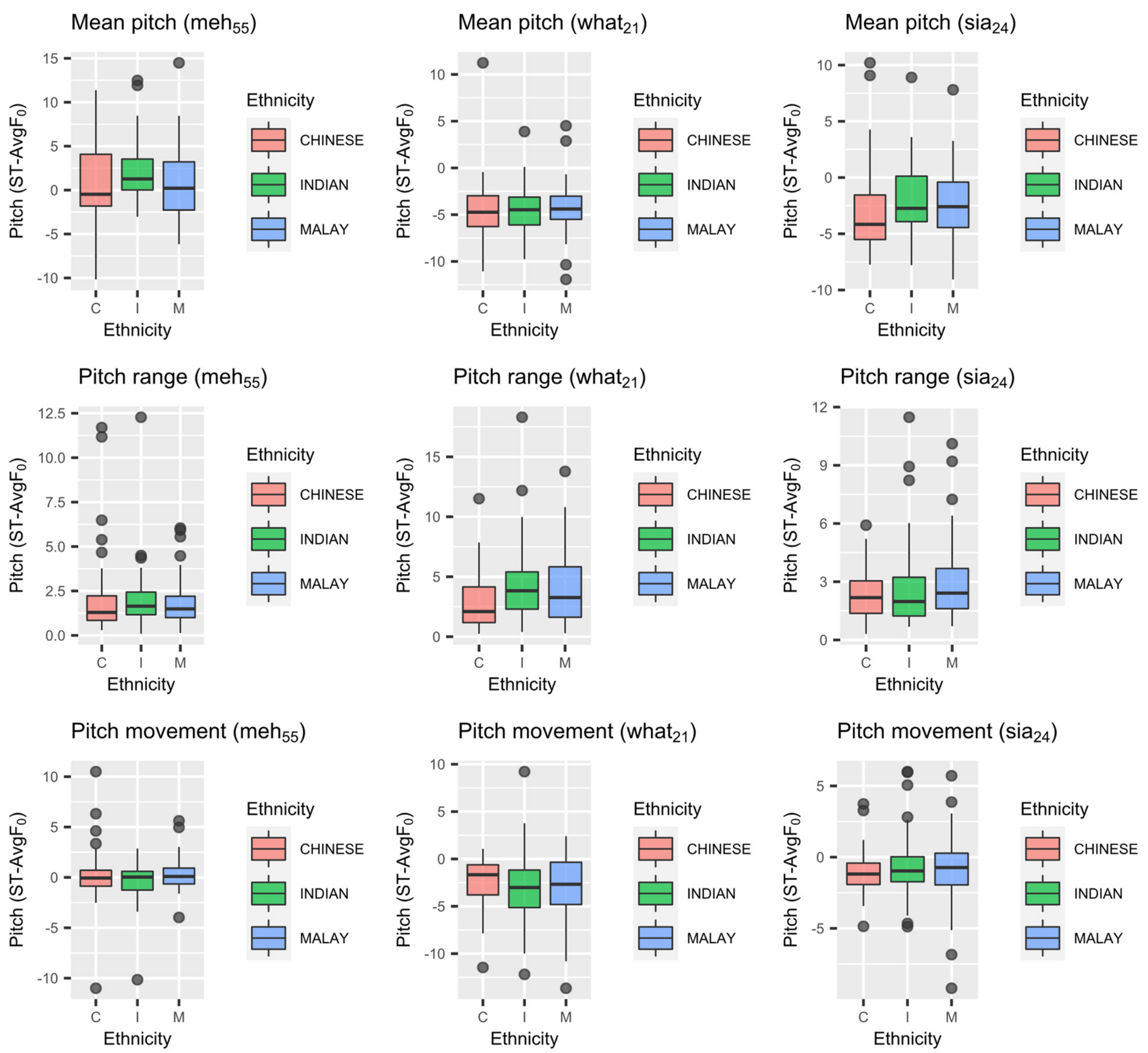

Figure 3. Boxplots of the three acoustic parameters.

Results from the statistical analyses indicate that the effect of ethnicity on the three acoustic parameters as well as their absolute differences was not significant in any of the linear mixed models that were fitted to the data, as shown in Table 2, which suggests that the ethnicity of the speaker has no discernible overall effect on the pitch height and contour of the particle tokens, as well as on the consistency of their tone patterns with others of the same ethnicity.

Table 2. ANOVA results of the effect of ethnicity.

Dependent Variable	Sum Sq	Mean Sq	NumDF	DenDF	*F*-Value	*p*-Value
Mean pitch	31.99	16.00	2	50.201	1.61	0.21
Pitch range	15.80	7.90	2	78.13	1.90	0.16
Pitch movement	6.48	3.24	2	140.82	0.57	0.57
Absolute difference of mean pitch	9.22	4.61	2	56.77	0.83	0.44
Absolute difference of pitch range	4.34	2.17	2	77.45	0.75	0.48
Absolute difference of pitch movement	3.97	1.98	2	74.42	0.62	0.54

3.1. Differences in Tokens' Tone and Contour

Despite the statistically non-significant main effect of ethnicity found previously, the speaker's ethnicity could still have a significant effect on how they pronounce each particle. For instance, a significant higher mean pitch of meh_{55} tokens from Chinese speakers relative to the other speakers may cancel out a significant lower mean pitch of $what_{21}$ tokens from Chinese speakers, resulting in an aggregate non-significant main effect of ethnicity. However, the interaction of ethnicity and particle in the GAMMs fitted separately to the pitch contours of tokens, as well as in the linear mixed models, is also not statistically significant, as shown in Table 3. This confirms that the speaker's ethnicity has no effect on the pitch height and contour of the particle tokens, even when we look at each particle specifically.

Table 3. ANOVA results of the interaction between ethnicity and particle.

Dependent Variable	Sum Sq	Mean Sq	NumDF	DenDF	*F*-Value	*p*-Value
Pitch contour (GAMM)	-	-	4	-	1.49	0.20
Mean pitch	24.76	6.19	4	68.73	0.62	0.65
Pitch range	26.72	6.68	4	118.17	1.61	0.18
Pitch movement	18.87	4.72	4	65.90	0.83	0.51

Planned pairwise comparisons of the estimated marginal means of the tokens' mean pitch, pitch range, and pitch movements based on the corresponding linear mixed-effects model also do not show a significant difference between speakers of different ethnicities. This further confirms that the pitch contours of tokens of each particle are generally similar across speakers of different ethnicities. Consistent with this general result, smooth plots from the GAMMs in Figure 4 show that the contours of meh_{55}, sia_{24}, and $what_{21}$ are largely similar across ethnicities, with overlapping confidence intervals.

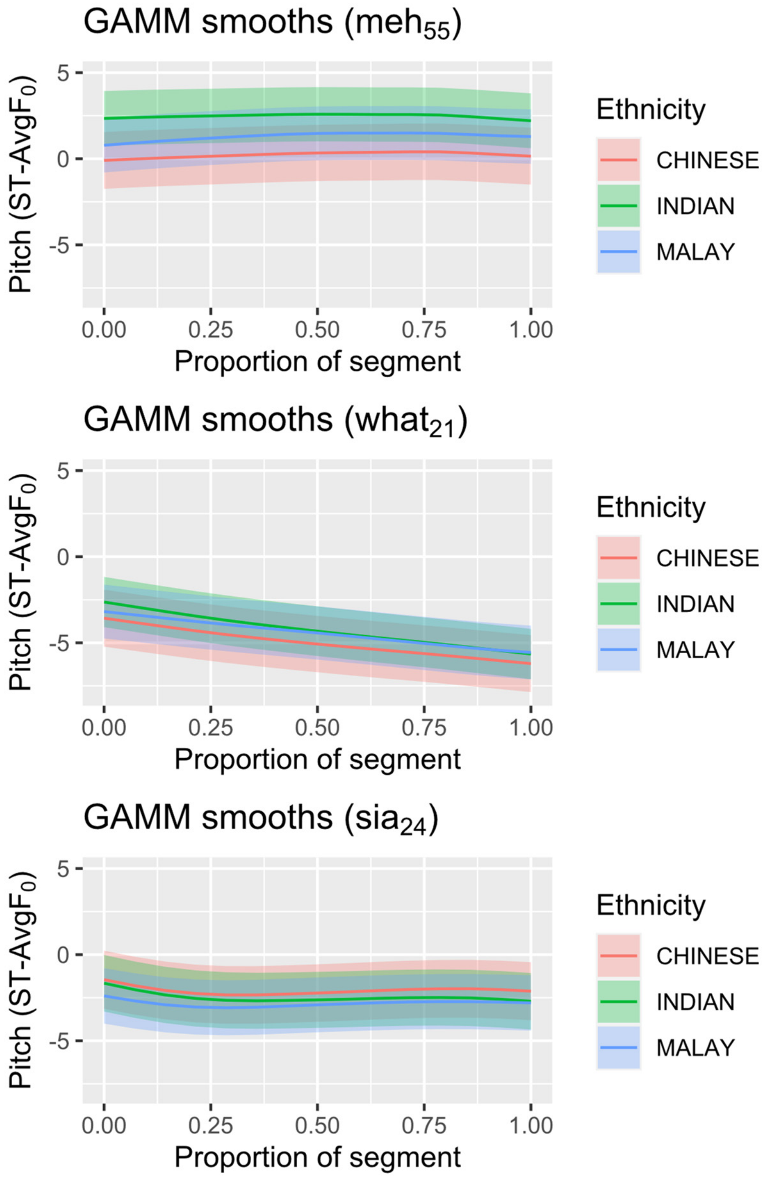

Figure 4. Smooth plots of token contours split by particle.

3.2. Differences in the Variance of Tokens' Tone and Contour

Although no strong conclusions about whether meh$_{55}$, what$_{21,}$ and sia$_{24}$ possess lexical tone can be drawn from our current study, one might expect that if some of the particles possess lexical tone while others do not, there would be a difference in the consistency of how speakers pronounce certain particles relative to others, i.e., a significant effect of ethnicity in the linear mixed models fitted separately to the absolute differences of the tokens' mean pitch, pitch range, and pitch movements. Indeed, the effect of particle is shown to be statistically significant, as presented in Table 4.

Table 4. ANOVA results of the effect of particle.

Dependent Variable	Sum Sq	Mean Sq	NumDF	DenDF	*F*-Value	*p*-Value
Absolute difference of mean pitch	93.02	46.51	2	316.80	8.34	<0.001
Absolute difference of pitch range	71.06	35.53	2	345.12	12.23	<0.001
Absolute difference of pitch movement	76.10	38.05	2	341.06	11.94	<0.001

However, pairwise comparisons of the estimated marginal means of the absolute differences of the tokens' mean pitch, pitch range, and pitch movements based on the corresponding linear mixed models in Table 5 show significant differences across all acoustic parameters between meh$_{55}$, which has the greatest variability, and what$_{21}$, which has the least. In addition, there are also significant differences in the absolute differences of pitch range and pitch movement between sia$_{24}$ and what$_{21}$:

Table 5. Pairwise comparisons by particle of the estimated marginal means of the absolute differences of the three acoustic parameters.

Dependent Variable	Contrast	Estimate	SE	df	t Value	Pr(>|t|)
Absolute difference of mean pitch	meh$_{55}$–sia$_{24}$	0.59	0.29	349	2.02	0.11
	meh$_{55}$–what$_{21}$	**1.21**	**0.30**	**314**	**4.08**	**<0.001**
	sia$_{24}$–what$_{21}$	0.62	0.30	293	2.07	0.10
Absolute difference of pitch range	meh$_{55}$–sia$_{24}$	−0.28	0.21	370	−1.34	0.38
	meh$_{55}$–what$_{21}$	**−1.00**	**0.21**	**341**	**−4.80**	**<0.001**
	sia$_{24}$–what$_{21}$	**−0.72**	**0.21**	**327**	**−3.46**	**0.0018**
Absolute difference of pitch movement	meh$_{55}$–sia$_{24}$	-0.17	0.22	367	−0.77	0.72
	meh$_{55}$–what$_{21}$	**−1.01**	**0.22**	**338**	**−4.58**	**<0.001**
	sia$_{24}$–what$_{21}$	**−0.84**	**0.22**	**321**	**−3.80**	**<0.001**

The results, therefore, are inconsistent with our suggestion in Section 1.2 that meh$_{55}$ is more likely to be tonal as it is of Cantonese origin, while sia$_{24}$ is more likely to be non-tonal. Instead of meh$_{55}$ being the least variable among the particles, which might be expected of a tonal particle, it is what$_{21}$ that exhibits the least variability across speakers.

While the main effect of particle in the linear mixed models fitted separately to the absolute differences of the three acoustic parameters is found to be statistically significant, the interaction of ethnicity and particle is not, as shown in Table 6. This suggests that for each particle, the ethnicity of the speaker has no effect on the consistency of their pronunciation.

Table 6. ANOVA results of the interaction between ethnicity and particle.

Dependent Variable	Sum Sq	Mean Sq	NumDF	DenDF	*F*-Value	*p*-Value
Absolute difference of mean pitch	9.82	2.46	4	295.27	0.44	0.78
Absolute difference of pitch range	16.43	4.11	4	331.72	1.41	0.23
Absolute difference of pitch movement	21.82	5.46	4	324.77	1.71	0.15

4. Discussion

As described in Section 1.1, Botha (2018) and Leimgruber et al. (2021) found ethnic differences in how Singaporeans use Singlish particles, with Chinese speakers and writers using more particles of Cantonese origin such as "hor" and "leh". Based on this, one possible result from our current study would be that speakers of a given ethnic group will produce the particle that originated from a language associated with their ethnic group differently, i.e., Chinese speakers' tokens of meh$_{55}$, and Malay speakers' tokens of sia$_{24}$, might center around different defaults relative to other particles or tokens from speakers of other ethnic groups. Chinese speakers' greater use of meh$_{55}$ may also lead them to pronounce the particle more consistently or less consistently relative to other speakers or other particles.

In addition, Gupta (2006, p. 250) suggests that "those who have a language repertoire devoid of tonal languages (as do many of the non-Chinese population) may be less likely to have lexical tone in Singlish than those who speak at least one variety of Chinese (as do most of the ethnic Chinese population)". Therefore, another possible result is that tokens of Chinese speakers would exhibit more consistency within particles than tokens of other speakers, as they are more likely to reproduce the particles with lexical tone given their language repertoire than speakers of other ethnicities with non-tonal mother tongues. If one or more of the particles in the study are tonal in nature, e.g., meh_{55}, there may also be an interaction between speaker ethnicity and particle, such that Chinese speakers pronounce meh_{55} with more consistency than other particles.

However, the lack of a statistically significant effect of ethnicity on the three acoustic parameters (namely mean pitch, pitch range, and pitch movement) and their absolute differences in our data indicate that, unlike with particle use, speakers' ethnicity has little to no effect on the tone, contour, and variances of the tokens. One possible explanation for this is that Singlish is acquired early enough in life by speakers of all ethnic groups, which allows them to reproduce the particles' pitch contours without interference from other languages in their differing language repertoires. If this is true, then Singlish is in fact acquired as a first language by Singaporeans, consistent with Chua's (2015) and Gil's (2003) claim that "Singlish constitutes a full-blown language system, and can be acquired in early childhood in ways typical of first or second language acquisition" (Chua 2015, p. 192).

Besides the lack of significant ethnic differences in speakers' production of the particles, results also indicate that $what_{21}$ exhibits the least variability among the three particles in the study, even though it is unlikely to be tonal given its origins. Conversely, meh_{55} and sia_{24}, the two particles most likely to be tonal and non-tonal, respectively, given their language origins, are found to be not significantly different in how their pitch contours vary across speakers. The latter finding may, therefore, suggest that they are either both tonal or non-tonal particles in Singlish. For example, sia_{24} may have acquired lexical tone due to the large proportion of Singlish speakers who also have Mandarin or another Chinese language in their language repertoire. Alternatively, meh_{55} may also have lost its tone from Cantonese as a result of Singlish's superstrate language being English, a non-tonal language. It is, however, unlikely that $what_{21}$ has acquired lexical tone while meh_{55} and sia_{24} have not—instead, the low variability of $what_{21}$ tokens could be due to it being pronounced in a low falling tone, i.e., at the bottom of the speakers' range, which would restrict how much it can vary.

Regarding the current dataset, one limitation is that, as explained earlier, the three particles sia_{24}, $meh_{55,}$ and $what_{21}$ each have only one possible meaning that is commonly associated with one tone, in contrast to other particles like "lah" where different tones can give rise to different meanings. Since "meh" only has one meaning, the sentence "You still have class meh?" would be interpreted the same way regardless of whether the particle is pronounced as meh_{55} (with a high level tone) or meh_{33} (with a mid level tone), i.e., "meh"'s tone can be underspecified in terms of pitch height, with the difference in pronunciation accommodated as part of speaker variation. Thus, there is no inherent need for speakers to accurately achieve a consistent pitch target for these particles in order to be understood. It is possible that differences in consistency between speakers of different ethnicities would emerge if we look at tokens of particles that can be pronounced with more than one pitch contour, which would require more precise pitch targets. One example is the particle "lah", which has been described by Wong (2004) as having four variants that correspond to the four lexical tones of Mandarin. Chinese speakers of Singlish may thus have an advantage when producing each variant, compared to Malay and Indian speakers. However, the difficulty of determining the "lah" variant of the tokens independent of their pitch contour—the main reason why the current dataset focuses on particles with only one variant—remains an issue, especially since the literature is unclear on the precise semantic or pragmatic contexts that can be used to identify each "lah" variant.

Alternatively, a follow-up study may also compare the pitch variation of the tokens produced by Singlish speakers of different ethnicities with the pitch variation of actual Mandarin tokens of one lexical tone, which would serve as a baseline of pitch consistency in a tonal language. Comparing the variability of the Singlish particle tokens to this baseline would thus provide stronger evidence for whether Singlish speakers are hitting pitch targets as accurately as Mandarin speakers do with words that possess actual lexical tone. Indeed, if the pitch variation of the tokens produced by Malay and Indian speakers are statistically indistinguishable from this baseline, it would provide evidence in support of the argument that they are able to produce tones in Singlish with the same accuracy as Chinese speakers despite having mother tongues that are non-tonal.

5. Conclusions

The aim of this study was to investigate whether speakers' ethnicity would affect their production of particles' pitch contours in Singlish. We analyzed 444 tokens of three Singlish particles—sia$_{24}$, meh$_{55,}$ and what$_{21}$—containing different tone contours and originating from different languages, and examined whether the different ethnic groups produced the particles' pitch contours in different ways. The results show that, unlike previous studies that found an effect of ethnicity on particle use, there is little to no effect of ethnicity on how speakers produce the particles in terms of their pitch contours. In addition, speakers are not significantly different in the variability in which they produce meh$_{55}$ and sia$_{24}$ tokens, respectively, despite the fact that meh$_{55}$ is more likely to be tonal and sia$_{24}$ non-tonal given their language origins.

The results of this study suggest several avenues for further research. For example, since speakers are not hitting the target pitch contour of meh$_{55}$ more accurately than sia$_{24}$, which would be the case if meh$_{55}$ is tonal and sia$_{24}$ non-tonal, this may indicate that meh$_{55}$ and sia$_{24}$ in Singlish are either both tonal or non-tonal in nature. Resolving this question in a future study would be especially relevant to the issue of tonality in Singlish, as either possibility would entail a shift in tonality in one of the particles from its original language to its current use in Singlish. In addition, one of the possibilities that may explain the lack of a significant effect of ethnicity on how speakers produce the particles in the study is that Singlish is acquired early enough in life by speakers of all ethnic groups to avoid interference from other languages in their respective language repertoires, and trying to ascertain to what extent Singlish can be acquired as a first language in its own right would be another fruitful direction for future work.

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Notes

1 In this paper, we indicate the particles' pitch contours in subscripts using Chao's (1930) system of tone letters, which divides the pitch range of the speaker along five equal points, with 1 being the lowest pitch and 5 being the highest. The onset and offset of the pitch contour are indicated by the first and second digits of the subscript, respectively; for example, the phoneme "ma" in Mandarin is written as "ma$_{55}$" when pronounced in a high level tone, and as "ma$_{51}$" when pronounced in a high falling (contour) tone.

[2] The number of tokens for each speaker ranges from 1 to 8. To control for the differing number of tokens per speaker, a random effect of speaker is included in the linear mixed-effects models used for statistical analysis of the data, which is discussed further in Section 2.2.

[3] This particular random effects structure is determined to have a lower AIC than other variants such as a random intercept of speaker or a random slope of particle, following Sóskuthy (2017).

[4] The Brown–Forsythe test was used rather than Levene's test as the distributions of the three acoustic parameters are positively skewed. However, since each speaker may contribute more than one token, an ANOVA of the absolute differences following the Brown–Forsythe test would be inappropriate, so the absolute differences were analysed using linear mixed-effects models instead, which can handle non-independent data points in the dataset through random effects.

[5] In order to accommodate the possibility that the three acoustic parameters would have different variances across speakers of different ethnicities, statistical procedures such as ANOVA that assume homogeneity of variance across groups were ruled out for the analysis. As mentioned previously, each speaker may also contribute more than one token to our dataset, so not all the data points in the dataset are independent. Besides their ability to analyse non-independent data points in the dataset, linear mixed-effects models are used here as well as they are fairly robust against heteroscedasticity (Schielzeth et al. 2020).

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