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Some Prosodic Consequences of Varied Discourse Functions in a Cantonese Sentence-final Particle

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Abstract

This study investigates the prosodic correlates of varied discourse functions for a Cantonese sentence-final particle. Three functions of the particle *ge2* were examined: blaming others (Blame), defending oneself (Defend), and asking for reasons (Reason). Ten native adult speakers of Cantonese participated in the production experiments. Results of both Smoothing Spline ANOVA and Generalized Additive Mixed Models suggest that, despite the same citation tone of *ge2* (high-rising tone), the pitch of Reason is significantly lower than that of Blame and Defend, and there is no significant difference between the latter two. Besides, mixed-effects regression shows that the relative vowel duration of Defend is significantly shorter than the other two functions. Additionally, k-means clustering suggests that Reason can be reliably classified based on its lower pitch. Blame and Defend have similar pitches and primarily differ in relative vowel duration. Our results suggest that different functions of the same Cantonese particle have different phonetic realization in pitch and duration.

Index Terms: sentence-final particle, pitch, duration, Cantonese

1. Introduction

This study investigates the prosodic correlates of varied discourse functions for the Cantonese sentence-final particle (SFP) *ge2*.

Cantonese (a tone language) possesses a complex system of SFPs, which typically attach to the end of an utterance. It has been estimated the number of distinct SFPs as low as 30 and as high as 206 [1], [2], [3], [4], [5], [6]. SFPs encode semantic and pragmatic functions similar to those encoded by intonation in languages like English [7], [8]. But as we will show, individual particles may have varied discourse functions, in which intonation-like prosodic differences are found.

Previous research on SFPs has revolved around the nature of their tone. The traditional view posit that their tones are lexical tones, substantiating this claim by demonstrating the fundamental frequency (F0) of their tones does not significantly differ from that of lexical words [9]. Conversely, another perspective suggests that the tones of SFPs are wholly intonational. According to this view, their surface tones result from the superimposition of boundary tones on SFPs with a hypothesized neutral tone, even though Cantonese phonology lacks a neutral tone [5], [10], [11], [12], [13]. Additional studies propose a combined perspective, arguing that the tones on SFPs comprise both lexical tone and intonation. This suggests the superimposition of boundary tones on the inherent lexical tones of SFPs [14], [15]. In a more recent study, it was revealed that SFPs with the same citation tone could exhibit significant pitch variations, indicating that some of their tones may be purely lexical, while others may represent a combination of lexical tone and intonation. [16]. Despite this dispute, prior studies shared a common methodological approach, involving the comparison of F0 in identical segments to analyze pitch variations among different SFPs. However, this methodology has a significant limitation as it assumes that each SFP encodes only one function. In fact, many SFPs serve multiple discourse functions, and the phonetic implementation of individual particles with varied discourse functions remains unexplored. Furthermore, we hypothesize that the prosodic correlates of diverse discourse functions may extend beyond mere pitch variations. For instance, it has been argued that Cantonese employs the duration of the utterance-final syllables as a component of intonation [17], [18], [19], [20], [21]. Some SFPs are observed with shorter duration, such as those traditionally annotated with the coda -/k/, which is argued to be interpreted as shortened (vowel) duration to intensify speakers' emotions [4], [12]. In the present study, we hypothesize that intonation-like prosodic differences in pitch and (vowel) duration can be found for individual particles that have varied discourse functions.

It is well studied that Cantonese realizes its intonation locally on the utterance-final syllables by boundary tones. SFPs are also argued to form a domain of intonation realization in themselves apart from the prosody in previous portion of the utterance [14], [15], [17], [22], [23]. Despite local realization of intonation at the syllable level, paralinguistic factors may have global effects on the prosody of the whole utterance. For example, speakers tend to have higher pitch and faster speech rate when they are emotionally aroused [24], [25]. The pragmatic functions of SFPs often interact with paralinguistics [26], [27], [28], so utterance-level intonation may also have effects on the phonetic realization of SFPs. We hypothesize that the pitch of SFPs with functions that involve speakers' excitement (e.g., blaming others) is generally higher than that of other regular functions (e.g., defending oneself and asking questions) as a consequence of a global rise in pitch over the whole utterance caused by emotional arousal. Also, their duration may be shorter than that of SFPs with other regular functions if they are affected by the faster speech rate/global tempo of the whole utterance.

To summarize, the current study examines the prosodic correlates of varied functions for the same SFP. We also investigate how the pitch and vowel duration of SFPs may interact with the overall pitch and speech rate of the whole utterance. This study can further our understanding of the phonetic realization of SFPs by considering both local

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(syllable-level) and global (utterance-level) temporal and durational factors, which is a missing piece in the literature. Also, it contributes to our understanding of the varied phonetic/prosodic implementation of different functions of individual particles, which was not previously explored.

2. Method

2.1. Participants and procedure

Ten native adult speakers of Cantonese were recruited (5 females, 5 males; mean age = 20.90 years, *SD* = 1.66 years). According to the language background questionnaires, Cantonese was reported to be the dominant and first language of all participants. None of them reported any history of speech, hearing, or language problems. The experiments were conducted individually in a sound-attenuated laboratory at a sampling rate of 44,100 Hz.

2.2. Materials

The Cantonese SFP *ge2* (tone 2, high-rising tone) was reported to encode three functions: (1) blaming others (Blame); (2) defending oneself (Defend); and (3) asking for reasons (Reason) [4], [29]. We chose *ge2* as the case to study because its three functions could be clearly delineated by other syntactic and semantic/pragmatic constraints. Other SFPs may be stated with multiple number of functions, but researchers had varying categorizations for their functions and some of which lacked support from independent linguistic constraints.

Table 1 shows the design of the experiments with the *Jyutping* romanization of Cantonese materials [30]. Three carrier phrases (i-iii) were designed for each function with the same lexical tones (tone 3, mid-level tone), length, and syntactic structures to ensure similar prosody and metrics of each sentence. Additionally, a prompt ((P), underlined in Table 1) was designed for each function of *ge2* to reinforce participants' intuition about the discourse function of *ge2*. With the aid of contexts, participants were asked to produce the prompt and the carrier phrase with *ge2* placed at the end of the sentence for three times. For instance, for Blame, *Ding2 nei5 aa4! Aa3baak3 fan3gaau3 ge2!* ("Damn you! The uncle is sleeping!). Total number of utterances analyzed = 270 (10 participants × 3 functions × 3 carrier phrases × 3 repetitions).

Table 1: *Design of the production experiments.*

Function	Prompt + Carrier phrase
Blame	(P) *Ding2 nei5 aa4!* "Damn you!" + (i) *Aa3baak3 fan3gaau3* __ "The uncle is sleeping" (ii) *Piu3sou3 zok3fai3* __ "The votes are void" (iii) *Taai3gaam3 bin3taai3* __ "Eunuch is psychotic"
Defend	(P) *Mat1je5 aa3?!* "What?!" + (i) *Gwaai3sau3 caak3lam3* __ "The monster destroys it" (ii) *Seon3zung3 daap3jing3* __ "The followers agree with it" (iii) *Zing3gwan3 cit3gai3* __ "The politicians design it"
Reason	(P) *Dim2 gaai2 aa3?* "Why?" + (i) *Kong3zin3 tung3faai3* __ "Confrontation is exciting" (ii) *Gaa3gaak3 faa3syun3* __ "The price is a good deal" (iii) *Ci3haak3 kyut3dau3* __ "The assassins fight"

2.3. Data analysis

Both the carrier phrases and all SFPs (*ge2*) were manually segmented in Praat [31]. The F0 of *ge2* was sampled at ten equal time-points using ProsodyPro [32]. Mean F0 of each carrier phrase was also calculated using ProsodyPro. All F0 data were converted to semitones with a reference value of the 0.1 quantile of all F0 values of a given speaker [33] and standardized using z-scores owing to speaker variation. Smoothing Spline ANOVA (SSANOVA) was conducted on the standardized F0 data (in semitones) of *ge2* using the *gss* package [34] in R [35] for the primary inspection of pitch contours. Additionally, to capture nested random effects, Generalized Additive Mixed Models (GAMMs) were subsequently conducted on the same data using the *bam* function from the R package *mgcv* [36]. We included the predictor Function (simple-coded) in our models. Smooths, defined as thin-plate regression splines with ten basis functions, were added for the predictor Normalized Time by Function. Random effects by Function were added by both participants and items. By-item and by-participant random smooths (thin-plate regression splines) for Normalized Time by Function were also respectively added to the model, configured as first-derivative penalties with ten basis functions (confirmed to be sufficient using *mgcv* function gam.check). Models were fitted to scaled-*t* errors, including an order-1 autoregressive process with $\rho = .5$. The smoothness selection criterion was the fREML criterion. After fitting the models, we computed pairwise differences in the predicted temporal trajectories between all three conditions, using the same approach as Voeten [37]. For each condition, we obtained the models' predicted values along a 100-point grid of Normalized Time, computed the pairwise differences of interest, and computed 95% Bayesian credible intervals using the approach by Wood [36]. Differences along a pitch's time course are considered significant where their credible interval excludes zero. Apart from the F0 data of the *ge2*, mixed-effects regression was carried out on the standardized mean F0 data (in semitones) of the carrier phrases using the R package *lme4* [38] with functions of *ge2* as the predictor. We also included participants as random intercepts. Post hoc analyses using estimated marginal means (EMMs) were carried out using the R package *emmeans* [39].

Both the vowel duration of *ge2* and the duration of the whole utterance were calculated using ProsodyPro. Relative vowel duration of *ge2* was calculated by dividing its vowel duration by the duration of the whole utterance. Speech rate of carrier phrases was calculated by dividing the duration of the carrier phrase by 4 (= no. of syllables). All temporal data were standardized using z-scores. Mixed-effects regression was conducted separately on the relative vowel duration of *ge2* and the standardized speech rate of the carrier phrases with functions of *ge2* as the predictor and random intercepts of participants. Post hoc analyses using EMMs were carried out.

To investigate if the prosodic features of the three functions of *ge2* are statistically distinct for identification, thereby indicating potential perceptual salience, k-means clustering – an unsupervised machine learning technique – was applied to the mean F0 (in semitone) and relative vowel duration data of *ge2* using the R package *factoextra* [40].

3. Results

Figure 1 shows the standardized mean F0 (in semitones) and standardized relative vowel duration of *ge2*. The three functions of *ge2* can be visually differentiated by these two dimensions. Reason (blue crosses) has a lower pitch than the other two functions. Defend (green dots) has a shorter relative vowel duration than Blame (red triangles).

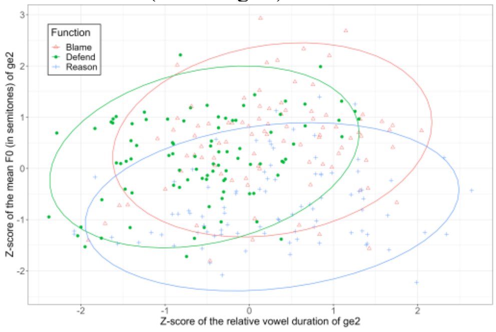

Figure 1: *Pitch and relative vowel duration of ge2.*

3.1. Pitch

Figure 2 shows the SSANOVA results of the pitch of three functions of *ge2*. Statistical significance is defined by non-overlapping regions. The pitch of Reason (blue crosshatched curve) is significantly lower than that of Blame (unpatterned red curve) and Defend (green curve with circles). The latter two curves are marginally overlapping with each other, suggesting that there is no significant difference in pitch between Blame and Defend.

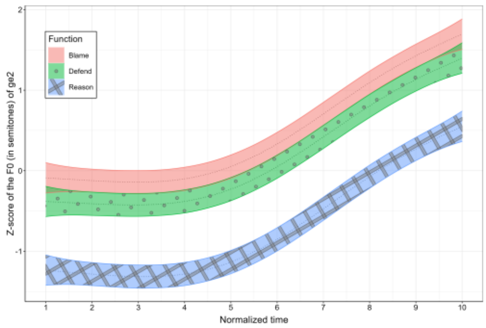

Figure 2: *SSANOVA results of the pitch of ge2.*

We follow the GAMMs visualization methods proposed by Pinget and Voeten [41]. Figure 3 shows the predicted F0 differences between three functions of *ge2*. Here, the gray bands denote the credible intervals, such that differences are significant at timepoints where they do not span zero. The results of GAMMs are consistent with the SSANOVA results. Throughout the entire time course, the pitch of Reason is significantly lower than both Blame (Figure 3(B)) and Defend (Figure 3(C)), while there is no significant difference in pitch between Blame and Defend (Figure (3(A)).

Figures 4 shows the quantiles of F0 (in semitones) of the carrier phrases to show the distribution of F0. The pitch of the carrier phrases of Reason (blue line with crosses) is generally distinctly lower than that of Blame (red line with triangles) but not than that of Defend (green line with dots) in the low end (e.g., 0.1 quantile) and high end (e.g., 0.9 quantile). The pitch of the carrier phrases of Blame and Defend is generally not distinctly different, especially from their mid-range (e.g., 0.5 quantile) to the high end.

Figure 5 shows the mean F0 (in semitones) of carrier phrases of each function of *ge2*. Mixed-effects regression shows the mean F0 (semitones) of carrier phrases can be predicted by the function of *ge2*, $F(2, 5.97) = 12.08$, $p < .008$. Post hoc analyses using EMMs show that the mean F0 of carrier phrases of Reason is significantly lower than that of Blame, $B = 1.19$, $SE = .24$, $t(6) = 4.91$, $p = .007$. However, there is no difference in pitch between the carrier phrases of Blame and Defend ($B = .53$, $SE = .24$, $t(6) = 2.17$, $p = .16$) or between that of Defend and Reason ($B = .66$, $SE = .24$, $t(6) = 2.73$, $p = .08$).

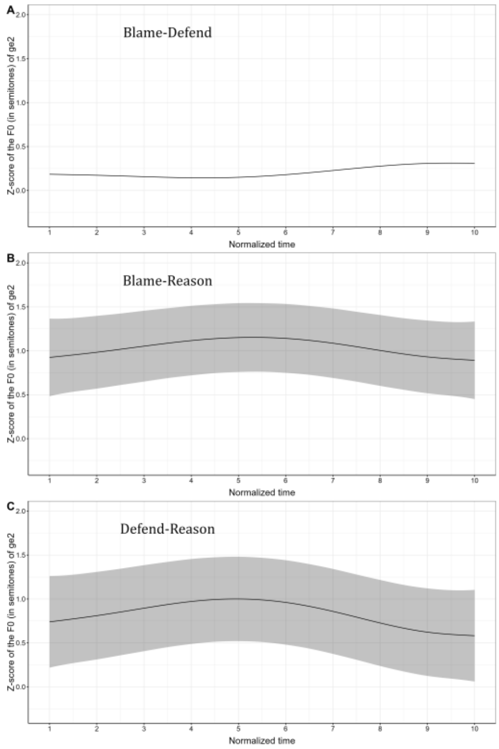

Figure 3: *GAMMs results of the pitch of ge2.*

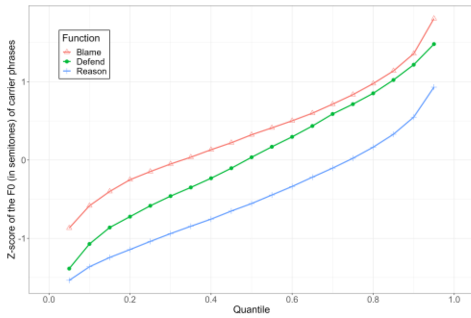

Figure 4: *Quantile plot of the pitch of carrier phrases.*

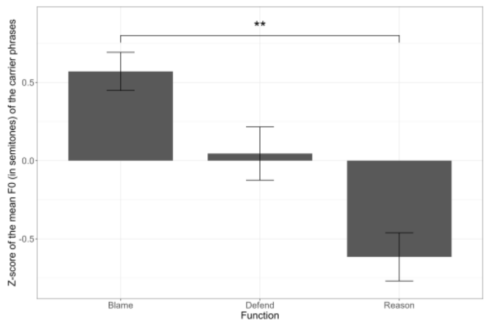

Figure 5: *Mean F0 (in semitones) of carrier phrases.*

3.2. Duration

Figure 6 shows the relative vowel duration of the three functions of *ge2*. Mixed-effects regression shows that their relative vowel duration can be predicted by functions, $F(2, 258) = 19.57$, $p < .001$. Post hoc analyses indicate that Defend has significantly shorter relative vowel duration than both Blame ($B = .64$, $SE = .11$, $t(258) = 5.67$, $p < .001$) and Reason ($B = -.58$, $SE = .11$, $t(258) = -5.13$, $p < .001$), but no significant difference between the latter two, $B = .06$, $SE = .11$, $t(258) = .54$, $p = .85$.

Figure 7 shows the speech rate of the carrier phrases of the three functions. Mixed-effects regression shows no significant difference between any of them, $F(2,87) = 2.90$, $p = .06$.

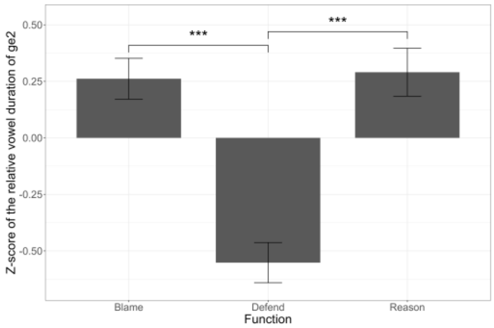

Figure 6: *Relative vowel duration of ge2.*

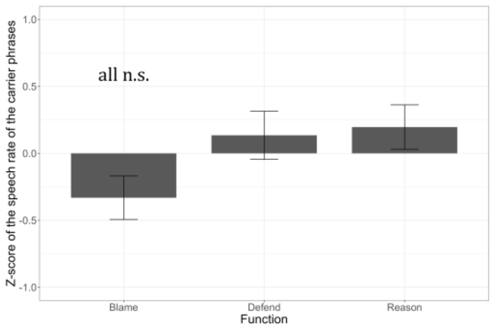

Figure 7: *Speech rate of carrier phrases.*

3.3. K-means clustering

Both elbow and silhouette methods indicate the optimal number of clusters to be 3. 90 tokens of each function were classified into 3 clusters by the machine without supervision. Table 2 shows the components of clusters. Figure 8 visualizes the clustering results.

Table 2: *Component results of k-means clustering.*

Cluster	Blame	Defend	Reason	Total
1	**42**	**46**	13	101
2	**32**	17	11	60
3	16	27	**66**	109

The three clusters in Figure 7 can be mapped to Figure 1: cluster 1 (green cluster with dots) is Defend; cluster 2 (red cluster with triangles) is Blame; and cluster 3 (blue cluster with crosses) is Reason. Reason is reliably classified as cluster 3 based on its lower pitch with an accuracy rate of 73.33% (66/90 correct tokens). Confusion occurs between Blame and Defend: 46.67% of Blame (42 tokens) is misclassified into cluster 1 (Defend), which can be attributed to their similar pitches. However, much fewer tokens of Defend (17 tokens = 18.89%) are misclassified into cluster 2 (Blame), which can be attributed to the shorter relative vowel duration of Defend than Blame.

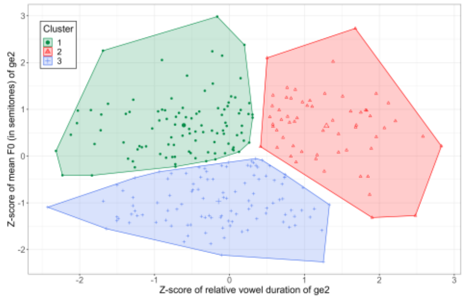

Figure 8: *Plot of k-means clustering results.*

3.4. Interim summary

Table 3 summarizes how the three functions of *ge2* are contrastive in pitch and duration.

Table 3: *Summary of the three functions of ge2.*

Function	Pitch	Duration
Blame	Higher	Longer
Defend	Higher	Shorter
Reason	Lower	Longer

4. Discussion and Conclusions

This study investigates the prosodic correlates of varied functions for the SFP *ge2*. Intonation-like prosodic differences are found in both pitch and duration.

First, in terms of pitch, both SSANOVA and GAMMs results showed that Reason has a significantly lower pitch than Blame and Defend, but there is no significant difference in pitch between the latter two. K-means clustering results also support that Reason differ from the other two functions primarily by lower pitch as it was reliably classified based on lower pitch. Mixed-effects regression showed that the pitch of the carrier phrases of Reason is significantly lower than that of Blame. This may support the hypothesis that the pitch of whole utterance of Blame is globally raised due to emotional arousal. Nevertheless, there is no significant difference in pitch between the carrier phrases of Defend and Reason, suggesting that *ge2* of Reason may have an inherently lower pitch than Defend, without being significantly affected by the global intonation.

Second, in terms of duration, mixed-effects regression showed that the relative vowel duration of Defend is significantly shorter than the other two functions. There is no significant difference in speech rate between the carrier phrases of the three functions, suggesting that the participants did not speak faster when they were blaming others. This also implies the duration of *ge2* with Defend function is inherently shorter than that of the other two functions as not being affected by the global tempo. Given that Blame and Defend have similar pitches, we argue that their difference is primarily manifested in duration. This is supported by k-means clustering results, where few tokens of Defend were misclassified as Blame owing to the shorter relative vowel duration of Defend.

This study has shown that individual Cantonese SFPs with varied discourse functions can have different phonetic realizations. This may have implications for the drastically diverging estimation of the number of Cantonese SFPs. Researchers may rethink if SFPs with varied functions are the same SFPs or merely homophones of different SFPs.

5. References

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