Individual-level cross-linguistic comparisons in Toronto Cantonese and English high vowels

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Abstract. Previous studies of Toronto Heritage Cantonese have suggested the lack of a similar phonological contrast in English as the source of cross-linguistic influence on the phonetic production of the /y/ vs. /u/ contrast in Cantonese. By comparing both the English and Cantonese production of the same individual speakers in spontaneous speech recordings, this study addresses Chang's (2021) call for more bilingual studies focused on individual-level cross-linguistic interactions. Results show three distinct patterns of cross-linguistic interaction: P1) three distinct vowels, P2) Cantonese /u/ merged with English /u/, and P3) Cantonese /y/ merged with English /u/. While P1 was the most frequently occurring pattern, the occurrence of P3 exclusively among second-generation speakers, among those with lower Cantonese Production Scores, and among those with the lowest Pillai Scores suggest that cross-linguistic phonetic similarity is what drives decreased acoustic distance between /y/ and /u/ rather than direct transfer of phonological categories.

Keywords. sound change; language contact; cross-linguistic influence; contact-induced change; heritage language bilingualism; Chinese - Yue

1. Introduction. A longstanding problem in linguistic studies of immigrant or heritage languages has been addressing the source of language change. If change has developed, did the change develop due to language contact or due to internal motivation? Studies of sound change in heritage language contexts introduce an additional problem. If a change develops due to cross-linguistic influence, is the cross-linguistic influence based on phonetic similarity or on phonological similarity? One way of addressing these questions is through a multi-comparative approach based on group-level patterns (cf. Nagy 2011; Umbal & Nagy 2021). To address the phonetics vs. phonology issue more precisely, however, comparative studies addressing cross-linguistic interaction within individual speakers, as advocated by Chang (2021), are also crucial.

The focus of this paper is the phonetic vs. phonological similarity question for two high round vowels in Toronto Cantonese: /y/ vs. /u/. While previous studies of these vowels suggest an English-influenced merger in progress (Tse 2022; Tse 2024), the precise nature of the English influence remains unclear. Is it due to phonological transfer (from a language lacking a similar contrast) or due to phonetic assimilation between Toronto English /u/ (henceforth 'UW') and either Cantonese /y/ or /u/? This paper addresses the following questions based on individual-speaker cross-linguistic comparisons of acoustic production:

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(Q1) Do individual speakers produce UW more like /y/ or more like /u/?
(Q2) How does /y/~UW~/u/ production vary based on generational (Gen1 vs. Gen2) and geographic (Hong Kong vs. Toronto) groups, Pillai Scores (distinctiveness of /y/ vs. /u/), and Cantonese Production Scores (a proficiency proxy)?
(Q3) Is English influence on /y/ vs. /u/ driven by phonetically based or phonologically based cross-linguistic equivalence?

2. Background. Cantonese is one of many heritage languages spoken in Toronto, Canada. For the current project, the Hong Kong variety is defined as the Homeland variety. The first major wave of immigration from Hong Kong to Canada began in the 1960s following the loosening of Canadian immigration laws (Chan 2011). According to the most recent census, Cantonese ranks number three after English and Mandarin in number of mother tongue speakers in the Toronto Census Metropolitan Area (Statistics Canada 2022).

Cantonese has a typologically large vowel inventory consisting of 21 vowels including 11 monophthongs and 10 diphthongs (Zee 1999). The two vowels that are the focus of this paper are /y/ vs. /u/ as illustrated in the sample words presented in Table 1. Also shown in this table are sample words containing English UW.

UW	/y/	/u/
group, *who*, *smooth*, *choose*, *tooth*, *balloon*	[kyn2] 捲 *roll*; [syl] 書 *book*; [tsy1] 豬*pig*; [tyn2] 短 *short*; [lyn6] 亂 *disorderly*	[kun2] 館 *public building*; [fu2] 苦*bitter*; [ku2] 古 *ancient*; [punl] 搬 *move*; [mun4] 門 *door*

Table 1. Sample UW, /y/, and /u/ words[1]

Previous research on /y/ vs. /u/ addressed English influence through a multi-comparative approach based on Nagy (2011). Part of the motivation behind this approach has been to develop more rigorous analyses of CONTACT-INDUCED CHANGE, which Thomason defines as a "linguistic change that would have been less likely to occur outside a particular contact situation" (2001: 62). This approach addresses problems inherent in studies of variation and change in intense contact settings. The outcome of a contact-induced change could be identical to the outcome of an internally motivated change. This makes the two types of change difficult to distinguish from each other. Contact-induced change could also develop through indirect influence such as changes that result from attrition or from structural imbalances triggered by earlier direct influence from a source language. Thus, given the difficulty of distinguishing between contact-induced and internally motivated change and the myriad of possible ways in which one language could influence another language, a multi-comparative approach helps address the likelihood a change would have developed outside a particular contact situation.

Umbal & Nagy (2021) provide an updated version of Nagy's (2011) set of comparisons. They present four stages of comparisons: inter-generational, cross-variety, Homeland, and English (dominant language). The inter-generational stage involves comparing use of a feature across generational groups. If there are differences observed, then contact becomes a possible

[1] IPA transcription of each Cantonese word appears in brackets with a number representing the tone category. This is followed by the traditional Chinese character and an English gloss. The tone numbers are as follows: 1 (high level), 2 (high rising), 3 (mid level), 4 (low falling), 5 (low rising), 6 (low level).

explanation. The dominant language comparison involves comparing the heritage language with the dominant language spoken in the same community, which is English in all studies based on Nagy (2011). If a source feature can be identified in the dominant language, then contact induced change becomes a possibility. The cross-variety stage involves comparing different heritage varieties while the Homeland comparison stage involves comparing the heritage variety with the Homeland variety. Observing the same changes in other varieties of a language weakens an argument for contact-induced change while the lack of the same change strengthens a case of contact-induced change.

Previous research on Toronto Cantonese /y/ vs. /u/ began with an inter-generational comparison of 11 vowel categories in terms of F1/F2 production. Tse (2019) showed /y/ to be significantly retracted among second-generation (Gen2) speakers compared to first-generation (Gen1) speakers. This study also compared Toronto speakers with Hong Kong speakers and found a lack of /y/ retraction among Hong Kong speakers. The lack of the same change in Hong Kong, thus, strengthens an argument that /y/-retraction is a contact-induced change.

A dominant language comparison has also been undertaken. Cui et al. (2014) show Cantonese heritage speakers producing UW with an F2 average of about 1600 Hz, which is midway between their production of Cantonese /y/ (with an F2 of about 2000 Hz) and /u/ (with an F2 average of about 1300 Hz). This study compared acoustic data from both the Contact in the City (CinC) Corpus (Hoffman & Walker 2010), which includes the Toronto English spoken by Cantonese heritage speakers, and the Heritage Language Variation and Change (HLVC) in Toronto Corpus (Nagy 2011), which includes the Cantonese spoken by individuals from the same community. This is consistent with dialectological descriptions of Toronto English, which show UW to be phonetically fronted as is the case in many dialects of English. In fact, Boberg (2011) describes UW fronting as more advanced among young Toronto and Vancouver English speakers than is the case of speakers in less urbanized Anglophone areas of Canada.

While the CinC and HLVC corpora include the same groups of individuals, they were not designed to include the same individual speakers speaking both languages. Thus, what remains unclear from these studies is how /y/ retraction is related to UW production. Is it the case that speakers who retract /y/ are those who have assimilated /y/ and UW into a single category? Group-level cross-linguistic comparisons also obscure intra-group variation. For example, while Tse (2019) showed /y/ significantly retracted among Gen2 speakers, Tse (2022) showed some speakers also fronting /u/.

As Chang (2021) mentions, a major gap in heritage language phonetics and phonology research is studies focusing on individual-level cross-linguistic comparisons. Such comparisons would especially help address whether cross-linguistic equivalence in the two languages is based on phonetic similarity or on phonological similarity. Chang et al. (2011) address a similar question in a study of different groups of Mandarin-English bilingual speakers. Like Cantonese, Mandarin also has a contrast between /y/ and /u/. They hypothesized that phonetic similarity would mean that UW would be treated as equivalent to /y/ because of the fronted nature of English UW while phonological similarity would mean UW would be treated as equivalent to /u/ due to typological considerations. The current study will use these hypotheses as the basis for interpreting the results.

3. Data and methods. The data for the current study comes from the HLVC Corpus (Nagy 2011). This corpus includes digital recordings (in .wav format) of hour-long sociolinguistic interviews following Labov's (1984) methods and protocols. The corpus includes multiple generations of speakers of 10 different languages including Cantonese. Complementing these recordings are recordings of Homeland speakers.

The current study uses raw formant measurements from HLVC recordings to compare acoustic production of three high vowels: two in Cantonese (/y/ and /u/) and one in English (UW). Although all participants were instructed to use Cantonese as the primary interview language, they were allowed to switch to English as often as was natural to them. This made collection of English UW tokens from the same speakers possible.

To facilitate the formant measurement process, Prosodylab Aligner was used to force align transcriptions with audio. Forced aligned text grids were then manually reviewed and corrected as needed. This process initially began with the 32 speakers analyzed in Tse (2019). Six additional speakers were added for a total of 38 speakers. Formant measurements from English UW were subsequently added. A Praat script was then used to extract midpoint F1 and F2 values in Hertz for each vowel token. Preceding /j/ and /w/ in both languages were excluded (ex: jyu4 and wu4 in Cantonese; 'cute' [kjut], 'woo' [wu], and 'you' [ju] in English). For English, pre-/l/ and pre-/r/ contexts were also excluded.

Participants varied substantially in the amount of English produced. English usage ranged from less than 1% to more than 80% of the interview recording. Participants who used more Cantonese consequently produced fewer tokens of English UW while those who used more English produced fewer Cantonese tokens. Only participants who produced at least four tokens from each of the three vowel categories under analysis were included. Although four is lower than ideal as a threshold, four makes it possible to include two Homeland participants instead of only one. Table 2 shows the participants from the Homeland group while Table 3 includes the Gen1 group and Table 4 includes the Gen2 group. Those eliminated due to insufficient number of tokens are indicated with strikethrough text.

Participant	/y/	UW	/u/
~~CXF16A~~	~~30~~	~~0~~	~~17~~
CXF19A	31	4	23
~~CXF43A~~	~~25~~	~~0~~	~~20~~
~~CXF49A~~	~~18~~	~~0~~	~~13~~
~~CXF77A~~	~~33~~	~~0~~	~~43~~
~~CXM20A~~	~~26~~	~~0~~	~~24~~
~~CXM27A~~	~~66~~	~~3~~	~~33~~
CXM52A	48	6	32

Table 2. Homeland participants

Participant	/y/	UW	/u/
~~C1F50A~~	~~52~~	~~0~~	~~20~~
C1F50B	50	14	19
~~C1F54A~~	~~45~~	~~1~~	~~35~~
C1F54B	41	11	56
~~C1F58A~~	~~83~~	~~0~~	~~35~~
C1F78A	74	7	50
~~C1F82A~~	~~70~~	~~0~~	~~14~~
~~C1F83A~~	~~45~~	~~2~~	~~25~~
C1M46A	35	6	17
C1M52A	65	9	62
C1M52B	52	5	59
C1M59A	33	6	15
C1M61A	78	15	57
~~C1M62A~~	~~38~~	~~0~~	~~32~~
C1M87A	25	4	24

Table 3. Gen1 Participants

Participant	/y/	UW	/u/
C2F16A	28	8	6
~~C2F16B~~	~~17~~	~~1~~	~~14~~
C2F16C	10	4	5
C2F20A	16	11	9
~~C2F21B~~	~~52~~	~~2~~	~~54~~
C2F21C	15	17	5
C2F22A	44	8	26
C2F24A	18	58	10
C2F41A	25	10	6
C2M21B	7	11	9
~~C2M21C~~	~~33~~	~~3~~	~~6~~
C2M21D	24	10	9
C2M22A	18	6	6
C2M27A	18	6	6
C2M44A	21	15	6

Table 4. Gen2 Participants

Table 5 tabulates the number that were retained and eliminated from the initial group of 38 while Table 6 shows the total number of tokens analyzed from the 23 participants that were retained.

Group	Initial # of participants	# of participants eliminated	# of participants retained
Homeland	8	6	2
Gen1	15	6	9
Gen2	15	3	12
Total	38	15	23

Table 5. Number of Participants Analyzed

Group	/y/	UW	/u/	Total
Homeland	79	10	55	144
Gen1	453	77	359	889
Gen2	319	183	111	613
Total	851	270	525	1646

Table 6. Tokens Analyzed

4. Analysis procedures. To address Q1, regression models were run for each individual speaker using Rbrul (Johnson 2009). In each model, the dependent variable was unnormalized F2 values in Hertz. The independent variable was vowel category (/y/ vs. UW or /u/ vs. UW). Significant results were interpreted as not merged while non-significant results were interpreted as cross-linguistic assimilation (or merger).

To address Q2, ANOVA models were run to determine the extent to which group, Pillai Scores, and Cantonese Production Scores (CPS) predict the patterns identified in Q1. Group included Homeland (Gen0), Gen1, and Gen2. Gen0 included lifelong Hong Kong residents. Gen1 included those who immigrated to Canada as adults and have lived in the Greater Toronto Area for at least 20 years. Gen2 included those who grew up in Toronto and have lived in the area since the age of 4 or younger.

The Pillai Score is a measurement of vowel distinctiveness. Its use has become common in sociolinguistic studies of vowels (Nycz & Hall-Lew 2015; Stanley & Sneller 2023). It is calculated based on results of a MANOVA test run for each individual speaker with F1 and F2 as the dependent variables and vowel (/y/ vs. /u/) as the independent variable. The Pillai Score is based on a continuous scale from 0 to 1. Lower scores indicate less distinctiveness (and hence more merger). The Pillai Score was included to determine whether there is a relationship between how merged Cantonese /y/ and /u/ are and whether it is primarily movement of one vowel that is driving the merger.

The third factor examined is Cantonese Production Score (CPS). This score is discussed in Tse (2022) and is introduced as a proficiency proxy score based on how much Cantonese was produced in the interview samples. The score is calculated as follows:

(1) CPS = Total number of Cantonese words uttered ÷ Total number of all words uttered[2]

[2] This includes both Cantonese and English. Use of other languages including Mandarin was negligible and limited to metalinguistic discussion.

5. Results. Results addressing Q1 show individual speakers grouping into three distinct patterns. These three patterns will henceforth be referred to as P1, P2, and P3 and are as follows:

(P1) /y/, /u/, and UW are all distinct vowels.
(P2) UW and /u/ are merged while /y/ is distinct.
(P3) /y/ and UW are merged while /u/ is distinct.

The following figures illustrate these patterns. In each figure, red squares indicate tokens of /y/, green circles indicate tokens of UW, and blue triangles indicates tokens of /u/. The ellipses indicate one standard deviation from the mean. As shown in Figure 1, P1 is characterized by three distinct vowels. There is a complete lack of overlap in F2. In contrast, P2 involves overlap in UW and /u/ as shown in Figure 2. Finally, in P3, it is /y/ that overlaps with UW as illustrated in Figure 3. In this case, we also see that UW has a very wide distribution of tokens that even partially overlap in the F2 range for /u/. Still, for the most part, Figure 3 shows assimilation between /y/ and UW rather than between UW and /u/. The difference in the F2 means of both UW and /u/ are statistically significant. A fourth possibility, the merger of all three vowels, was completely absent.

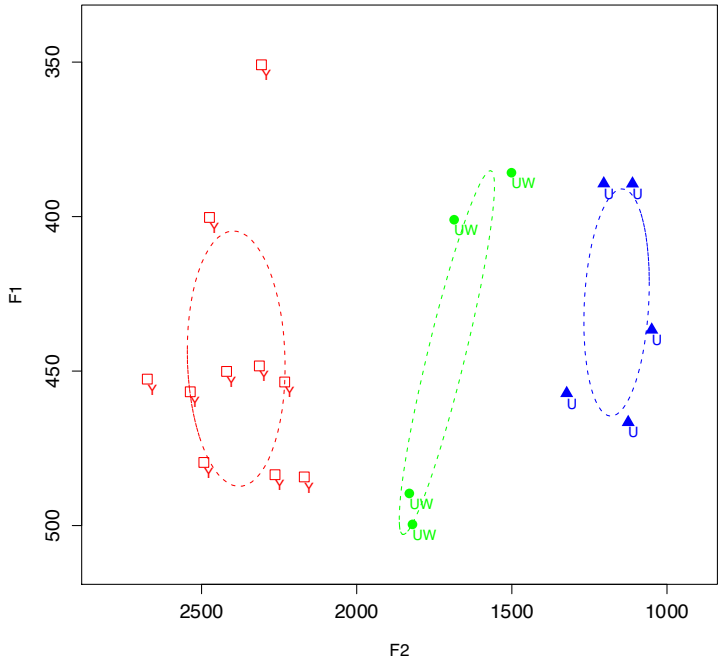

Figure 1. Plot illustrating P1 (three distinct vowels)

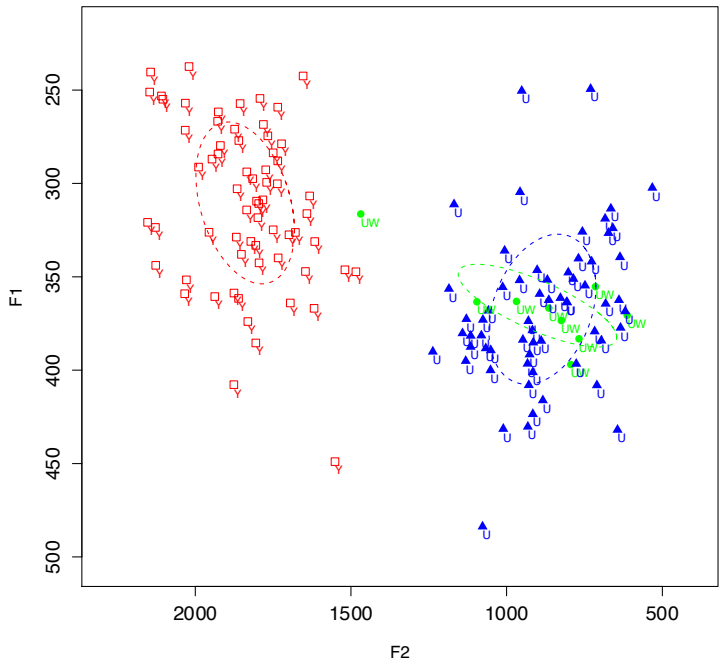

Figure 2. Plot illustrating P2 (UW and /u/ are merged)

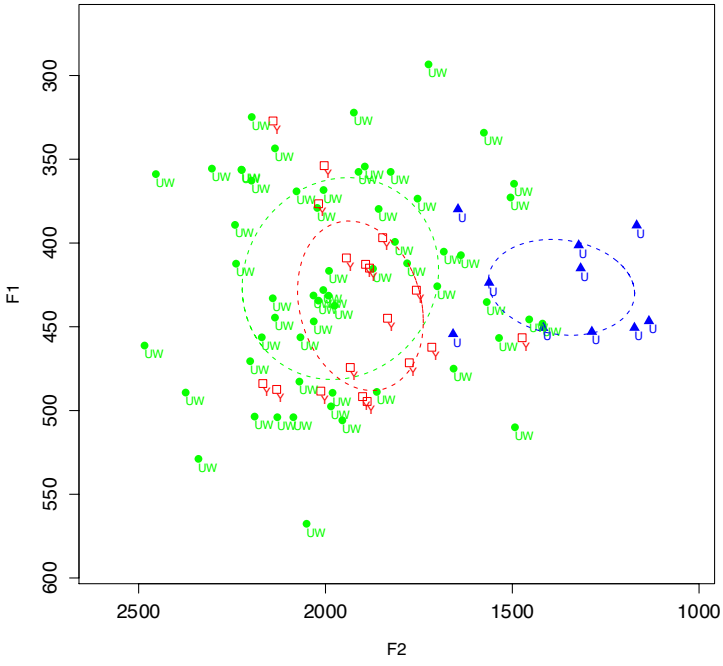

Figure 3. Plot illustrating P3 (/y/ and UW are merged)

To address Q2, the three patterns were then grouped in three different ways based on the following factors: group, Pillai Scores, and CPS. Figure 4 shows the frequency of each pattern and the proportion of each pattern by group. As can be shown, P1 is by far the most common pattern while P3 is the least common pattern. Figure 4 also shows P3 occurring exclusively among Gen2

speakers. P1, on the other hand, occurs among both Gen1 and Gen2 speakers but not among Gen0 speakers. For P2, we see only Gen0 and Gen1 speakers.

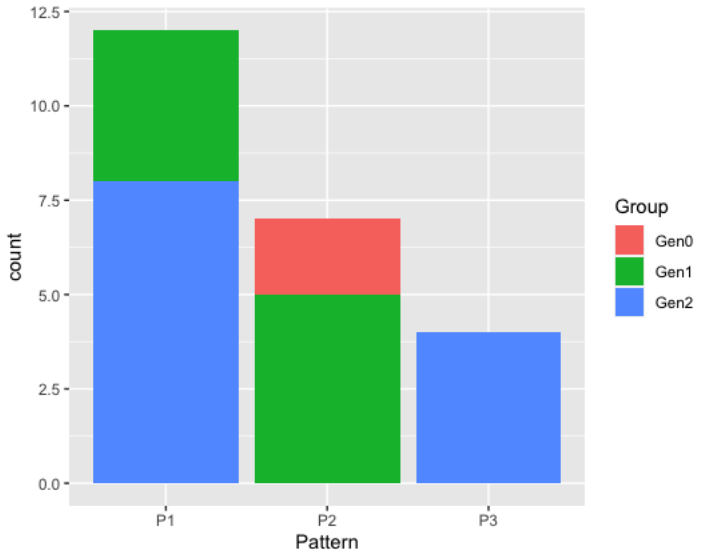

Figure 4. Pattern frequency by group

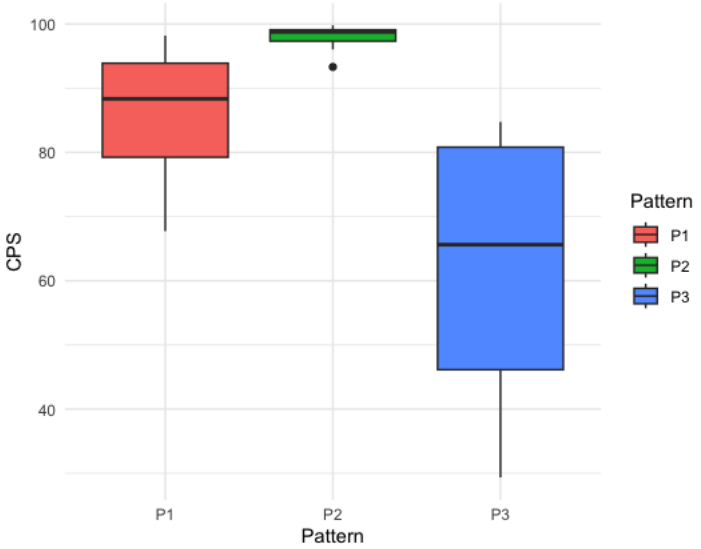

Figure 5. Patterns based on CPS

In Figure 5, we see the relationship between pattern and CPS. What is particularly striking is the contrast between P2 and P3. Participants showing P2 have both the narrowest range in CPS and the highest mean CPS. In contrast, P3 has the widest range of CPS and the lowest average CPS. P1 is in between these two groups both in terms of the CPS range and in terms of the mean CPS. The mean CPS of the P1 group is closer to the mean CPS of the P2 group.

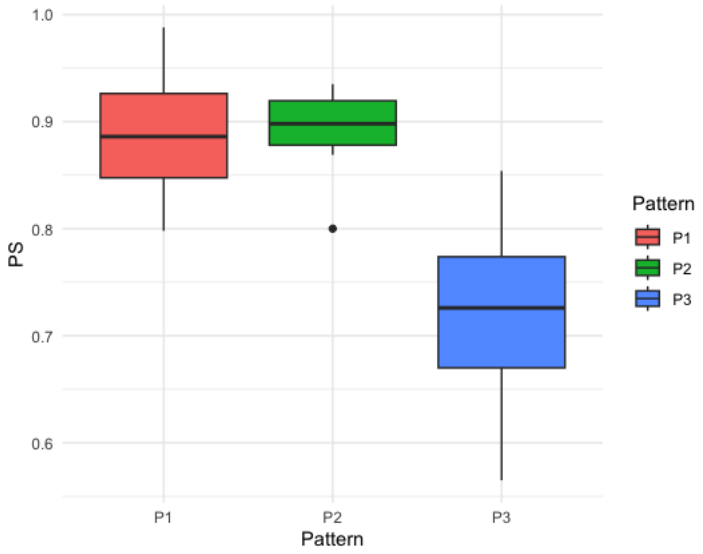

Figure 6. Pattern by Pillai Scores (PS)

Finally, Figure 6 shows the relationship between Pillai Scores and vowel production patterns. P1 and P2 generally occur among those with the highest PS. The average PS among these two groups is also similar. In contrast, P3 has both the widest range of PSs and the lowest average PSs. Thus, once again, P3 stands out in contrast to the other two patterns in terms of the factors examined.

6. Discussion. As discussed in Section 2, Chang et al. (2011) hypothesize that cross-linguistic equivalence between /y/ and UW would be phonetically based while equivalence between UW and /u/ would involve phonological considerations. Their results show the latter equivalence relationship among Mandarin speakers of L2 English in their production of UW. They also show how Mandarin L2 speakers of English differ from heritage Mandarin speakers who speak English as a dominant language. While the Mandarin L2 speakers retract English UW so that it is produced more similarly to Mandarin /u/, Mandarin heritage speakers produce the greatest cross-linguistic and language internal distinctions among the bilingual groups they analyzed.

The current study's focus on individual speaker cross-linguistic patterns support Chang et al.'s (2011) discussion while adding nuance. First, the presence of P2, which was found exclusively among Gen0 and Gen1 speakers and was the most common pattern in these two groups, supports their claim that phonological similarity overrides phonetic similarity when establishing cross-linguistic equivalence among those who learned English as adults. Their finding that heritage speakers are more likely to maximize cross-linguistic and language internal distinctions is also generally supported. P1 is the most common pattern observed among Gen2 speakers. What Gen2 speakers have in common with the Mandarin heritage speaker group is early acquisition of both English and the heritage language.

The current study paints a clearer picture of how proficiency and overall phonetic distinctiveness are tied to the three patterns observed. We see P3 occurring exclusively among Gen2 speakers and occurring among speakers with lower CPS and lower Pillai Scores. This suggests that the merger identified in previous studies (Tse 2022, 2024) is tied to both lower Cantonese proficiency and to cross-linguistic phonetic similarity between /y/ and UW rather than between UW and /u/. Although some speakers may still front /u/ as shown in Tse (2022), /y/

retraction driven by /y/~UW phonetic equivalence may be much greater, which would explain why Tse (2019) showed group-level /y/-retraction but not group-level /u/-fronting. The phonological transfer of vowel categories discussed in previous studies may be better described as an epiphenomenal consequence of /y/~UW merger. If it were due to direct transfer, we might expect to see all three vowels merged, but that was not observed among any of the speakers analyzed.

These results also address Q3 by showing how phonetic vs. phonological similarity may depend on the type of individual-level bilingualism involved. Thus, for Gen0 and Gen1 speakers (who generally learned English as adults), cross-linguistic equivalence is based on phonological similarity while for Gen2 speakers (who generally learned both English and Cantonese at an early age), it is based on phonetic similarity.

A major limitation of this study, however, is the small number of tokens from some individual speakers. While the fact that many speakers mixed in English with their Cantonese speech made it possible to use the HLVC Corpus for individual-level cross-linguistic comparison, the corpus remains limited in its capacity to provide sufficient data for all three vowels produced by the same individual speakers. Thus, it should not be surprising to find Gen0 speakers lacking UW tokens especially those who used less English either due to the interview context or due to low overall proficiency. Results involving Gen0 need to be taken with a grain of salt. Similarly, Gen2 speakers who produced more English also produced fewer tokens of Cantonese vowels, which makes it difficult to address the full range of their Cantonese vowel production patterns. The lack of /u/ data from Gen2 speakers may also be due to their low overall token frequency in Cantonese spontaneous speech (Tse 2024).

Despite these limitations, this study established a relationship between greater use of English and the likelihood of P3 at least in a context in which the primary language was expected to be Cantonese. This study sets a departure point for future studies based on a larger set of data of speakers producing all three vowels in both languages across different phonetic contexts and with dynamic vowel measurements.

7. Conclusion. To conclude, this study highlights the importance of making multiple sets of comparisons in the study of heritage language varieties. In addition to inter-generational, Homeland, and group-level cross-linguistic comparisons, it is also important to consider individual-level cross-linguistic comparisons especially for the study of phonetic and phonological variation and change. The individual-level cross-linguistic comparisons revealed three different ways in which Cantonese and English vowels interact with each other among Toronto Cantonese speakers. While some speakers clearly produce three distinct high vowels (/y/, UW, and /u/), others cross-linguistically merge UW with either Cantonese /y/ or /u/. Those who merge UW with /u/ are found exclusively among Gen0 and Gen1 speakers. Meanwhile, those who merge /y/ and UW are found exclusively among Gen 2 speakers. The latter group is more likely to have lower Pillai Scores and lower CPS. This suggests that the previously reported merger of /y/ and /u/ (Tse 2022, 2024) is driven primarily by the cross-linguistic merger of /y/ and UW.

Finally, as Weinreich is well known for having stated, “the individual is the ultimate locus of language contact” (1953: 6). By focusing on individual-level cross-linguistic comparisons, this study contributes towards research on contact-induced sound change by addressing the precise nature of cross-linguistic influence among heritage language speakers. How this leads to community-level sound change remains a fruitful topic for future research.

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