Language Change for the Worse

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High vowel fricativization in Northern Wu Chinese and its neighbors

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Language change has been argued to be optimizing as a rule, which parallels a strict ADAPTATIONIST stance formerly common in evolutionary biology; both have seen their share of critique, and the time is ripe for a reassessment in the linguistic sciences. The goal of this chapter is to discuss the possibility that an intracategorical sound change, a shift in the typical phonetic implementation of some phonological category, might unambiguously reduce the fitness of the category at issue in some sense, such that we might declare it *maladaptive*. I argue that HIGH VOWEL FRICATIVIZATION (HVF) is a strong candidate for just such a sound change, mainly due to the nature of the FRICATIVE VOWELS that it produces. After confirming the nature of the contrast between fricative vowels and high front vowels in a representative Northern Wú dialect, Sūzhōu Chinese, with an ultrasound tongue imaging study, I present evidence that HVF introduces a relative reduction in fitness for the affected vowels in the Northern Wú context. This reduction in fitness, which can mainly be attributed to the phonologization of a fricative noise source in fricative vowels, is not found to be balanced by some larger functional improvement, although a social function of HVF cannot be ruled out.

1 Introduction

In response to the strong proposition that language change always acts to improve or optimize a changing linguistic system (Giacalone Ramat 1985; Vennemann 1993), the overarching goal of this volume (as I have understood it) is to ask whether any language change can be taken to represent some worsening of the language it affects. The task at hand is essentially to "recognize a pejoration … this being the only way to invalidate the theory" (Vennemann 1993: 13). In my

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view, this task can be approached more fruitfully in an explicitly evolutionary framework, in which innovative variants in a linguistic system are successful inasmuch as they are well-adapted for communicative purposes (Wedel 2006; Blevins 2006). One might then seek out a maladaptive language change, then, on the basis of its stability and "survival", with maladaptive changes (a useful redefinition of changes "for the worse") tending to "go extinct". After elaborating these ideas in this section, I propose HIGH VOWEL FRICATIVIZATION (HVF) to be a candidate for just such a language change and describe it in detail as it affects the northern dialects of Wú Chinese and its neighbors.

1.1 Adaptationist thinking and language change

Early research into language change as improvement generated much debate (Lass 1980; Samuels 1987; Lass 1987), and many strong positions were taken in favor of the concept (Giacalone Ramat 1985; Vennemann 1993). I find that there are striking, and perhaps unexamined, parallels between the strongest accounts in favor of change as optimization and early research into biological evolution's adaptive mechanisms. Both could be argued to have followed a theoretical program of adaptationism at all costs: all developments of the systems being studied have, at some point in the history of both linguistics and evolutionary biology, been argued to improve fitness; in the case of biology, this is usually by way of natural selection. In linguistics, the mechanism has often been less specifically defined, but the parallels between Vennemann (1993)'s position and the early adaptationist program critiqued by Gould & Lewontin (1979) are still quite clear.

Particularly striking is the shared assumption that any local reduction in fitness cannot be pinned on natural selection, but rather on the need to implement local trade-offs to effect global optimization. As Vennemann (1993) notes, "…it is impossible to optimize a language in all domains at once. There cannot be a perfect language but only languages in which certain parameters are optimized at the expense of others" (14). Nearly a decade before, Gould and Lewontin had criticized a remarkably similar viewpoint prevalent in evolutionary biology and noted its major fault:

> … an organism cannot optimize each part without imposing expenses on others. The notion of 'trade-off' is introduced, and organisms are interpreted as best compromises among competing demands. […] Any suboptimality of a part is explained as its contribution to the best possible design for the whole. *The notion that suboptimality might represent anything*

other than the immediate work of natural selection is usually not entertained (Gould & Lewontin (1979: 585-6), emphasis mine).

Now is as good a time as any to reassess suboptimality in language change: evolutionary characterizations of language change at various levels of structure have become more frequent in recent years (Croft 2000; Mufwene 2008; Blevins 2006; Wedel 2006). The role of natural selection is sometimes explicitly foregrounded in this line of linguistic research: well-adapted innovations in word forms and the substantive makeup of phonemes, for instance, are more "successful" in terms of increased usage in the speech community due to their increased fitness at signalling linguistic contrast (Wedel 2006: 261–63).

But these newer typologies of language change also give prominent roles to non-adaptive change, such as language contact in Blevins (2006) or pruning of lines of descent in the case of Wedel (2006), a view much closer to mainstream evolutionary biology today: in many cases developmental structures in biology can be demonstrated to have a non-adaptive origin, such as the well-known evolutionary "spandrels" that have coincidentally developed as a side effect or interaction of unrelated adaptive developments (Gould & Lewontin 1979; Gould 1997). I take it as uncontroversial that, likewise, not every language change is adaptive in the sense that it improves speech communication in some way. Such non-adaptive changes abound in biological systems – most biological mutations are in fact neutral from an adaptive standpoint (Orr 1998) – and should also be commonly seen in linguistic systems upon further inspection.

1.2 Maladaptive language change

It may also be possible to find evidence for another phenomenon: sound change that is not merely non-adaptive, but MALADAPTIVE, or causing deviation from known adaptive peaks (Schluter & Nychka 1994; Crespi 2000). Maladaptation is in fact discussed in the evolutionary biology literature but is under-studied relative to adaptation (Brady et al. 2019), likely owing to the difficulty of picking out true maladaptations in biological organisms. What constitutes fitness for a given trait in a given context must first be determined to evaluate the degree of adaptation or maladaptation that an innovation introduces (Lewontin 1979; Crespi 2000), and there are competing interpretations of how to evaluate this fitness (Hendry & Gonzalez 2008).

One way of pinpointing a maladaptive outcome of change, in theory, is to document an innovative variant that, once it appears, tends to immediately be selected against and eliminated from the organism (or language) in question.

This approach is similar to the methodology suggested in Baum & Larson (1991) in that the examination is essentially phylogenetic, examining the inheritance of an innovative character over time (here, transmission of some novel linguistic variant within a lexicon and across a speaker population). In language, such a change should carry clear disadvantages for speech communication, perhaps in terms of contrast maintenance, so as to present a strong case. A relatively unambiguous "change for the worse" might be, as such, a change that clearly moves from a local optimum of performance (in terms of communicative efficiency) to a local non-optimum (Crespi 2000). Below, I put forward a candidate for just such a language change, on the grounds that the variant it creates is unambiguously unstable and results in a difficult-to-maintain contrast, an ecological situation that can be observed to result in relatively fast "extinction" (within a language) of the new variant.

The reader should note that I am eschewing terms like "worse" in favor of *maladaptive*. The term *maladaptive* not only identifies the concept at issue here with the one explored in evolutionary biology, but also eliminates the value judgment implicitly cast by the term "worse", in that it has a more limited and precise definition related to local fitness of a novel linguistic variant within a language. Sloppily characterizing maladaptivity of particular linguistic innovations as a general worsening that characterizes the broader linguistic system may serve to perpetuate popular conceptions of some languages as "primitive" or poorly adapted to the modern world (Harlow 1998; Evans 1998). As we breach the topic of maladaptive change, it is important to remain clear-eyed about the racist foundations of evolutionary biology and linguistics (for an especially lurid example of both, see the portion of Ernst Haeckel's writings presented in Koerner (1983)) and to be careful that we do not plant the seeds for further unscientific mischaracterizations of linguistic diversity.

Furthermore, no language is perfectly optimal: language has been conceptualized as an complex adaptive system (Gell-Mann 1992; Lindblom et al. 1995), but no one language can be said to be perfectly adapted to speech communication. Any biological organism can be thought of as slightly maladapted in certain respects (Crespi 2000); analogously, I assume that all languages exhibit local non-optimality from time to time as a consequence of random drift being randomly amplified. The task at hand is thus not (trivially) demonstrating that language encompasses inefficiencies, rather to highlight a linguistic change which appears to produce, for all intents and purposes, a variant of a linguistic feature that is less fit than its predecessor.

1.3 A possible maladaptive sound change: high vowel fricativization

An unusual sound change affects numerous varieties of Northern Wú Chinese, spoken in central coastal China in and near Shànghǎi, as well as a handful of dialects in closely related families. Based on comparison among related Wú varieties, reconstructible high front vowels **i* and **y* have come to exhibit fricative noise resembling that of a [ʑ] across much of Northern Wú, with the latter reflex also retaining its lip rounding. Given the spectral properties of the frication in these segments and the fact that they are fully and modally voiced, the fricative noise cannot be attributed to non-modal phonation or devoicing, and is more readily attributable to the postalveolar constriction thought to characterize both sounds (Ling 2007; 2009). As such, I transcribe these FRICATIVE VOWELS throughout as /i̻/ and /y̻/, respectively.[1] These two vowels typically contrast phonemically with each other and with the high front vowels /i/ and /y/, which in modern Wú dialects are usually developments of lower, diphthongized, or nasalized rhymes **jen* and **ɥɤn* (see Section 3.1 for further details).

There is reason to label this sound change, which I will refer to as HIGH VOWEL FRICATIVIZATION (HVF), as maladaptive. The fricative vowels which result from HVF could be argued to be less well-adapted to speech communication than their reconstructible starting states. Under HVF, high front vowels, which are noted for the stability of their motor-articulatory and articulatory-acoustic mappings (Fujimura & Kakita 1979; Stevens 1989), become fricative vowels, which are more aerodynamically fickle and demanding of high articulatory precision (Ohala 1983); they are accordingly especially prone to merging with acoustically similar vowels. It is difficult to find a motivation in phonetic substance for HVF in the Sūzhōu Chinese case: based on comparison with neighboring dialects, HVF does not appear to contribute to maintenance of contrasts between the reflexes of **i*, **y*, and other vowels. Rather, HVF seems to have occurred by chance, with no apparent adaptive advantage conferred on the affected segments.

In Section 2, I present basic information on the Sūzhōu Chinese vowels as a descriptive example; I include evidence from an ultrasound tongue imaging study which confirms that the Sūzhōu Chinese fricative vowels differ in tongue shape from high front vowels (i.e., /i/) and are in fact more similar to postalveolar fricatives in tongue shape (i.e., /ɕ/). Following Section 3, which outlines a historical-comparative account of how HVF has proceeded in Northern Wu and nearby dialect families, in Section 4 I provide several arguments from phonetic

[1] These ad hoc transcriptions use the IPA's laminal subscript diacritic, in an extension of its typical use on coronal consonants.

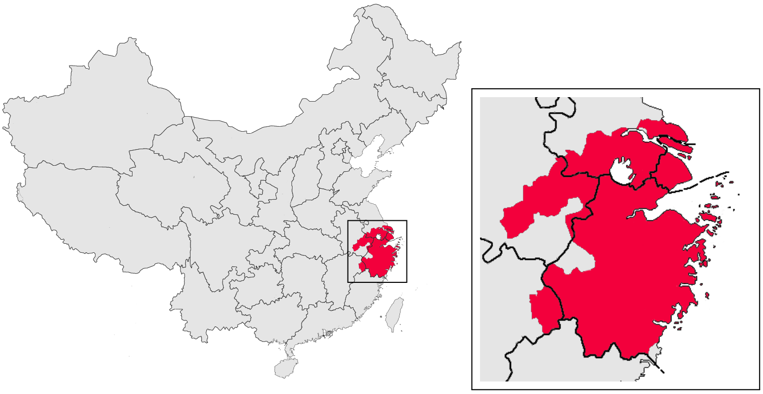

Figure 1: The Wú Chinese area (red) (Yan 1981; 1988; Zhao 2008), and the location of Sūzhōu within it (shaded, right). Map derived from https://commons.wikimedia.org/wiki/File:China_County-level.png under the image's CC BY-SA 3.0 license.

substance for viewing HVF in this geographical area as a maladaptive change. In Section 5, I speculate on the possible role of language contact in triggering HVF, but note that any social advantage that HVF confers on speakers is offset by the apparent reduction of fitness of speech sounds affected by HVF in communication. I conclude by considering the implications of maladaptive change for adaptationist theories of sound change.

2 High vowel fricativization in Northern Wú

The present study examines *high vowel fricativization* (HVF) in Northern Wú Chinese. I use the variety of Sūzhōu Chinese to exemplify the results of the change in detail. Sūzhōu Chinese here refers specifically to the variety of Wú Chinese spoken in the urban core of the city of Sūzhōu 苏州 and its immediate surroundings (Figure 1); the specific variety at issue is spoken in and around the district containing the old city (Gūsū qū 姑苏区). Below, I provide some relevant details on the vowel system of Sūzhōu Chinese in Section 2.1, followed by a discussion of HVF in Sūzhōu Chinese and neighboring Wú dialects in Section 2.2.

2.1 Sūzhōu Chinese apical and fricative vowels

The vowel inventory of Sūzhōu Chinese, given in Figure 2, is noteworthy for including two FRICATIVE VOWELS and two APICAL VOWELS (Ling 2009; Wang 2011).

		Unrounded	Rounded		
Coronal	Anterior (“apical”)	ɿ	[ʮ]		
	Posterior (“fricative”)	i̪	ʉ̪		
		Front		Central	Back
		Unrounded	Rounded		
Dorsal	High	i	y		
	Mid	ɛ	ø	ə əʔ	o oʔ
	Low	a aʔ			ɑ ɑʔ
Other: Diphthongs əu, eɪ ∼ øʏ; Labial [ɯ^{v}], [ɯ^{β}]					

Figure 2: The vowel phonemes of Sūzhōu Chinese, after Wang (1987; 2011) and Ling (2009). The four glottalized vowels are treated as separate phonemes, as in Y. Chen (2008). Vowel qualities not phonemic on distributional grounds are given in square brackets [ ].

As described below, both sets of vowels are produced with a coronal constriction, which is particularly unusual given that a dorsal constriction location is typical of the lingual contribution to the articulation of most attested vowels (Lindblom & Sundberg 1971; Lindau 1978; Honda 1996). Some articulatory and acoustic characteristics of these two vowel types in Sūzhōu Chinese and other languages further afield are discussed in this section. The focus here is on the fricative vowels, which are phonotactically less restricted than the apical vowels and are described as typically exhibiting a posterior coronal (i.e., postalveolar) constriction.

Some disambiguation of the apical vowels and the fricative vowels is in order. Apical vowels (shéjiān yuányīn 舌尖元音) occur in Standard Chinese (Lee-Kim 2014; Faytak & Lin 2015), and they are broadly attested throughout the Chinese dialects (Zee & Lee 2007; Lee & Zee 2015), including all Wú dialects (Qian 1992). Apical vowels have characteristic phonotactic restrictions: they must occur following a fricative or affricate consonant that shares their place of articulation. Because of this pattern and the fact that they are most often allophones of high front vowel phonemes such as /i/, they are generally presumed to have arisen from high front vowels via total coarticulation with their onsets (M. Y. Chen 1976; Yu 1999). In Sūzhōu Chinese, the unrounded and rounded apical vowels /ɿ/ and /ʮ/ have the characteristic phonotactics, occurring only after apico-alveolar fricative and affricate onsets (/s/, /ts/, etc.). Unlike in Standard Chinese, on distributional grounds, the Sūzhōu Chinese unrounded apical vowel is phonemic (see

Table 3). The Sūzhōu Chinese vowels are described as having an apico-alveolar constriction (Ling 2009; Wang 2011), similar to the Standard Chinese apical vowel [ɿ] that occurs following apico-alveolar fricative and affricate onsets (/s/, /ts/, etc.).

The fricative vowels (mócāhuà yuányīn 摩擦化元音) in Sūzhōu Chinese exhibit a different, more posterior constriction location compared to the apical vowels. Ling (2007; 2009) identifies this constriction location as lamino-postalveolar, resembling Sūzhōu Chinese's lamino-postalveolar fricative consonants, e.g. /ɕ/. On the basis of Ling's data, I transcribe these two vowels as laminal /ɨ̻/ and /ʉ̻/. In both Sūzhōu Chinese and in other Chinese varieties that have them (Zhu 2004), fricative vowels are phonotactically less restricted than apical vowels, and may occur not only with homorganic fricative and affricate onsets (/ɕ/, /tɕ/, etc.) but also with bilabial and labiodental onsets (/ɨ̻/) and without any onset (both /ɨ̻/ and /ʉ̻/). Fricative vowels such as they occur in Sūzhōu Chinese, then, appear to arise not through assimilation to onset consonants (as is the case with apical vowels); the process of high vowel fricativization that does appear to give rise to them is explored in the next section. All Sūzhōu Chinese fricative and apical vowels phonemically contrast with one another, except perhaps [ʮ], which in distributional terms could be considered an allophone of /ʉ̻/ (Figure 3).

Apical and fricative vowels are attested in the Chinese dialects (Zee & Lee 2007; Zhu 2004) and in various languages beyond (Björsten & Engstrand 1999; Connell 2007; Westerberg 2016), notably Swedish. The acoustic characteristic uniting the various descriptions of these segments is the consistent presence of voiced fricative noise, which appears to form part of the segments' production goals in the case of the fricative vowels. In the case of apical vowels, which obligatorily follow strident fricative or affricate onset consonants, the presence of fricative noise is perhaps unsurprising;[2] for fricative vowels, more interestingly, the affiliation of the fricative noise appears to be to the vowel itself.

Both fricative and apical vowels also exhibit a clear formant structure resembling a high central vowel, "rather than [the] schwa-like quality often associated with syllabic fricatives" (Connell 2007: 15). For both of the Sūzhōu Chinese fricative vowels and the comparable unrounded vowel in dialectal Swedish, F1 is somewhat higher, and F2 slightly lower, than a comparable high front vowel with the same lip rounding (Björsten & Engstrand 1999; Ling 2009; Westerberg 2016; Schötz et al. 2011); apical vowels tend to have a lower F1 than fricative

[2] See Lee-Kim (2014) on Standard Chinese apical vowels as an apparent counterexample to this generalization: although they exhibit fricative-like tongue shapes and immediately follow fricative onsets, they do not appear to exhibit fricative noise consistently.

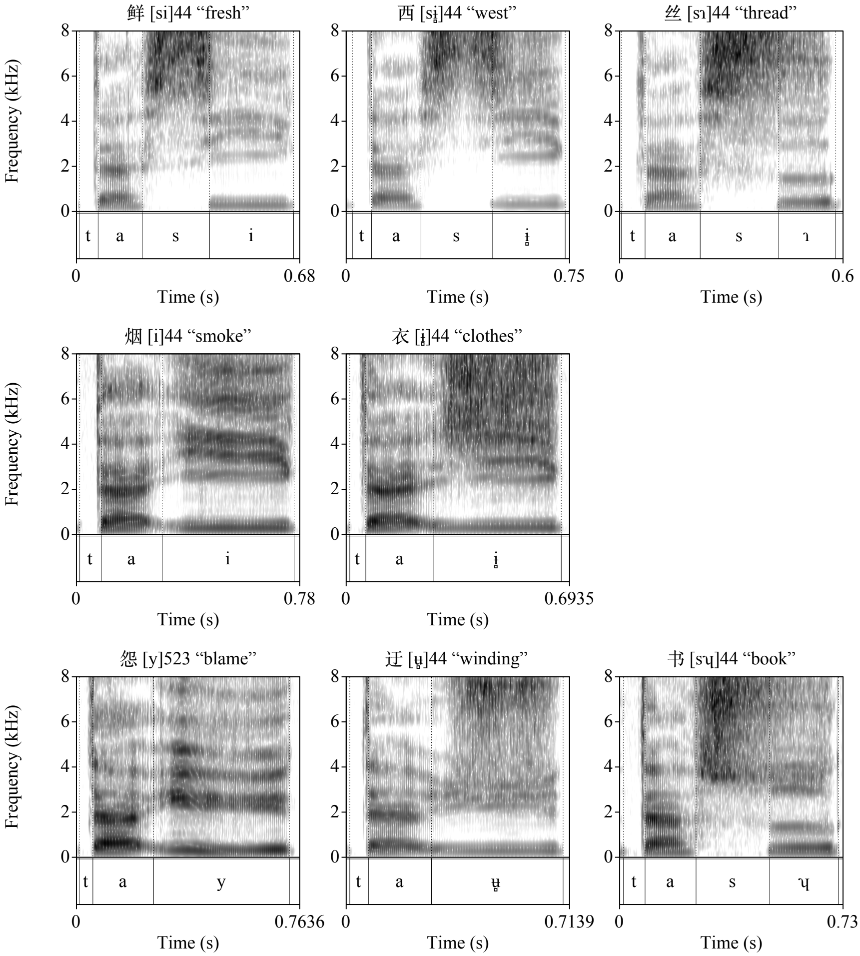

Figure 3: Spectrograms for minimal sets of Sūzhōu Chinese high front vowels /i/, /y/, fricative vowels /ɨ̻/, /ʉ̻/, and apical vowels /ɿ/, [ʮ]. Examples extracted from a frame sentence with segmental context [ta ___ kɛ].

vowels with the same lip rounding (Ling 2009). Both the characteristic fricative noise at high frequencies and the typical formant frequencies described here can be seen in the example spectrograms of the Sūzhōu Chinese apical and fricative vowels in Figure 3.

The fricative noise associated with both apical and fricative vowels is typically strident in quality (Rose 1982; Björsten & Engstrand 1999; Connell 2007; Ling

2009), suggesting that the tongue is configured to direct a turbulent jet of air at the alveolar ridge or teeth, but the specific quality and intensity of the resulting frication varies somewhat among speakers. Other plausible sources of fricative noise can be ruled out. The Wú dialects are known for their register systems involving contrastive use of breathiness or other non-modal phonation (Rose 1989; Cao & Maddieson 1992; Chen & Gussenhoven 2015). The fricative noise in apical and fricative vowels does not appear to be a manifestation of a register contrast in Sūzhōu Chinese or related Wú dialects. Fricative and apical vowels are characterized by unbroken modal voice, and the non-laryngeal character of their fricative noise is evident from its spectral shape, visible in Figure 3 above 4 kHz, in a reasonable range for sibilant or shibilant fricatives. The common element across speakers is the production of some type of fricative noise with a supralaryngeal constriction, most often coronal.[3]

2.2 The fricative vowel-high front vowel contrast: an ultrasound study

A relative abundance of data exists showing that the apical vowels are produced with a constriction made at the alveolar ridge by the tongue tip, similar to [s], in both Standard Chinese and Sūzhōu Chinese (Zhou & Wu 1963; Lee-Kim 2014; Faytak & Lin 2015; Ling 2009). To confirm that the fricative vowels are articulated similarly to other fricative consonants such as [ɕ] in Sūzhōu Chinese, data on the Sūzhōu Chinese high front vowel /i/, the fricative vowel /i̻/, and the fricative consonant /ɕ/ were collected using ultrasound tongue imaging. Eight participants (four male, four female) were recruited at the University of California, Berkeley and were compensated for their time and effort; all procedures described here were approved by the local institutional review board.

Recording took place in a sound-attenuated booth in the UC Berkeley PhonLab. Participants were asked to read the monosyllabic stimuli shown in Table 1 with a Sūzhōu Chinese reading (as opposed to a Standard Chinese reading). Stimuli containing the target segments were displayed as simplified Chinese characters on a computer screen. Each stimulus item was read embedded in the frame sentence given in 1:

[3] An anonymous reviewer points out that all of the languages mentioned in this chapter are tonal in some sense. We reserve further comment on the connection between tonality and HVF for future research: it cannot be ruled out, for instance, that some third characteristic predisposes languages to the development of both lexical tone contrasts and fricative noise contrasts on vowels.

(1) Frame sentence (Sūzhōu Chinese)
我 说 ___ 拨 你 听。
ŋəu˩ səʔ˧ ___ pəʔ˧ neɪ˩ tʰɪŋ˧
1SG say ___ give 2SG hear
'I say ___ to you'

Readings for each stimulus item were prompted in randomized order for eight blocks. This resulted in a maximum of 48 stimuli per participant containing 64 tokens of target segments (since two words contain both /ɕ/ and a vowel: 24 tokens of /ɨ̻/, 24 /i/, and 16 /ɕ/). Speakers 1 and 2 completed only five blocks of the study and so have only 40 tokens of target segments (15 /ɨ̻/, 15 /i/, and 10 /ɕ/). Several tokens were discarded due to recording errors; as a result, Speaker 03 has one less token of /ɕ/ and /ɨ̻/ than would be expected, Speaker 04 is missing one token of /ɨ̻/, Speaker 7 is missing one token of /i/, and Speaker 08 is missing one token of /ɕ/ and two tokens of /ɨ̻/.

Table 1: Stimuli for ultrasound study; from Ye (1988).

Onset	/ɨ̻/	/i/
/Ø/	衣 ɨ̻^{44} 'clothes'	烟 i^{44} 'smoke'
/p/	比 pɨ̻˥˩ 'compare'	边 pi˥ 'side'
/ɕ/	稀 ɕɨ̻˥ 'rare'	掀 ɕi˥ 'flip'

Ultrasound video of the resulting utterances was recorded in midsagittal section at a frame rate of 107 Hz using an Ultrasonix SonixTablet. The device was equipped with a C9-5/10 microconvex transducer held in place by an Articulate Instruments Ltd. stabilization headset (Scobbie et al. 2008). Audio was recorded with an AKG 535 EB microphone and digitized through a Steinberg UR22 USB audio interface. Frames corresponding to the acoustic midpoints of /ɨ̻/, /i/, and /ɕ/ were selected using acoustic landmarks in time-aligned audio, and tongue surface contours were semiautomatically extracted using EdgeTrak (Li et al. 2005).

Each speaker's contours were submitted to a smoothing-spline ANOVA (SSANOVA) model to estimate the speaker's typical tongue shape for each segment (Gu 2002; Davidson 2006); a polar coordinate system was used to reduce distortion in the tongue blade and root regions (Mielke 2015). Separately, the position of a portion of the hard palate was estimated for each speaker from the average of five frames showing maximal tongue-palate contact during a swallow task.[4] Since individual anatomical variation cannot easily be factored out of the data, tongue shape comparisons are made within the model outputs of single speakers.

SSANOVA splines are presented for each speaker in Figure 4, which shows that /ɨ̻/ is more similar to /ɕ/ than /i/ across speakers: /ɕ/ and /ɨ̻/ both typically exhibit a retracted tongue root, lowered tongue dorsum, and raised tongue blade in opposition to [i], which exhibits an advanced root, raised dorsum, and lowered blade. Speaker 6 excepted, enough of the tongue blade is visible to directly suggest a similar postalveolar constriction for both /ɕ/ and /ɨ̻/. Most speakers' /ɨ̻/ tongue shapes differ from those used for /ɕ/ primarily in that /ɕ/ exhibits a raised tongue dorsum relative to /ɨ̻/. For speakers 1, 2, and 5, this difference is slight, but for speakers 3, 4, 6, and 7, a greater degree of tongue dorsum raising distinguishes /ɕ/ from /ɨ̻/.

This inter-speaker variation in similarity between /ɕ/ and /ɨ̻/ appears to be mediated by coarticulation of the onset consonant /ɕ/ with the following vowel. Tokens of /ɕ/ which are followed by /i/ have a more domed tongue shape which differs substantially from /ɕ/ followed by /ɨ̻/ as well as /ɨ̻/ itself, a difference which can be attributed to coarticulation with /i/ (Figure 5). The extent of this coarticulation in half of the /ɕ/ tokens mirrors the extent to which a speaker's /ɕ/ resembles their /ɨ̻/ in terms of *overall* tongue position found by the SSANOVA models shown in Figure 4. Speakers 1 and 5 shows the least coarticulation, which is reflected in the close overall similarity of their /ɕ/ and their /ɨ̻/. Other speakers (notably Speakers 3 and 6) have more dramatic coarticulatory differences, and the overall SSANOVA result for /ɕ/ in Figure 4 is a spline intermediate in shape between the two /ɕ/ variants but resembling neither.

Speaker 8 qualitatively differs from the other speakers in producing /ɨ̻/ similarly to /ɕ/ in some respects and to /i/ in others. Speaker 8's /ɨ̻/ has a raised tongue blade closer in character to that of /ɕ/, a behavior exhibited in common with the other seven speakers. However, Speaker 8's /ɨ̻/ is produced with an advanced tongue root and raised tongue dorsum, more akin to /i/. This variant of /ɨ̻/ could be described as dorso-postalveolar in articulation, somewhat akin to an [i] articulated further front, with the tongue dorsum and blade shifted toward

[4] No palate trace is available for Speaker 3 due to their incomplete swallow task.

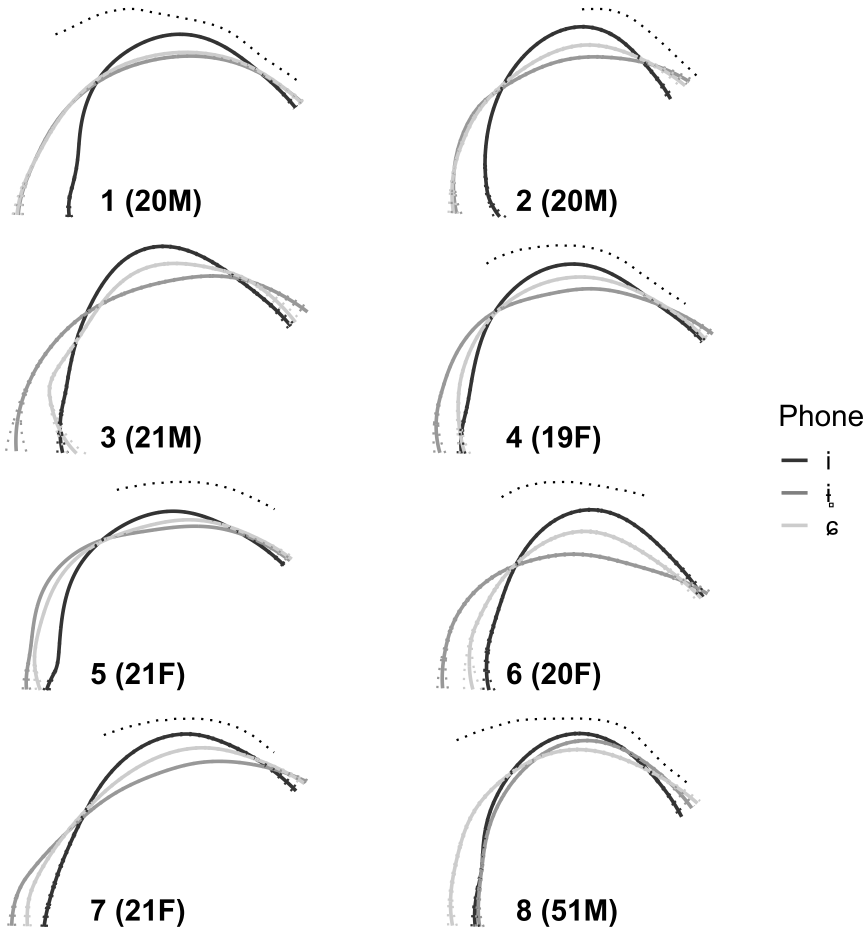

Figure 4: Smoothing-spline ANOVA estimates of tongue contour position with 95% confidence intervals for /ɨ̞/, /i/, and /ɕ/, with palate trace (dotted line) when available. Right is anterior.

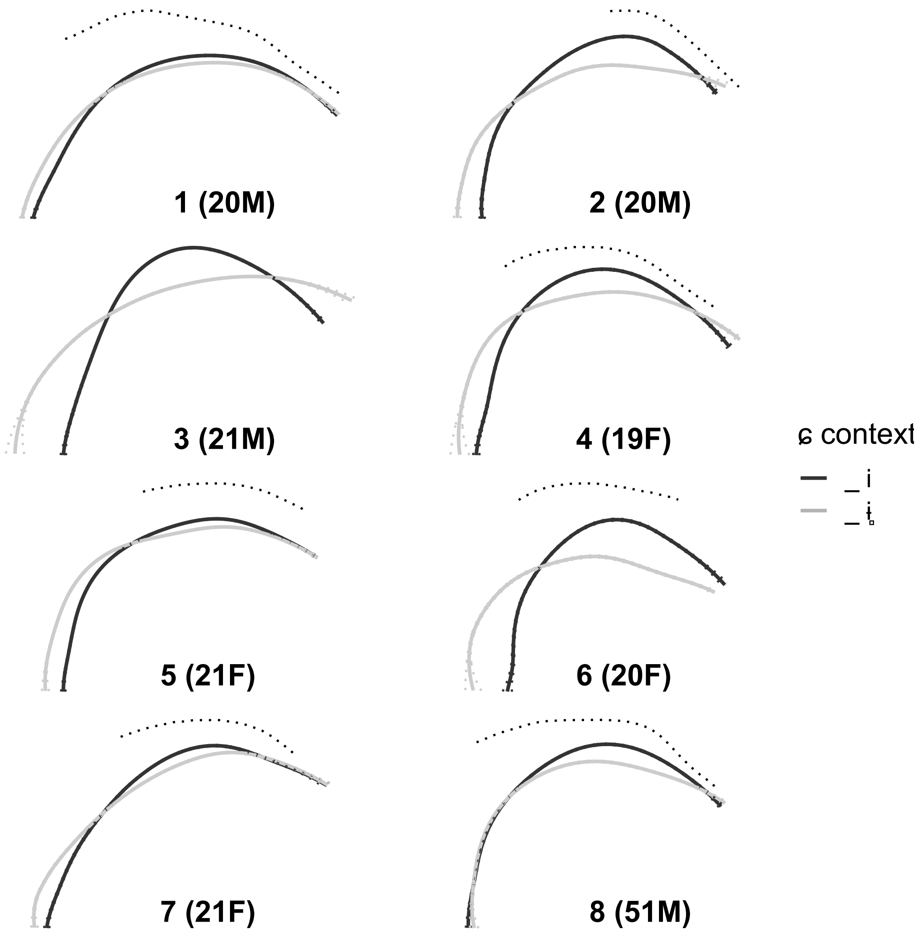

Figure 5: Smoothing-spline ANOVA estimates of tongue contour position for /ɕ/ preceding the two vowels in the data set, with 95% confidence intervals and palate trace (dotted line) when available. Right is anterior.

the postalveolar area. Speaker 8 is closer in age to the population studied in Ling (2009), members of which are described as using one of two articulations for /ɨ̻/: a lamino-postalveolar variant similar to the one described here for Speakers 1–7, and a dorso-postalveolar variant which resembles Speaker 8's /ɨ̻/. This raises the possibility that the observed difference is related to speaker age.

Regardless of speaker idiosyncrasies, and taking coarticulation of /ɕ/ with /i/ into account, the typical articulation of /ɨ̻/ is much more similar to /ɕ/ than to /i/ for all speakers, especially in that a postalveolar constriction location is observed for /ɨ̻/ which is absent in /i/. The location of this constriction is typically quite close to the constriction for /ɕ/, which suggests an articulatory-acoustic goal shared among these segments: the production of strident fricative noise of a specific quality close to that of /ɕ/.

3 Diachrony of high vowel fricativization in Wú Chinese

Having confirmed the nature of the contrast between /i/ and /ɨ̻/ – and by extension, that between /y/ and /ʉ̻/ – we turn to high vowel fricativization (HVF), the sound change that gives rise to the fricative vowels from high front vowels. The focus here is on the Northern Wú dialects, most of which belong to the Tàihú (Lake Tài) subgroup of Wú dialects. Tàihú Wú can in turn be subdivided into the coastal Sūhùjiā 苏沪嘉 group, which contains the relatively well-studied local dialects of Sūzhōu and the Shànghǎi area[5], and the inland Pílíng 毗陵 group, spoken north and east of Lake Tài to the Yangtze River (Qian 1992: 2–3). The Southern Wú dialects are phonologically conservative and with one apparent exception (Jīnhuá 金华 dialect; see Qian (1992)) do not undergo HVF (Cao 2002: 229). As such, they are not discussed here except as an out-group to Northern Wú, for instance in Table 3.

After an overview of HVF in Tàihú Wú, I begin to consider motivations for the sound change. I describe the process as one of transphonologization starting in Section 3.2. Two possible origins for this transphonologization are considered: one in which encroachment of the lower rhymes on the acoustic space of the higher rhymes gradually makes frication a more important cue to the latter, and one in which frication becomes an important cue essentially at random. Surprisingly, the second origin is better supported by the detailed chronology of HVF and related changes to the lower rhymes in Tàihú Wú, a finding which later factors in to the conclusion that HVF does not confer any clear advantage on the

[5] *Sūhùjiā* is an initialism referring to Sūzhōu 苏州, 沪渎 Hùdú (an archaic name for Shànghǎi), and 嘉兴 Jiāxīng.

Tàihú Wú high vowels.

3.1 History and extent of HVF in Northern Wú

Comparative data from Wú Chinese makes it clear that historical high front vowels are the origin of today's fricative vowels in Sūzhōu Chinese and other closely related Wú dialects. HVF has affected most of the Northern Wú varieties within Tàihú Wú and relatively few Wú varieties beyond it to the south, although it is also observed in the less closely related Jiānghuái 江淮 Mandarin dialects spoken to the north and west across the Yangtze, for instance Yánchéng 盐城 Mandarin (Cai 2011) and Héféi 合肥 Mandarin (Hou 2009; Kong et al. 2019).

Wú-internal comparative evidence laid out in Table 2 indicates that the fricative vowels are common reflexes of the Proto-Wú (PWú) vowels **i* and **y*, as reconstructed in Ballard (1969). Comparison of the Tàihú Wú group with Wú dialects further afield makes it clear that PWú **i*, **y* were likely conventional high front vowels, given that an overall majority of reflexes for this reconstructed set are [i] or [y]. In the Tàihú Wú varieties spoken west of Shànghǎi, exemplified here by Dānyáng and Sūzhōu, Qian (1992) transcribes the reflexes of the PWú high front vowels as high front vowels with subscripted *z* or *j*/*ɥ*. The subscripts are intended to indicate subtle differences in the quality of the frication noise produced: the former indicates that the vowel is "accompanied by a [z] sound," while the latter refers to a more general "accompanying frication" (Qian 1992: 12). Qian's transcriptions (i_z, i_j, y_z, etc.) can readily be identified as the fricative vowels [i̞̝] and [y̝] described in Section 2.1.

HVF as a sound change does not uniformly apply across Northern Wú, judging from the varied reflexes of PWú **i* and **y*. Wú varieties spoken at the southern end of the Northern area do not appear to have undergone HVF for the most part. This group is represented in Table 2 by the Tàipíng variety, one of the southernmost and most phonologically conservative Northern Wú dialects. In addition, the Shànghǎi-area dialects at the core of the Tàihú area do not exhibit fricative vowels at present, and in fact the reflexes of PWú **i* and **y* are sometimes merged with the reflexes of two other PWú rhymes, **jen* and **ɥɤn*, in these varieties. In Table 2, these varieties are represented by the Shànghǎi dialect of the city center.

There is evidence, however, that the Shànghǎi-area dialects *did* undergo HVF, only to subsequently merge the unrounded fricative vowel and unrounded high front vowel and lose frication on the rounded fricative vowel. Merger of reflexes of **i* and **jen* is prominently mentioned in a number of descriptions of urban Shanghainese beginning in the mid-twentieth century, starting with speakers who came of age in the 1980s (Xu & Tang 1962; 1988; Z. Chen 2007). The unmerged

Table 2: Some Tàihú Wú cognate sets that undergo HVF, from Qian (1992) with Proto-Wú reconstructions from Ballard (1969). Vowel qualities in Sūzhōu Chinese are from my own notes.

Proto-Wú		Dānyáng	Sūzhōu	Shànghǎi	Tàipíng
闭 *pi^{III}	‘close’	pɨ̻^{324}	pɨ̻^{412}	pi^{334}	pi^{35}
移 *ɦi^{I}	‘move’	ɦɨ̻^{213}	ɦɨ̻^{223}	ɦi^{113}	ɦi^{312}
变 *pjen^{III}	‘change’	pɪ^{324}	pi^{412}	pi^{334}	piẽ^{35}
片 *p’jen^{III}	‘slice’	pʰɪ^{324}	pʰi^{412}	pʰi^{334}	pʰiẽ^{324}
居 *ky^{I}	‘home’	tɕʉ̻^{22}	tɕʉ̻^{44}	tɕy^{52}	tɕy^{523}
雨 *ʔy^{II}	‘rain’	ʉ̻^{44}	ɦʉ̻^{231}	ɦy^{113}	ɦy^{22}
捐 *kɥɤn^{I}	‘donate’	tɕʏ^{22}	y^{44}	tɕyø^{52}	tɕyœ̃^{523}
远 *ʔɥɤn^{II}	‘far’	ʏ^{44}	ɦy^{231}	ɦyø^{113}	ɦyœ̃^{22}

reflex of **i* is described as fricated whenever a detailed phonetic description is included: Qian (1992: 45) notes that some speakers still read modern Shànghǎi /i/ and /y/ with a fricative quality, and both Zhu (2006: 14) and Chen & Gussenhoven (2015: 329–30) observe a contrast based in part on the presence or absence of frication in the reflexes of PWú **i* and **jen* for some of their older consultants. HVF also seems to have affected PWú **y* in Shànghǎi, based on Qian’s comments, but the resulting fricative quality was not, on its own, the primary means of signalling contrast with some other vowel: PWú **ɥɤn* has diphthongal [yø] as a reflex in Shànghǎinese (Qian 1992). Loss of fricative vowels in the city center has gradually radiated outward to suburban areas of Shànghǎi, owing to the city’s role as an economic and cultural center starting in the early 20th century (Qian & Shen 1991; Z. Chen 2007).

Thus, nearly all of the Tàihú Wú dialects appear to have undergone HVF at some point; Table 3 provides a more thorough listing of the typical reflexes of PWú **i*, **jen*, **y*, and **ɥɤn* and conveys the extent to which HVF has affected the various Wú subgroups. The available evidence suggests that HVF has in fact only recently occurred in Tàihú Wú. As mentioned above, fricative vowels cannot be reconstructed for proto-Wú (Ballard 1969); they also are not reconstructible for the proto-language of the nearby Jiānghuái Mandarin group (Coblin 2000). Systematic description of the Wú dialects begins in the mid-19th century with the dialects of urban Shànghǎi and Sūzhōu. Starting in these early time periods and up through the mid-20th century, in the Chinese-language dialectological literature, there is essentially no reference to fricated reflexes of PWú **i* or **y* in Tàihú Wú

Table 3: Reflexes of **i*, **jen*, **y*, and **ɥɤn* in various Wú dialects. Proto-Wú (PWú) from Ballard (1969), other Wú from Qian (1992), except Sūzhōu from my own notes. Qian's various transcriptions of fricative vowels are shown here as ɨ̻ or ʉ̻.

		Proto-Wú	**i*	**jen*	**y*	**ɥɤn*
Northern	Pílíng 毗陵	Yíxīng 宜兴	ɨ̻	ɪ	ʉ̻	yẽ
		Jīntán 金坛	ɨ̻	ĩ	ʉ̻	yĩ ∼ yʊ̃
		Dānyáng 丹阳	ɨ̻	ɪ	ʉ̻	ʏ
		Jìngjiāng 靖江	ɨ̻	ĩ	ʉ̻	yɯ̃
		Chángzhōu 常州	ɨ̻	ĩ	ʉ̻	iɔ
	Sūhùjiā 苏沪嘉	Sūzhōu 苏州	ɨ̻	i	ʉ̻	y ∼ iɵ
		Shànghǎi 上海	ɨ̻ → i	i	ʉ̻ → y	y ∼ yø
		Sōngjiāng 松江	ɨ̻ → i	i	ʉ̻ → y	ø ∼ yø
		Jiāxīng 嘉兴	i	ie	y	yɤə
		Wúxī 无锡	i	ɪ	y	io
	Other	Shàoxīng 绍兴	i	ĩ	ʉ̻	yɵ̃
		Chóngrén 崇仁	ɨ̻	iẽ	ʉ̻	yœ̃
		Tàipíng 太平	i	iẽ	y	yœ̃
Southern		Qúzhōu 衢州	i	iẽ	y	yə
		Yǒngkāng 永康	i	ie	ʏ	yə
		Jīnhuá 金华	ɨ̻ ∼ ie	iæ̃	ʉ̻	yæ̃
		Wēnzhōu 温州	ɪi	i	y	y

(Ting 2003; Qian 2003; Z. Chen 2007). It is likely, however, that a fricated quality was present but mostly unremarked upon, except in cases where researchers included fine phonetic detail in their transcriptions: for instance, Chao Yuen-ren's 1928 description of Shanghainese (as cited in Qian 2003) transcribes the reflex of **i* as i_j, indicating a degree of constriction greater than for [i] (see Qian (1992) as discussed above). Even if the arrival of HVF in Tàihú Wú can thus be pushed back to the 1920s, it is likely that fricative vowels have constituted a part of the Northern Wú segmental repertoire for only a few generations of speakers.

3.2 HVF as transphonologization

The motivations for HVF have yet to be discussed here, a task we now approach. We may treat HVF as a type of intra-categorical change, TRANSPHONOLOGIZAtion, in which one means of acoustically signaling a phonological category is used in place of another (Hyman 1976; 2013; Ohala 1993b; Kirby 2011; 2013). Two important aspects of the phenomenon are addressed in more detail here. In this subsection, we elaborate on the precursor fricative noise most likely to give rise to HVF. In the following subsection, we consider how this noise may be exaggerated and eventually exchanged for more typically vowel-like cues, and the phonetic biases which may have led to this exchange.

The most plausible phonetic precursor for HVF is the aperiodic energy sporadically and unintentionally produced during production of high vowels such as [i] and [y]. As a high vowel becomes increasingly high and front, airflow during the production of the vowel is increasingly biased towards being turbulent. On first principles, the narrower the tongue-palate aperture, the more likely a given rate of air flow through that apterure is to spontaneously give rise to turbulence (Catford 1977; Shadle 1990). Modally voiced vowels require a high level of airflow, which itself also makes spontaneous turbulence more likely to spontaneously arise in a subset of instances of [i] or [y] production. The turbulent airflow that incidentally results may then be phonologized as a fricative noise source intrinsic to the vowel, likely due to listeners' misattribution of the fricative noise source to a constriction deliberately produced in association with the vowel (Ohala 1993a).[6] However, transphonologization does not proceed without some phonetic bias pushing it along (Kirby 2013; Garrett & Johnson 2013; Kirby & Sonderegger 2015), and so we must also ask what phonetic bias or biases led to a gradual increase in importance for fricative noise as a cue to reflexes of Proto-Wú **i* and **y*.

3.3 Motivating fricative noise as a cue

At first glance, HVF appears to have its basis in contrast maintenance: specifically, of the contrasts between these rhymes and the reflexes of **jen* and **ɥɤn*, respectively. Probabilistic enhancement (Kirby 2013) of fricative noise could occur if the reliability of formants as cues to the relevant contrasts were reduced, in this case due to crowding of vowels in the acoustic space near [i] and [y]. As seen in Table 3, the reflexes of PWú **jen* and **ɥɤn* have been denasalized, monophthongized, and raised in various combinations and to various extents in the Wú dialects (Qian 1992: 15), moving the reflexes of **jen* and **ɥɤn* closer to the

[6] HVF typically results in constrictions which produce strident frication. We speculate that this could be due to an intermediate stage of enhancement which takes place during HVF: as the importance of fricative noise as a cue to category grows, speakers preferentially enhance frication with stridency (Kingston & Diehl 1994; Stevens & Keyser 2010).

reflexes of **i* and **y* in acoustic space. In Sūzhōu Chinese, for instance, the reflex of PWú **jen* has lost its nasal coda and internal dynamicity and is produced as high, monophthongal, and oral [i].

The pair of contrasts at issue, between PWú **i* and **jen* on the one hand and **y* and **ɥɤn* on the other, have high functional load in Sūzhōu Chinese and related Wú dialects.[7] High functional load has been shown to inhibit contrast loss in diverse languages (Wedel et al. 2013), and perhaps in some cases serves as a driver of contrast maintenance. To maintain a contrast, listeners must attend to reliable cues. We might assume, then, that as the reflexes of **jen* and **ɥɤn* gradually neared the reflexes of **i* and **y* in formant space, listeners made greater use of the fricative noise more frequent in **i* and **y* to reliably distingish each pair, eventually leading to HVF and the use of fricative vowel reflexes.

The interaction described above would essentially be a push chain shift, in which the reflexes of **jen* and **ɥɤn* encroach on those of **i* and **y*, causing displacement of the latter (Ettlinger 2007; Faytak 2014). Puzzlingly, however, HVF appears to lead a pull chain in Tàihú Wú, occurring first for its own unclear reasons rather than as a result of encroachment of another vowel on its acoustic space.

3.4 HVF does not occur due to encroachment

Detailed inspection of the chronology of HVF and associated sound changes is possible for two Tàihú Wú varieties, Sūzhōu Chinese and Shanghainese. HVF in Sūzhōu Chinese, for instance, likely precedes raising of monophthongal reflexes of **jen* and **ɥɤn* into the acoustic space occupied by reflexes of **i* and **y*. Through the first half of the twentieth century, **jen* and **ɥɤn* in Sūzhōu Chinese develop from approximately [ie] and [yø] Lu (1935, cited in Ting 2003) to [iɪ] and [iɵ], respectively (Ye 1988; Qian 1992). Monophthongal reflexes of **jen* and **ɥɤn*, i.e. [ɪ] and [ʏ], only enter the descriptive record after the mid-1980's (Wang 1987; Ling 2008; 2009), although [ʏ] is still diphthongal [iø] for some speakers (Ling 2008). Taking into account the stated preference of the above sources to work with speakers over the age of 40, some speakers examined in these sources, who were born as late as the early 1940's, appear to maintain diphthongization of the lower series, and speakers born after this point appear to maintain a height difference, although the youngest speakers today produce [i] and [y] for **jen* and **ɥɤn*.

[7] While there is no source of lexical statistics available for Tàihú Wú to quantify functional load for these contrasts, minimal pairs are easy to find. For instance, the mid-twentieth century merger of **i* and **jen* in Shanghainese created numerous homophones (Qian 2003; Zhu 2006).

HVF in Sūzhōu Chinese appears to predate this raising and monophthongization of the lower rhymes by decades, with frication already a noticeable aspect of production of the reflex of **i* in Chao (1928, cited in Ling 2009). Later descriptions confirm the presence of frication for both **i* and **y* for speakers born roughly from 1930 to 1960 (Wang 1987; Qian 1992; Ling 2009).

More detailed historical data are available for Shanghainese, much of which is collected in Qian (2003). An even larger acoustic gap between **i* and **jen* in Shanghainese is readily evident at the time that HVF began affecting **i*. Nasalization of **jen* and **ɥɤn* is absent in the descriptive record as early as the first decades of the 20th century, but the rhymes were still diphthongized at this time, similar to Sūzhōu Chinese (Qian 2003: 22-23). Shortly thereafter, vowel fricativization is first explicitly described for the reflex of **i*; at this time, the lower rhymes are still described as diphthongized, oral [iɛ] according to Chao (1928, cited in Qian 2003). While it is logically possible that frication on the reflex of **i* existed earlier but was not described, an earlier onset of HVF would mean that **jen* was *even more* acoustically distinct from **i* at the time of HVF. In Shanghainese, the development of a fricative vowel reflex for **i* thus seems to precede any close encroachment of gradually raising **jen*.

Outside of Tàihú Wú, when HVF affects the refexes of PWú **i* and **y*, the acoustic difference between these and the reflexes of **jen* and **ɥɤn* tends to be even larger. In the Chóngrén dialect (Northern Wú, outside Tàihú) and Jīnhuá dialect (Southern Wú), both the **jen* and **ɥɤn* rhymes are nasalized and diphthongized with a very low second part, yet both dialects have fricative vowels as reflexes of PWú **i* and **y*. The overall appearance is thus one of HVF diffusing from north to south, and of a gradual, entirely optional filling of the vacuum left behind in the high front area of the vowel space by HVF, but crucially subsequent to HVF and not causing it via push chain.

To sum up, in each of the Wú cases reviewed here, there is evidence for a large acoustic gap between the high, monophthongal reflexes of **i*, **y* and the lower, diphthongal, or nasalized reflexes of **jen*, **ɥɤn* at present or at some point in recent history, which may signal that HVF of the higher rhymes occurs before monophthongization and raising of the lower rhymes.[8] In the context of Tàihú

[8] An anonymous reviewer points out that the chronologies described here could involve simultaneous gradual developments in both the higher and lower rhymes, rather than occurring in a discrete sequence as described here. Such a chronology would not disqualify the broader point made in this section, however: my aim has not been to emphasize that a pull chain must have taken place, but rather that a push chain decidedly has not taken place. Whether the "pull" was discrete and sudden or continuous and gradual in nature is beside the point, since the point is that HVF does not seem to be systematically related to developments of the lower rhymes.

Wú, then, HVF does not appear to be a strategy for contrast maintenance. Rather, it seems to have occurred essentially at random and spread throughout a small area, more akin to random genetic drift which has been amplified for unclear reasons. The apparently spontaneous and unmotivated nature of HVF in Tàihú Wú is significant for further discussion in the next section.

4 Maladaptivity of high vowel fricativization

The data presented up to this point suggest that HVF is *non*-adaptive for speakers of Sūzhōu Chinese and other Northern Wú varieties, at least in terms of the mechanics of speech communication. The basic acoustic and articulatory properties of the fricative vowels that result from the sound change have also been described for Sūzhōu Chinese. In the section below, I provide evidence suggesting that HVF in Northern Wú is not only non-adaptive, but relatively *maladaptive*, causing a relative reduction in fitness relative to a known adaptive peak. I begin this section by providing basic evidence that HVF removes languages undergoing it from such an adaptive peak in speech communication terms: high front vowels like **i* and **y* are highly optimal for speech communication (Section 4.1), and the results of HVF, fricative vowels, are substantially less so (Section 4.2).

I then approach the question of maladaptation from a phylogenetic angle in Section 4.3: whether or not fricative vowels are a maladaptive characteristic can be gauged by their long-term success in the phylogeny relative to other comparable speech sounds (high front vowels, apical vowels, rising diphthongs such as [əi̯], and so on). Reliably signaling contrast is a major aspect of fitness and success for phonemes, per models in, e.g., Wedel (2006) and Wedel et al. (2013), so the question is whether contrasts between fricative vowels and other vowels remain stable or are lost to merger. A number of other Northern Wú or Jiānghuái Mandarin dialects have merged fricative vowels to either high front vowels or apical vowels, suggesting that fricative vowels are not well-adapted for the types of contrasts that they end up participating in.

4.1 High front vowels are an adaptive peak

High front vowels, particularly unrounded [i], are known to be produced using a configuration of articulators that is highly optimized for the physical constraints of the human vocal tract and the perceptual dimensions used to contrast vowel qualities. High front unrounded [i] is extremely stable in terms of its articulation-acoustics mapping, with so-called quantal effects resulting in consistent acoustic outputs for a relatively wide range of articulatory inputs (Stevens 1989; Stevens & Keyser 2010). Furthermore, the formant frequencies that characterize the quantal zone for [i] are especially salient and recoverable due to the focalization of F3 and F4, in which the formant frequencies converge on a common frequency band and perceptually reinforce each other (Schwartz et al. 1997: 258–9). High front vowels such as [i] are known to gain added stability in production from SATURATION, by which a variety of motoric inputs result in relatively invariant articulatory output. Specifically, various levels of genioglossus muscle activation result in a relatively invariant amount of tongue front bunching (Fujimura & Kakita 1979).

Front rounded [y], and labial-palatal vowels in general, are not a global optimum of stability in the way that [i] is (Stevens 1989; De Jong & Obeng 2000). However, for larger vowel systems such as those present in Tàihú Wú, [y] is a *local* adaptive peak and a frequently recurring vowel quality, in part due to its own perceptual focalization, in this case of F2 and F3 (Schwartz et al. 1997: 259). As [y] has a lingual articulation quite similar to, though not identical to, [i] (Wood 1986), we may also expect saturation to add to the segment's articulatory stability to some extent. Much as for [i], then, it is probable that [y] will be relatively fit compared to a number offayta speech sounds which it might develop into.

4.2 Fricative vowels are relatively difficult to produce

If high front vowels such as [i] and [y] are adaptive peaks, then fricative vowels are relatively maladapted compared to these peaks. The fricative vowels [ɨ̻] and [ʉ̻] are similar to syllabic voiced fricatives, apparently with the production of strident frication as a goal for production on par with their particular formant frequency targets. This specification introduces a number of added complications in their production compared to [i] and [y]; while comparisons cannot properly be made in terms of motor-articulatory mappings due to a lack of research on fricative vowels, a number of observations strongly suggest that fricative vowels are less stable in articulation-acoustics mappings. On the whole, transformation of [i] into [ɨ̻] or [y] into [ʉ̻] seems to trade an easily achieved target in formant frequencies for a relatively fragile target, based in part on voiced frication, which uses different articulatory controls with less robustness to noise and fewer degrees of freedom.

The two aerodynamic goals of producing a voiced obstruent, phonation and turbulent airflow upstream of the phonating larynx, are antagonistic. The production of voicing interferes with the production of turbulent air flow owing to the need for a double drop in air pressure, one across the vocal folds and another across the frication-producing constriction (Catford 1977; Ohala 1983). Achieving strident frication specifically, which appears to be characteristic of fricative vowels, requires a high degree of articulatory precision, and articulation strongly influences salient details of the acoustic output (Iskarous et al. 2011), in contrast to the quantal zones that characterize [i] and [y]. These factors place limits on the precise production of fricative noise targets in voiced segments such as fricative vowels, and is known to make related contrasts less reliable (Solé 2010).

In my experience, fricative vowels sporadically involve the production of less fricative noise than might be expected. If fricative noise is not achieved in [ɨ̻] or [ʉ̻] due to a failure to reach the appropriate aerodynamic conditions, then the resulting vowels will differ only slightly from [i] and [y] in their formant frequencies, a precarious position for maintaining contrast. A need to prioritize voicing over frication likely further destabilizes articulatory-acoustic mappings. Phonologically "voiced" fricative consonants are in fact often devoiced across most of their duration (Haggard 1978; Stevens et al. 1992), which enables more consistent production of fricative noise. Fricative vowels, on the other hand, are fully voiced over their entire duration (see Figure 3) and bear lexical tone in Tàihú Wú, making them even more antagonistic to the consistent production of frication than apparently comparable voiced fricatives elsewhere.

4.3 Fricative vowels are relatively predisposed to merger

Contrasts involving fricative vowels appear to be less resilient than contrasts that involve the outputs of other sound changes affecting high front vowels. For instance, chain shifts involving diphthongization of high front vowels are amply attested in the world's languages (Labov 1994), in part because they tend to leave clear traces in the form of diphthongs that remain contrastive with monophthongs. HVF, on the other hand, cannot be reconstructed nearly as frequently. This may simply be because HVF is rarer, but I argue for an additional contributing factor: contrasts that have passed through HVF are intrinsically fragile due to the aerodynamic factors described in the previous section, as well as the fact that the "competitor" vowels are [i] and [y]. In Tàihú Wú and Jiānghuái Mandarin alone, one can find at least two major mergers affecting the lexical set that has undergone HVF.

Following some instances of HVF, aerodynamic failure cannot immediately threaten merger, since a language that has undergone HVF may have no phonetic monophthongal [i] or [y] to compete with now-fricativized **i* and **y*. In Tàihú Wú, for instance, the entire Pílíng group lacks monophthongal [i] or [y] (see Section 3.1, Figure 3). A gap for [i] is also documented in Yancheng Mandarin, a Jiānghuái Mandarin dialect (Cai 2011: 53), and in Swedish (Westerberg

2016: 70–71). However, given the tendency for languages to fill gaps in acoustic space through "pull chain" shifts (Labov 1994), and given that the acoustic gap in this case corresponds to a local optimum of vowel production, other vowel phonemes will tend to utilize the empty acoustic space that would otherwise be occupied by [i], [y], making the fragile conditions for fricative vowel production especially critical. Nearly all of the Sūhùjiā Wú dialects and some Jiānghuái Mandarin dialects have found themselves in the latter situation: a shaky contrast between fricative vowels and high front vowels that is cued mainly by fricative noise, which is unreliably produced.

Occasional failure to generate audible fricative noise could encourage a contrast between fricative vowels and high front vowels to be lost after a few generations of language transmission. For instance, as discussed above in Section 3.1, Shànghǎi and many of the Sūhùjiā dialects spoken near it merge the fricative vowels /ɨ̻/, /ʉ̻/ with two high front vowel rhymes /i/, /y/ that develop as reflexes of **jen* and **ɥɤn*, respectively. There is a fair amount of evidence in the descriptive record for a contrast between high front vowels and fricative vowels that is later merged, particularly for the urban Shànghǎi dialect, shown in Table 4 (left). Both Zhu (2006) and Chen & Gussenhoven (2015) describe fricative /ɨ̻/ as occurring for some older speakers, and Qian (1992: 45) mentions that a segment of his speaker population (for which he does not describe the age) produces fricative vowels for the expected rhymes, but that another portion does not.

Beyond merger with high front vowels, which have a constriction location posterior to the typical fricative vowel, merger with the more anterior apical vowels is also observed (see Section 2.1). Apical vowels are well-established across the Chinese languages (Zee & Lee 2007) given that they were innovated in Middle Chinese, the common ancestor of many modern varieties (M. Y. Chen 1976; Yu 1999). For instance, in Héféi Mandarin, a Jiānghuái Mandarin dialect, HVF is known to have affected reconstructible **i* and **y*, but the fricativized reflexes of these vowels have merged with the apical vowels (Wu 1995). In the case of unrounded **i*, the resulting reflex is merged with the pre-existing unrounded apical vowel phoneme /ɿ/ (Table 4, right); in the case of **y*, a newly innovated rounded apical vowel /ʮ/ is the result (Wu 1995; Hou 2009). Although fricative vowels stably contrast with both high front vowels and apical vowels for most Sūzhōu Chinese speakers (see Table 2), some among the youngest Sūzhōu Chinese speakers are also reported to collapse the distinctions between the fricative and apical vowel sets (Li 1998; Wang 2011).

Merger with apical vowels might represent development to a local, rather than absolute, adaptive peak: unlike the merger with high front vowels in the Sūhùjiā

Table 4: Development of representative lexical items affected by HVF in Héféi Mandarin (Wu 1995) and Shanghainese (Qian 1992). PWú reconstructions from Ballard (1969).

	Shanghainese	
HVF:	比 'compare' **pi*^{III} > **pɨ̝* > pi^{334}	居 'residence' **ky*^{I} > **tɕʉ̝* > tɕy^{52}
	移 'move' **ɦi*^{I} > **ɦɨ̝* > ɦi^{113}	雨 'rain' **ʔy*^{II} > **ɦʉ̝* > ɦy^{113}
Merged into:	变 'change' **pjen*^{III} > pi^{334}	*n/a* (**ɥɤn*> yø; contrast)
	Héféi 合肥 Mandarin	
HVF:	比 'compare' **pi* > **pɨ̝* > pɿ^{24}	居 'residence' **tɕy* > **tɕʉ̝* > tsɥ^{31}
	西 'west' **ɕi* > **ɕɨ̝* > sɿ^{31}	雨 'rain' **jy* > **jʉ̝* > zɥ^{24}
Merged into:	思 'think' **sɿ* > sɿ^{31}	*n/a* ([ɥ] was innovated)

group in Tàihú Wú, merger with apical vowels preserves the important contrast between reflexes of **i*, **jen* and **y*, **ɥɤn*. Apical vowels are also typically much more acoustically distinct from high front vowels than fricative vowels are: given their very anterior constrictions, they have an even lower F2 than is typical for fricative vowels (Ling 2009), resulting in a large, easily perceptible acoustic difference from high front vowels that may contribute to their persistence as innovative variants.

5 Discussion

The research program which I have begun to describe here requires us to locate a maladaptive language change, a "pejoration" in the words of Vennemann (1993). High vowel fricativization as described here for Northern Wú Chinese is a good candidate for such a change. Fricative vowels, the outputs of high vowel fricativization (HVF), can in this specific case be taken as deviations from the adaptive peak represented by high front vowels, and are relatively unreliable compared to high front vowels in production owing to their production of fricative noise as a cue to category. Fricative vowels are, then, poor competitors for acoustic space, and tend to be outcompeted by the especially stable high front vowels that tend to develop in the nearby acoustic space cleared by HVF. They also compete poorly with apical vowels, which are common throughout the Chinese dialects and present throughout Northern Wú and neighboring dialects, occasionally resulting in merger into that category.

Before concluding, I consider a handful of more speculative points. First, social factors have largely been left out of the discussion here, but they may be taken to define an additional 'fitness space' upon which HVF might confer some advantage, separate from the clear disadvantages it introduces in the physical circumstances of speech production. As such, I consider possible social motivations for HVF in Section 5.1, and how social advantage might relate to overall advantage in language change as a whole. Second, in Section 5.2, I discuss where we might expect to find more maladaptive changes, based on a few characteristics of the HVF case. These two points together represent a first step at generalizing the type of maladaptative change described here, and beginning to predict where more of them might be found in the world's languages.

5.1 The role of social advantage in maladaptive change

Given the apparent north-to-south diffusion of HVF mentioned in Section 3.2, we can speculate at the social dimensions of HVF as a sound change. It is possible that HVF in Northern Wú actually originated in Jiānghuái Mandarin, a distantly related dialect group spoken across the Yangtze River to the north and west. A detailed description of HVF in Jiānghuái Mandarin is beyond the scope of this chapter, and there is some serious speculation involved in suggesting that HVF in the area originated there: the historical record for Jiānghuái Mandarin is far less developed than it is for Northern Wú, and from the evidence available, there is no obvious reason to reconstruct HVF to an earlier date in Jiānghuái Mandarin Coblin (2000).

Regardless, the above evidence suggests that if HVF did spread due to some advantageousness conferred by the innovation, it was likely socially motivated, albeit for sociolinguistic dimensions that are not entirely clear at present. Diffusion of innovative variants created by HVF from Jiānghuái Mandarin into Wú would be unsurprising, given patterns of linguistic diffusion long known to have affected the Wú dialects: Northern Wú has long been subject to influence from the Mandarin dialects percolating southward across the Yangtze (Norman 1988;

Ramsey 1989). HVF also seems to skip over small population centers, with the notable exception of the Pílíng group (which is nonetheless located very close to the border with Jiānghuái Mandarin). This suggests a spread of HVF from north to south through major population centers, particularly the densely populated, economically important Sūhùjiā area; HVF is in this sense reminiscent of other, better-known sound changes such as the development of "guttural" rhotics from alveolar trills in the population centers of northern continental Europe (Trudgill 1974).

It is possible that most, if not all, maladaptive changes yet to be discovered are only maladaptive in the domain of communicative efficiency, but will prove to confer some social advantage upon their speakers. This may signal that we may again have reached the impasse of whether a change actuated across an entire community can ever be truly maladaptive for the entire linguistic "organism" if change that negatively impacts the mechanics of speech production and comprehension is generally advantageous socially, or vice-versa. The need to consider potentially antagonistic adaptive outcomes in these multiple adaptive spaces – the physical act of communication on one hand, and its received social value on the other – may present an important non-isomorphism between the study of adaptation in language change and in biological evolution. In the latter case, a good case can be made against analysis of adaptation solely in terms of its discrete effects on single functional units (i.e., appendages, organs) (Gould & Lewontin 1979); in language change, approaching social and non-social advantage separately may be unavoidable.

5.2 Identifying maladaptive changes elsewhere

The findings here for Wú Chinese may also be supported by finding other maladaptive changes in the recent historical record of other languages. HVF itself can be observed in several other language families which are genetically and areally well removed from Wú Chinese, providing a means of assessing the claims made here. A fricative vowel (the *Viby-i* or *Goteborges-i*) that has developed recently from **iː* has featured prominently in descriptions of dialectal Swedish for more than a hundred years (Gjerdman 1916; Karlgren 1926; Björsten & Engstrand 1999; Schötz et al. 2011) and is growing in use in standard Swedish (Riad 2013; Westerberg 2016). Fricative vowels have also been noted as reflexes of reconstructible high front vowels in the Ring subfamily of Grassfields Bantu in northwestern Cameroon and at least two regions of Mandarin Chinese dialects that are geographically discontinuous with Wú (Faytak 2014). In fact, HVF is likely under-reported in the world's languages, given the unexpected nature of the contrast between fricative vowels and high front vowels.

One might consider a few additional factors at the outset of work aiming to identify maladaptive language changes. First, context is important: a given sound change may not be maladaptive when it affects certain inventories, depending on the other segments present that might "outcompete" a less robust variant. For instance, a major contributing factor to HVF being considered maladaptive here is the fact that the change affects high front vowels; this "niche", once emptied, repopulates quite quickly through intracategorical change of some other vowel category. Given a sufficiently crowded inventory of monophthongs, true of both Wú Chinese and Swedish, it is highly probable that high front vowels will eventually redevelop and outcompete fricative vowels; in a less crowded vowel system, this may not prove to be the case. Thus, maladaptive sound changes may prove to be more common when they produce minor variants on commonly attested, robust segments, which will tend to appear again and re-incorporate the unsustainable variants. These less robust variants should be highly improbable, but still possible (Blevins 2006).

This brings us to a second suggestion: arguing for highly improbable developments that may quickly disappear requires improbably good evidence, and so the data for illustrating maladaptive changes must have a good temporal resolution. That is, data on the segments affected by the sound change will probably have been collected and recollected a number of times in a fairly short time period by a number of different researchers. This would allow us to determine an order of developments directly, rather than infer it, which is essentially required to effectively argue for a non-adaptive (let alone maladaptive) basis for a change in biology (Gould 1997; Crespi 2000). This is especially important given that evidence for a maladaptive linguistic variant might quickly disappear: in the case of HVF, without documentation of fricative vowels in Shànghǎi-area dialects in the mid-20th century, a historical linguist would reasonably assume that the reflexes of **i* and **jen* simply merged into modern /i/ without ***i* first undergoing HVF.

5.3 Conclusion

Vennemann (1993) asks how the study of language change can "recognize a pejoration" as a way of invalidating the idea of change as optimization. I have taken steps toward doing just that, but rather than recognizing "pejoration," I have couched my discussion in maladaptivity in context of innovative linguistic variants. Acknowledging that maladaptive change is occasionally found in the world's languages may allow for a more neutral study of language change that is not hobbled by the "blind adaptationism" criticized in (Gould & Lewontin 1979).

None of this is to say that language is not fundamentally an adaptive system, but rather that not all synchronic linguistic features and inventory characteristics can be treated as optimized outcomes of natural selection, as some linguistic researchers have also suggested (Lindblom et al. 1995). Regardless of one's theoretical orientation toward evolutionary programs of linguistic change (or even one's interest in the research program of this volume), I hope that this chapter will also be useful as a detailed reckoning of an unusual and under-reported sound change.

Abbreviations

Acknowledgements

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