SOUND CHANGE AND FUNCTIONALISM

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ABSTRACT

Functional (speaker-based) and non-functional (listener-based) accounts are often equally satisfactory in explaining internally motivated diachronic sound change. Here we report a case clearly favoring the non-functional account: In some dialects of English, /æ/ is raised before /g/ but not /k/. The raising may be an attempt to reduce the conflict between producing the low front vowel before the voiced velar, or it may be due to listener misapprehension. Using acoustic and articulatory data from General American English to simulate the conditions prior to /æ/-raising, we show the precipitating stimulus for /æ/-raising had to have been listener misapprehension. Specifically, even though both /g/ and /k/ exert a coarticulatory effect on /æ/, acoustic evidence for the coarticulatory effect is found only before /g/.

Keywords: Sound change, functionalism, ease of articulation, misapprehension.

1. INTRODUCTION

Explanations of internally motivated diachronic sound change often invoke FUNCTIONAL considerations to explain the precipitating cause of change. That is, change takes place to accomplish a specific purpose. This is a view that, according to Boersma [2], goes back at least to the nineteenth century (e.g. [10]) and still has wide acceptance today. Boersma gives the example of a language that contains underlying /p/ and /b/. According to him, speakers may start aspirating the /p/ or spirantizing the /b/ to "enhance the contrast" between the two segments. More recently, Kirchner [7] cites "ease of articulation" or "reduction of effort" to account for cases of diachronic lenition (e.g., degemination /tː/ ➔ /t/ or spirantization /t/ ➔ /θ/). The functionalist approach would also include so-called "lazy" constraints in Optimality Theory, which are "promoted" or "demoted" within the phonology of a particular language to derive a typology of lenition (i.e., one demanding less effort).

In contrast, NON-FUNCTIONAL theories [4,5,9] account for change as listener "error" in reconstructing an underlying representation. According to this view, speech production introduces small coarticulatory effects into the speech signal, which listeners normally learn to correct for. When they fail to perform a correction, their misapprehension can result in a sound change. In other words, if listeners misperceive the structure of an incoming signal, they'll start to produce a distorted (i.e., changed) version of that signal themselves. For example, Ohala [9] notes that the enhanced intensity of the release burst of /t/ before /j/ has allowed those two segments to be reinterpreted as the affricate /ʧ/ in English, as in *actual*. These positions are summarized in Table 1.

Table 1: Comparison between accounts of diachronic sound change.

Functional	Non-functional
speaker	listener
production	perception
purposeful	non-purposeful
"reduce effort"/ "enhance contrast"	"error"

Quite often, both accounts are equally satisfactory in explaining internally motivated sound change. That is, any articulatory accommodation normally coincides with some sort of acoustic effect that is discernable to listeners.

For example, /s/ becomes /ʃ/ before suffixes beginning with /j/ in American English, e.g. *press/pressure* and *confess/confession* [13]. (Both the *-ure/-ion* suffixes begin with a palatal glide, as illustrated by *fail/failure* and *domain/dominion*.) On the one hand, functional considerations are capable of explaining the change from /s/ to /ʃ/ before the glide. /j/ requires a low tongue tip and a high tongue body, as does /ʃ/. However, /s/ requires the opposite configuration, a raised tongue tip and a low tongue body. Thus, speakers can be said to reduce the "effort" of making [sj] in *pressure* by changing the /s/ to /ʃ/ in order to accommodate the

/j/. Synchronic evidence of this conflict persists in a gradient shift from /s/ to /ʃ/ in *press your* and *confess your*.

On the other hand, listener "error" is equally capable of explaining this change. The center of the frequency for /s/ before /j/ is lowered into the acoustic space of /ʃ/. If listeners fail to correct for this regular coarticulatory effect, then they will perceive /ʃ/ in this environment instead of /s/ and will make /ʃ/ the new target. In this account, the change has nothing to do with reducing articulatory "effort" at all.

The issue, then, becomes one of determining whether diachronic change is caused by the speaker's attempt to reduce articulatory effort or by listener misapprehension. In this paper, a case is reported clearly favoring the non-functional account of sound change.

2. PREVELAR RAISING

In several dialects of English along the U.S.-Canadian border, but most notably in the state of Wisconsin, /æ/ before /g/ is raised. In this dialect, *bag* sounds like *beg* and *hag* sounds like *Haig.* Zeller [12] and Labov et al. [8] report this raising as a merger with /e/, but we report in another study that /æ/ has not "merged" with another vowel at all; it's simply a raised variant of /æ/ [1]. In other words, speakers of this dialect have added a rule (or constraint) to their grammars raising /æ/ before /g/.

We explain this sound change as a case of listeners failing to correct for a coarticulatory effect and then "phonologizing" that effect in the form of a rule. The segment /g/ clearly has a coarticulatory effect on the preceding /æ/: /æ/ requires the tongue to be low and front, whereas /g/ requires the tongue to be high and back; thus, /æ/ is raised to accommodate the /g/ in all dialects of English. What's happened in the Wisconsin dialect is that one or more listeners have failed to correct for this effect and have constructed a novel rule to account for the raised variant of the vowel that they "hear."

3. ISSUE

This phenomenon bears on the issue at hand: Is this sound change precipitated by functional considerations (i.e., ease of articulation), or is it merely listener "error" (i.e., failure to correct for a perturbation in the signal)? The fact that this new rule applies before /g/ but not before /k/ means that the stimulus precipitating this change occurs in the presence of /g/ but not in the presence of /k/ in all varieties of North American English.

This situation provides a test case for separating the competing sources of change. Both accounts crucially depend on the antagonistic tongue gestures required by /æ/ and /g/. Therefore, if tongue configuration (e.g. height) is significantly *different* for /æ/ before /g/ vs. /æ/ before /k/, then we can conclude that the cause of the change is essentially articulatory accommodation. That is, it is in some sense "easier" to produce a raised /æ/ before /g/ than a non-raised /æ/; but, at the same time, it is not "easier" to produce a raised /æ/ before /k/.

If, on the other hand, tongue configuration is the *same* or similar for /æ/ before both /g/ and /k/, we will have to conclude that the cause of this change is something other than simple articulatory accommodation.

4. EXPERIMENT

4.1. Setup

Three male speakers of General American English (GAE) participated in the study (ages 22, 24, and 34). Two are from suburban Chicago, and the third is from suburban Washington, DC.

Participants read a set of six monosyllables, each beginning with /pæ/ and ending with /p,b,t,d,k,g/. They read the monosyllables five times each in the frame *Say* ___ *again*.

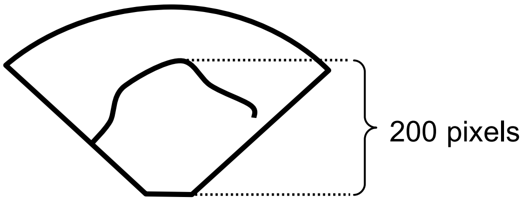
Acoustic recordings were made using a Sennheiser shotgun microphone. Articulatory recordings were made using a Sonosite Titan portable ultrasound unit with a C11 8-5 MHz transducer set to image at a depth up to 8.2 cm. The ultrasound unit and microphone were attached to an analog/digital video converter, which transmitted the display of the ultrasound in synch with the acoustic signal to a desktop computer.

4.2. Measurements

Audio data were extracted from the video files and analyzed with Praat [3]. Images from the ultrasound video were extracted at the nearest frame to 20%, 50%, and 70% vowel duration for each token, and analyzed using ImageJ [11].

Acoustic measurements of F1 and F2 were obtained at 20%, 50%, and 70% of vowel duration. A 25ms window was selected at each of the three points in the vowel, and formant measurements were made using formant queries in Praat.

Figure 1: Schematic demonstrating measurements of tongue body height. (Tongue tip faces right.)



Articulatory measures of tongue body height were obtained from the extracted ultrasound images. Tongue body height was measured in pixels from the base of the ultrasound display to the highest point achieved by the tongue body, Fig. 1. (Forty vertical pixels equals about 1 cm.)

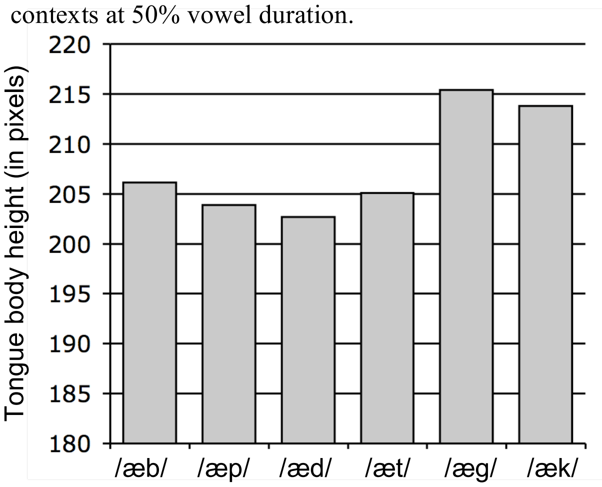
4.3. Results

Results from the experiment indicate that velars exert a coarticulatory effect on /æ/, but acoustic evidence for the coarticulation is found only before /g/.

4.3.1. Articulatory results

The articulatory results indicate that /æ/ is equally sensitive to coarticulatory effects from /k/ and /g/ compared to other places of articulation. Evidence supporting this conclusion comes from two sources.

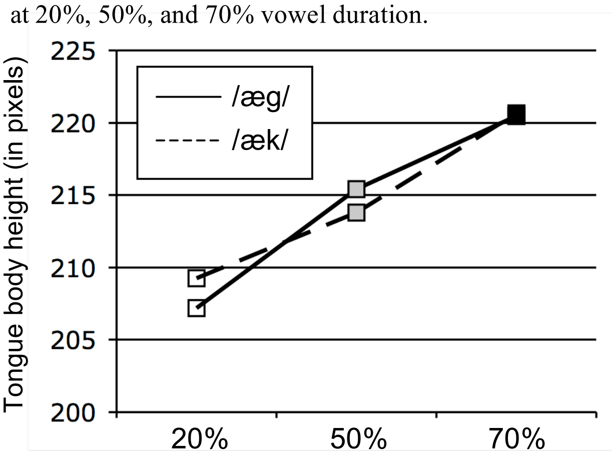
Figure 2: Tongue body height of /æ/ across several contexts at 50% vowel duration.



First, the tongue body is higher at the midpoint of /æ/ before velar compared to labial and coronal stops. The difference is slight but significant. A two-way ANOVA was performed, using as factor groups PLACE OF ARTICULATION and VOICING of the consonant following /æ/. Results revealed a main effect from PLACE, $F(2,89)=9.45$, $p<0.01$. The tongue body of /æ/ is about 0.25cm higher before the velars than before the other places of articulation, Fig. 2. There was, however, no effect from VOICING and no interaction.

Second, when /æ/ before the velars is examined in isolation, the tongue body height of /æ/ does not differ before voiced vs. voiceless velars at any point throughout the duration of the vowel. A two-way ANOVA was performed, using as factor groups PERCENT DURATION OF VOWEL and VOICING. Results revealed a main effect on PERCENT DURATION, $F(2,84)=11.04$, $p<0.01$. Tongue body height for /æ/ is about 0.25 cm higher at 70% than at 20% duration of the vowel, Fig. 3. There was no effect from VOICING, and no interaction. At 20%, 50%, and 70%, the tongue body height of /æ/ before /g/ patterns identically to /æ/ before /k/.

Figure 3: Tongue body height of /æ/ before /k/ and /g/ at 20%, 50%, and 70% vowel duration.



Overall, the tongue body for /æ/ is slightly higher before both /g/ and /k/ than before labials and coronals at the mid point of the vowel. Moreover, the tongue body height of /æ/ patterns identically before /g/ and /k/ over the vowel's duration. These results lend support to the conclusion that there is a natural articulatory conflict between the low front vowel and velar consonants. More importantly, the articulatory conflict between /æ/ and the following consonant is equally present before both /k/ and /g/.

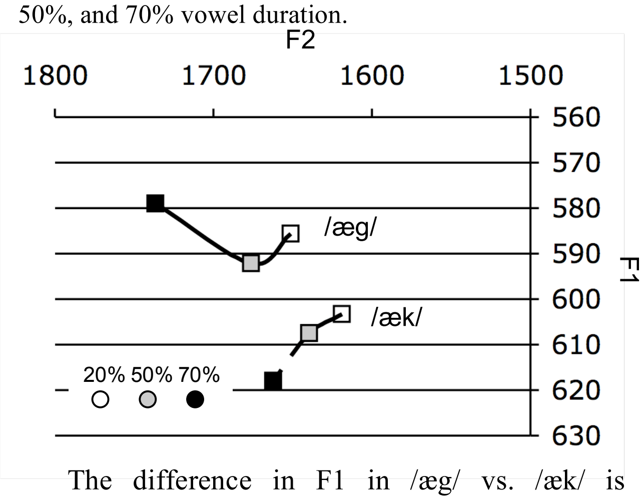
4.3.2. Acoustic results

In contrast to the articulatory results, the acoustic results indicate that the coarticualtory effect on /æ/

before velars is manifested before /g/ but not /k/. In particular, /æ/ moves high and significantly forward in the acoustic space before /g/, whereas /æ/ moves forward and quite low before /k/, Fig. 4.

A two-way ANOVA was performed on F1 of /æ/ before the velars, using as factor groups K VERSUS G and PERCENT VOWEL DURATION. Results revealed a main effect from K,G on F1, $F(1,84)=6.81$, $p<0.01$, but no effect from DURATION, and no interaction. Whereas /æ/ rises throughout the vowel's duration before /g/, /æ/ lowers before /k/. At 70% vowel duration, /æ/ before /g/ is 40 Hz higher than /æ/ before /k/, or about 0.31 Bark. At 50% and 20%, the difference is about 20 Hz, or about 0.13 Bark.

Figure 4: F1 and F2 of /æ/ before /g/ and /k/ at 20%, 50%, and 70% vowel duration.



The difference in F1 in /æg/ vs. /æk/ is consistent with Hillenbrand et al. [6], who found significant F1 lowering in voiced environments (e.g. [bæb]) compared to voiceless environments (e.g. [pæp]) by about 70–100Hz. They suggest the effect is likely due to the "slightly lower position of the larynx for the voiced environments…with the difference carrying over to the vowel" (755). A lower larynx increases the size of the pharyngeal cavity, with the effect of lowering F1, which correlates with vowel raising.

In general, the acoustic characteristics of /æ/ before velars do not mirror its articulatory characteristics. The results are summed up as follows:

- The tongue body is higher at the midpoint of /æ/ before velar compared to labial and coronal stops but does not differ in height between the voiced and voiceless velar at any point throughout the duration of the vowel.
- /æ/ moves high in the acoustic space before /g/ but moves quite low before /k/.

Overall, the coarticulatory pressures exerted on /æ/ by the velars is evidenced acoustically only before /g/.

5. CONCLUSION

We examined acoustic and articulatory data from three speakers of GAE in order to simulate the conditions prior to the onset of /æ/-raising in some dialects of English, where /æ/ raises before /g/ but not /k/. The raising may be caused by an attempt to reduce antagonism between the production of /æ/ and the following /g/, or it may be due simply to listener misapprehension of an acoustic effect. Results from the experiment indicate that the stimulus precipitating the occurrence of /æ/-raising must have been acoustic in nature. Even though both /g/ and /k/ exert a coarticulatory effect on /æ/, the acoustic evidence for the coarticulation is found only before /g/.

6. REFERENCES

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