Is Ash-tensing driven by acoustics or articulation? An ultrasound study

Paul De Decker & Jennifer Nycz
New York University

This paper presents the results of an ultrasound study of the articulation of tense /æ/ as produced by speakers of Mid-Atlantic dialects of American English. In these dialects, the lax low front vowel [æ] (as in *cat* and *have*) coexists with a variant that may be impressionistically described as "raised" or "tense" (henceforth represented by the symbol [æ̝]). One striking aspect of this alternation is the particular subset of environments which conditions it. In Philadelphia, [æ̝] occurs before [+anterior] voiceless fricatives (e.g. [pæ̝θ] *path* and [pæ̝s] *pass*), before [+anterior] nasals ([hæ̝m] *ham* and [pæ̝n] *pan*), and in the words *mad, bad*, and *glad* (Ferguson 1975, Labov 1989). In New York City, this set is expanded to include the voiceless fricative [ʃ] ([læ̝ʃ] *lash*) and the rest of the voiced stops (Labov 1994). New Jersey speakers, meanwhile, exhibit a variety of tensing patterns (Ash 2002).

As the term "tensing" implies, this shift is commonly understood to involve a change in tongue position. However, as Plichta (2002) has shown in his study of the Northern Cities shift, the acoustic properties of tensing may also result from coarticulatory nasalization. Given these two options for producing [æ̝], is this phone articulated the same way in every relevant environment? The answer to this question will ultimately bear on the formulation of the phonological rule of ash-tensing. If the rule specifies a unique articulatory target, then we expect the same lingual gesture to occur in each tensing environment: either the tongue root will be advanced in all contexts, or there will be a lack of lingual advancement in all contexts, indicating that all of the [æ̝]s are the result of nasalization. However, if the rule specifies an acoustic goal, then the lingual gesture can differ across environments: while tongue root advancement may characterize [æ̝] in some tensing contexts, there may be no lingual tensing in others, since nasalization will achieve the same acoustic end.

To decide between these possibilities, we designed an experiment using ultrasound technology, which offers a non-invasive means of tracking tongue position during speech (see e.g. Stone 1999, Davidson 2004). Several speakers from the Mid-Atlantic region who exhibit ash-tensing were asked to read a series of carrier phrases containing words with /æ/ in four different environments, three of which typically condition tensing and one of which does not (see below for elicited phrases). During these productions, ultrasound was used to capture mid-sagittal images of the tongue; from these images, contours of the tongue shape were extracted using Edgetrak (Li et al. 2004) and were then compared using a smoothing spline ANOVA (Wang et al. 2002) to test for differences. In this way, we were able to compare phonetic variants which may be deemed "the same" on impressionistic or acoustic grounds in terms of their underlying articulatory patterns. Our results indicate that, in the speech of some speakers, there is a significant difference between the degree of tongue root advancement in the pre-nasal vs. pre-obstruent environments. Therefore, [æ̝] cannot be attributed to a single lingual gesture. This implies that the tensing rule does not specify a single articulatory goal, but an acoustic one.

Stimuli. Stimulus carrier phrases were elicited along with 8 filler phrases for a total of 12 sentences per block; each speaker completed 12 blocks, 10 of which were used for analysis.

Carrier Phrase	**Environment**
Say pat very loudly.	Nontensing: pre-voiceless stop
Say pad very loudly.	Tensing: pre-voiced stop
Say pass very loudly.	Tensing: pre-voiceless fricative
Say pan very loudly.	Tensing: pre-nasal

References

Ash, Sharon. 2002. The distribution of a phonemic split in the Mid-Atlantic region: Yet more on short a. *U. Penn Working Paper in Linguistics, Volume 8.3*, 1-15.

Davidson, Lisa. 2004. The influence of articulation, perception and coordination on non-native phonotactics and repairs. Talk presented at the "Redefining Elicitation: Novel Data in Phonological Theory" Workshop, NYU, April 9-11, 2004.

Ferguson, Charles. 1975. "Short a" in Philadelphia English. In E. Smith (ed.), *Studies in Linguistics in Honor of George L. Trager*, The Hague: Mouton.

Labov, William 1989. The exact description of the speech community: Short a in Philadelphia. In R. Fasold and D. Schiffrin (eds.), *Language Change and Variation*, Washington, D.C.: Georgetown University Press, 1-57.

Labov, William. 1994. *Principles of Linguistic Change. 1: Internal Factors*. Oxford: Blackwell.

Li, M., Akgul, Y., and Kambhamettu, C. 2004. Edge Extraction and Tracking program. Department of Electrical Engineering and Computer Information Systems University of Delaware.

Plichta, Bartek. 2002. Coarticulatory Nasalization and the Northern Cities Vowel Shift: Is /æ/ Really Raising? Paper presented at NWAV 31, Stanford University, California.

Stone, M. 1999. Laboratory Techniques for Investigating Speech Articulation. In Hardcastle, WJ. and Laver, J., (eds.) *The Handbook of Phonetic Sciences*. Oxford, Blackwell Publishers.

Wang, Yuedong, Ke, Chunlei and Brown, Morton B.. 2003. Shape Invariant Modeling of Circadian Rhythms with Random Effects and Smoothing Spline ANOVA Decompositions. *Biometrics*, **59:**804-812