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What's Really Happening to Short A before L in Philadelphia?

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Philadelphia's **split short-*a* system**: a phonemic split with phonological patterning.

- Traditionally described as follows (Ferguson 1972):
  - tense /æh/ before **non-intervocalic** /f θ s m n/
  - lax /æ/ in other environments
  - various morphophonological constraints and lexical exceptions
- Numerous studies reporting **additions to tensing environments** (Labov 1989, Roberts & Labov 1995, Banuazizi & Lipson 1998, Brody 2009):
  - intervocalic /n/ (as in *planet*)
  - /l/ (as in *pal*)
  - typically described as processes of **lexical diffusion**.

Brody (2009) reports **tensing before /l/** is going to completion, while **tensing before intervocalic /n/** has "crystallized at one word, *planet*".
Banuazizi & Lipson (1998) note /æh/ before /l/ is **phonetically intermediate** between canonical /æ/ and /æh/, and tensing before /l/ is **unconstrained by syllable structure** (unlike other /æh/ environments).

This paper's question:
Why is the behavior of short-*a* before /l/ **different from other tensing environments**, whether stable ones or ones involved in change in progress?

Hints to the answer:
Banuazizi & Lipson find more tensing in **l-vocalization environments** (Ash 1982) and no clear evidence of lexical diffusion.
Tucker (1944) gives early report of **/aw/-fronting** in Philadelphia:

"The diphthong written *ou* or *ow* has [æ] instead of [ɑ] as its first element…. When *ou*, pronounced [æu], loses its second element, the result is simply 'flat *a*': *hour* [æ:r], *owl* [æ:l], *Powell* [pæ:l], the latter two hardly to be distinguished from *Al* and *pal*."

Our hypothesis:

- /æ/ and /aw/ merged before /l/ as a result of /aw/-fronting and /l/-vocalization
- /aw/ continued raising and fronting (cf. e.g. Labov 2001)
- /æl/ words raised along with /aw/ to the neighborhood of /æh/

So in this analysis, **/l/ has not become a conditioning environment for /æh/**; rather, /æl/ is **raised because it is identified with /aw/**.

Our data source: the **Philadelphia Neighborhood Corpus** (PNC):
a corpus of sociolinguistic interviews conducted by students of Linguistics 560 ("Study of the Speech Community") at Penn, 1972–2010

Corpus details:

- 59 Philadelphia-area neighborhoods sampled
- 1,087 recordings in total
- over 100 years of apparent-time coverage; speakers born 1888–1990
- 49 neighborhoods, 318 speakers **transcribed** to date
  - over 150 hours of speech (average 29 minutes/speaker)
  - 1.6 million words
- 235 speakers **phonetically analyzed** to date
  - speech aligned to transcript and vowels measured using FAVE program suite (see *http://fave.ling.upenn.edu*)
  - 598,901 vowel tokens measured (average 2,549 tokens/speaker)

To date, phonetically analyzed PNC (excluding non-Philadelphian speakers) contains:

- 226 speakers who produced at least one token of /æl/
- 41 speakers who produced at least 10 tokens of /æl/
- 24 /æl/ lexical items occuring 10 or more times
- 1,308 tokens of /æl/ altogether

Very **few tokens of /awl/** in data:

- Some speakers vary between **clearly diphthongal [æwl] for some careful tokens** and **monophthong identical to /æl/** for less careful tokens
- A **natural /awl/~/æl/ misunderstanding**:

  A: Yeah, that owl's gonna be on TV tonight.
  Sam: Who, Al? …Yeah, who, Al?
  B: The *owl*.
  Sam: Oh, the *owl*.
  B: The *owl*. Interview PH79-3-6: Sam Y., 48 years old in 1979
- /æl/ tends to occupy **same area of phonetic space** as /awl/, **regardless of whether** that overlaps more with /æ/ or /æh/.

So we **measure whether /æl/ tokens are closer** to the speaker's mean /æ/, /æh/, or /aw/.

Z-distance: Cartesian distance of token from phoneme's mean position, scaled by stdev.
E.g., if F1(æ) and F2(æ) are a speaker's mean formant values for /æ/, and σ_{F1}(æ) and σ_{F2}(æ) are the corresponding standard deviations, the **z-distance from /æ/** of a token of /æl/ from that speaker will be:

$$\sqrt{\left(\frac{\mathrm{F1(æl)} - \mathrm{F1(æ)}}{\sigma_{\mathrm{F1}}(\mathrm{æ})}\right)^2 + \left(\frac{\mathrm{F2(æl)} - \mathrm{F2(æ)}}{\sigma_{\mathrm{F2}}(\mathrm{æ})}\right)^2}$$

Overall, /æl/ is **closer in z-distance to /aw/** than to /æ/ or /æl/:

- **Plurality** of /æl/ tokens (48%) are closer to /aw/ than to /æ/ (37%) or /æh/ (15%)
- **Mean** z-distance to /aw/ is shorter than to /æ/ or /æh/, though lots of overlap:

z-dist /æl/ tokens to **/æ/**		z-dist /æl/ tokens to **/æh/**		z-dist /æl/ tokens to **/aw/**	
mean	st.dev	mean	st.dev	mean	st.dev
1.86	1.30	3.06	1.78	1.47	0.907

n = 1308; means significantly different ($p < 10^{-25}$)

Is /æl/ **correlated** with /aw/?

	n	/æ/		/æh/		/æw/	
		F1	F2	F1	F2	F1	F2
all /æl/	1308	–0.029	0.069*	0.10**	0.16**	0.33**	0.25**
born before 1940	595	0.14**	0.11*	0.086*	0.15**	0.25**	0.17**
born since 1940	713	–0.11*	0.051	0.16**	0.19**	0.33**	0.30**
iv before 1992	811	0.042	0.089*	0.044	0.14**	0.31**	0.22**
iv since 1992	497	–0.17**	0.047	0.20**	0.22**	0.38**	0.31**

Pearson r-correlations between /æl/ tokens and speaker means for /æ/, /æh/, /æw/
$*p < 0.05$; $**p < 0.001$

F1/F2 of /æl/ are **more strongly correlated** with /aw/ than with /æ/ or /æh/,
in **both apparent-time halves** and **both real-time halves** of the data,
though most of the /æ/ and /æh/ correlations are also statistically significant.

Multiple linear regression,
using F2–2F1 to model movement up the front diagonal of the vowel space:
/æ/ and /æh/ are **no longer correlated with /æl/** once /aw/ is accounted for.

actor	coefficient	t	p
/aw/ mean F2–2F1	0.599	11.4	≤ 0.0001
/æ/ mean F2–2F1	0.111	1.68	0.0928
/æh/ mean F2–2F1	-6.85×10^{-3}	0.161	0.8725

Multiple regression of F2–2F1 of /æl/ tokens vs. speakers' phoneme means; $r^2 \approx 0.112$

For the **older half** of the sample alone, /æ/ remains significant (though /aw/ is stronger);
but for the younger half, /æh/ does not become significant:

	born before 1940 ($r^2 \approx 0.069$)			born since 1940 ($r^2 \approx 0.133$)		
	coefficient	t	p	coefficient	t	p
/aw/ mean F2–2F1	0.397	5.74	≤ 0.0001	0.734	8.45	≤ 0.0001
/æ/ mean F2–2F1	0.311	2.62	0.0091	0.0700	0.878	0.380
/æh/ mean F2–2F1	–0.0736	1.09	0.277	–0.0425	–0.693	0.488

Multiple regressions of F2–2F1 of /æl/ by apparent-time halves

Kitchen-sink multiple regression of /æl/ F2–2F1 vs. a whole lot of factors:
year of birth; year of interview; gender; word frequency in corpus; duration; stress; syllable onset (labial obstruent, /m/, apical obstruent, /n/, postalveolar, velar, /r/, cluster); F2–2F1 of /æ/, /æh/, /aw/; word boundary or consonant after /l/; 21 high-frequency lexical items (*Al, Albert, Alex, algebra, Alice, alcohol, alley, balance, California, gallon, Hallahan, Halloween, Italian, nationality, pal, personality, Ralph, salad, salary, valley, value*)

Only five factors significant at the $p < 0.00125$ level (Bonferroni correction);
/aw/ still substantially the strongest

factor	coefficient	t
/aw/ mean F2–2F1	0.567	13.4
coda cluster	–140	–9.06
Halloween	–726	–8.63
gallon	360	5.55
year of birth	1.42	4.38

Multiple regression of F2–2F1 against kitchen sink of 40 potential factors; $r^2 \approx 0.232$

Overall results:

- Quantitative evidence fairly convincing that /æl/ is associated with /aw/, not /æ(h)/
- This accounts for differences in behavior between /æl/-raising and ordinary /æh/
- Little evidence for lexical diffusion of /æl/ words previously argued to lead change
- /æl/ merged **enough** with /aw/ to raise, although not fully merged in careful speech

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