Top-down and bottom-up influences in English s-retraction

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s-retraction — Previous Research

- Impressionistically, /s/ has a pronunciation similar to [ʃ].
- Contexts: /stʌ/ clusters, to a lesser extent /skʌ/, /spʌ/, /sʌ/ and /ʌʃs/
- The change is fairly widespread; we don’t have a complete picture of the social boundaries.
We show that the retraction of /s/ has a two-part phonetic motivation.

- A large “common” coarticulatory effect shared by all speakers.
- A smaller, speaker-specific coarticulatory effect.

We argue that:

- Speaker-specific patterns of coarticulation are important factors in the initiation of sound changes.
- Small speaker-specific coarticulatory biases can be more influential than large common patterns of coarticulation.
- Taking both speaker-specific phonetics and social factors into account allows for some partial answers to questions surrounding the actuation problem.
Inaudible [ʌ] allophony

- [ʌ] is part of the conditioning environment for s-retraction (i.e., [s]trand, *[s]tand)
- The change can be thought of as conventionalized coarticulation from the [ʌ] to the [s].
- But there are multiple articulatory allophones of [ʌ].
  - canonically “bunched” v. “retroflexed”
  - Delattre & Freeman 1968, Tiede et al. 2004, Mielke et al. 2006
- We hypothesized that different productions of [ʌ] lend themselves to different degrees of coarticulation.
Subjects

- 32 U of A undergraduates recorded
  - 6 discarded either for imaging poorly, or technical problems
- Age range: 18-22 years, mean = 18.7
- Subjects were judged to be retractors or non-retractors.
  - Trained phoneticians made the judgment (often two)
  - Never a difficult task
- 16 non-retractors, 10 retractors
Materials

- Words were read in the frame “Please say ____ again.”
- Initial onsets:
  - s
  - š, š
  - sp, st, sk
  - spu, str, sku
- With following vowels: i, ɪ, æ, u
- Two items from each phonetic context (e.g., stack and stab)
- Four tokens of each item.
Recording

- Simultaneous recording of:
  - ultrasound video of tongue
    - The hard palate was also imaged.
  - facial profile video (for lips)
  - audio signal
Acoustic analysis

- We used the centroid frequency to distinguish between [s]-like and [ʃ]-like fricatives.
- Weighted average of spectral envelope, from 1-10 kHz (5 ms analysis window).
- Spectra from middle half of the fricative were averaged, 2 ms time step.
- Tokens were averaged across item before statistical analysis.
Ultrasound analysis

- Ultrasound frames chosen by hand:
  - all sibilants
  - [u] in /stu/ clusters.

- Tongue and palate tracings were produced with the Palatoglossatron software (Baker, Mielke, & Archangeli 2006).

- Tracings were adjusted to compensate for head and transducer movement.
We treat present day non-retractors as models of pre-retractors.

- i.e., as individuals with phonetic but not (compelling) social motivation for s-retraction

This allows us to study the phonetic motivation for s-retraction in isolation of the social motivation.
Experimental Results

1. Overview of fricatives in centroid frequency space
2. Effect of consonant context on coarticulation
3. Social and speaker-specific phonetic factors in s-retraction
4. Speaker-specific and “common” coarticulatory effects
Overview of centroid frequency space

Data from non-retractors. The presence of both a stop and [ɾ] both contribute to a lower centroid for /s/.
Effect of consonant environment (non-retractors)

Centroid Frequency by Cluster Type

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Effect of consonant environment (non-retractors)

- The centroid of /s/ is lowest in an /str/ cluster, followed by /skr/, then /spr/.
- This is consistent with what we see in the sound pattern, where [s] is most prevalent in /str/, followed by /skr/ and /spr/.
- One subject retracted in /str/ and /skr/ clusters, but not /spr/.
- This may indicate an implicational hierarchy of retraction contexts; more observation is needed.
Investigating effect of /ɹ/ allophones

- Speakers were classified according to the degree of similarity in their /ɹ/ and /s/ tongue shapes.
- Assumption: the extent of coarticulation is directly proportional to the postural change required of the tongue.
  - e.g., a uvular consonant would produce more coarticulation than would a palatal consonant, before [i]
- People with more dissimilar ɹ/s shapes should have more coarticulation (i.e., a lower centroid in [s]).
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Social and phonetic factors

- Two-factor between-subjects ANOVA with data from all speakers
  - RetractorJudgment \{retractor, non-retractor\}
  - \(J/s\)-similarity \{similar, disimilar\}
- Significant main effects, no significant interaction
  - RetractorJudgment \(F(1, 143) = 12.8429, (p < 0.0004638)\)
  - \(J/s\)-similarity: \(F(1, 143) = 4.1010, (p < 0.0447178)\)
  - RetractorJudgment \(\times\) \(J/s\)-similarity
    \(F(1, 143) = 2.0476, (p < 0.1546306)\)
Social and phonetic factors

Centroid Frequency by Social and Phonetic Factors

- Non-retractor
  - Dissimilar r/s
  - Similar r/s
- Retractor
  - Dissimilar r/s
  - Similar r/s

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Relatively small effects

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Top-down and bottom-up influences in English s-retraction
Relatively small effects

The effect sizes of the /s/-similarity and RetractorJudgment factors are small relative to the “common” coarticulatory consequence of /s/ being in an /stə/ cluster.

Averages
- Non-retractor’s [s] from simple onset: 7035 Hz
- Non-retractor’s [s] from /str/: 5829 Hz
- Retractor’s [s] from /str/: 5607 Hz

Important: non-retractors are 84% of the way to retraction, *purely* on the basis of “common” coarticulation.
Empirical facts

1. In non-retracting speakers, the centroid of [s] is significantly lower in an /stʌ/ cluster, compared to a simple [s].

2. There are speaker-specific patterns of /stʌ/ coarticulation.
   - People with more similar ʌ/s shapes have higher [s] centroids in /stʌ/ than do people with more dissimilar ʌ/s shapes.
   - This holds for both retractors and non-retractors.

3. The speaker-specific portion of coarticulation is small when compared to “common” /stʌ/ coarticulation.

   - These facts answer some questions, but create new questions elsewhere.
Actuation Problem

But if the pursuit of ease is the cause of sound change in idiolects, the fundamental questions arise: why do not speakers go about it more quickly, and why do Language Customs split in that some speakers set out on a particular ease-seeking path whereas other retain their less comfortable pattern?....For even when the course of a language change has been fully described and its ability explained, the question always remains as to why the change was not actuated sooner, or why it was not simultaneously actuated wherever identical functional properties prevailed. The unsolved actuation riddle is the price paid by any facile and individualistic explanation of language change. It creates the opposite problem—of explaining why language fails to change. (Weinreich, Labov, & Herzog 1968: 111–112)
**Actuation Problem**

Two questions from Weinreich, Labov, & Herzog (1968: 111–112):

- “The unsolved actuation riddle is the price paid by any facile and individualistic explanation of language change. It creates the opposite problem—of explaining why language fails to change.”
- “Why do Language Customs split in that some speakers set out on a particular ease-seeking path whereas other retain their less comfortable pattern?”
Why change? / Why not change?

- Sound change can be thought of as the phonologization of coarticulation (e.g., Neogrammarians, Pierrehumbert 2001):
  - Coarticulation affects production systematically.
  - Listeners adjust their acoustic targets accordingly.
- This creates the necessary feedback loop.

- But this model is too strong.
- We saw that, with “common” coarticulation, non-retractors are 84% of the way to retraction.
- In this case, how could s-retraction have failed to occur?
Role of speaker-specific biases

- We argue that the answers to these questions lie in the interaction of speaker-specific phonetic and social factors.

- Sound changes are initiated when speaker-specific patterns of coarticulation gain social significance.

- Consideration of speaker-specific biases admits another order of complexity into the model.

- We can suggest some answers to the questions posed by Weinreich, Labov, & Herzog (1968)
Why “common” coarticulation doesn’t cause retraction

“Common” /ɾ/ to /s/ coarticulation is quite large, while speaker-specific effects are relatively small.

But a bias shared by all speakers cannot attain social significance.

- It can’t be a social variable if it doesn’t vary.

Therefore we do not expect the large, common articulatory consequence of /s/ being in an /stɾ/ cluster to initiate a sound change.
Speaker-specific phonetics

- Conversely, speaker-specific phonetic motivations can serve to differentiate speakers socially.
- These phonetic effects are therefore available to be taken up as social indicators.
- This makes a small, speaker-specific phonetic motivation more efficacious at bringing about a sound change than a large, common phonetic motivation.
Why was the change not actuated sooner?

- Speech communities are made of speakers heterogeneous w.r.t. phonetic motivation.
  - Only 21% of our subjects were judged to have dissimilar /s/ shapes.
  - And there are certainly other as-yet unidentified factors influencing the degree of /ɛ/ to /s/ coarticulation.
- These speakers are also heterogeneous w.r.t. social standing.
  - Presumably only a relatively small segment of a social group has the clout to initiate a sound change.
Why was the change not actuated sooner?

Based on this model, the probability of the initiation of a sound change is governed by

- the probability of an individual having a conducive coarticulatory bias
- the probability of that individual having the right social standing

These two factors do not necessarily come into alignment very often.

More data would be required to validate, but this could explain why sound changes occur as often as they do.
Why do language customs split?

(two senses of this question)

1. Why would a split occur when communities are in contact?
   - Different social groups have different structures.
   - We expect to find as many divergences in sound patterns as we can find sociological patterns.

2. Why should isolated communities not develop in parallel? (i.e., “wherever identical functional properties prevail”)
   - Functional properties are influential only so far as they are identifiable with speakers of high social standing.
   - Since different groups have different social dynamics, different phonetic biases are expected to prevail in different speech communities.
We have argued that speaker-specific phonetic motivations are more important than common phonetic motivations in sound change.

Speaker-specific coarticulatory biases make better social markers than do common coarticulatory biases.

This explains why common coarticulation in an /stu/ cluster does not lead to across-the-board retraction.

Such a model begins to offer partial answers to the actuation problem.
Thank you