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Sverre Stausland Johnsen
Harvard University
johnsen@fas.harvard.edu

On the origin of asymmetry in Norwegian retroflexion

1. Outline

- In Norwegian, initial /s/ optionally undergoes retroflexion to [ʂ] after /ɾ/.
- Whether this process occurs or not is well predicted by a phonological factor:
  - /s/ undergoes retroflexion to [ʂ] less often in simple onsets.
- /s/ is also seen to undergo retroflexion less often in words in dense neighborhoods.
- I propose that the asymmetry in retroflexion originates as a neighborhood effect, and that it has been phonologically generalized in the grammar.

2. Norwegian retroflexion

2.1 Retroflex /ʂ/

- Norwegian has two distinct phonemes /s/ and /ʂ/:

(1)

/sɛː/ ‘see’	/ʂɛː/ ‘happen; spoon’
/sʋæːʈ/ ‘very’	/ʂʋæːʈ/ ‘huge’
/tɔsk/ ‘fool’	/tɔʂk/ ‘cod’
/mɑːs/ ‘nagging’	/mɑːʂ/ ‘Mars’

2.2 Retroflexion of /s/ to [ʂ]

- When a morpheme ends in /-ɾ/, and the following morpheme begins with /s/, the /-ɾ/ deletes and the /s/ optionally surfaces as a retroflex [ʂ].
- This happens both before a vowel (2) and before a consonant (3):

(2)

/ʋɔːɾ-suːʈ/	>	[ʋɔː-suːʈ] ~ [ʋɔː-ʂuːʈ] ‘spring sun’
/ʋɔːɾ-syːn/	>	[ʋɔː-syːn] ~ [ʋɔː-ʂyːn] ‘spring vision’

(3)

/ʋɔːɾ-spiɭ/	>	[ʋɔː-spiɭ] ~ [ʋɔː-ʂpiɭ] ‘spring games’
/ʋɔːɾ-stœːʋ/	>	[ʋɔː-stœːʋ] ~ [ʋɔː-ʂʈœːʋ] ‘spring dust’
/ʋɔːɾ-skuː/	>	[ʋɔː-skuː] ~ [ʋɔː-ʂkuː] ‘spring shoes’

3. Asymmetry in optionality

- The optionality of retroflexion is not evenly distributed. Some words undergo retroflexion more often than other words.
- Specifically, there seems to be an effect of onset complexity: Words of the kind in (2) with a simple onset seem to undergo retroflexion less often than words of the kind in (3) with a complex onset.

3.1 Characterizing the onset complexity effect

- What is the best way to characterize the effect of onset complexity in Norwegian retroflexion?
- Two different measures will be compared and evaluated in the following:
    a) *Phonology*: The grammar directly encodes different application rates of retroflexion according to a phonological distinction between simple onsets in /s-/ and complex onsets in /sC-/.
    b) *Neighborhood density*: Words in simple onsets are less likely to undergo alternation because they are in denser neighborhoods.

4. Predicting alternations with phonology

- The default assumption in traditional phonology would be that differences in phonological alternations are governed by phonological factors.
- If items with a simple onset /s-/ are less likely to undergo retroflexion, this would be because the constraints or rules enforcing retroflexion are specified differently for /s/__/V/ than for /s/__/C/.
- By this characterization, we hypothesize the following prediction:

Retroflexion is less likely to occur with simple onsets (/s-/) than with complex onsets (/sC-/).

5. Predicting alternations with neighborhood density

5.1 Neighborhood density

- The neighbors of a word *cat* /kæt/ are the words that are one segment away from it, by adding (/skæt/), deleting (/æt/), or changing a segment (/kæp/, /pæt/). If there are many such words, *cat* is in a *dense neighborhood*.
- Neighborhood density is known to impact words in several domains:

5.1.1 Neighborhood density in processing

- Words in dense neighborhoods are less accurately identified than words in sparse neighborhoods (Luce & Pisoni 1998, Dirks et al. 2001).

5.1.2 Neighborhood density in phonetics

- Words in dense neighborhoods are produced with more phonetic contrast (Wright 2003, Stephenson 2004, Munson & Solomon 2004).

5.2 Neighborhood density in phonological alternations

- Some claim that words in dense neighborhoods are less likely to participate in phonological alternations (Wedel 2002, Ussishkin & Wedel to appear).
- Others maintain that lexical factors such as neighborhood density play no role in phonological alternations (Pycha et al. 2007, Becker & Nevins 2009).

5.2.1 How neighborhood density affects alternation

- (4)-(5) illustrate the optional retroflexion after /-ɾ/:

(4) /suːɽ/ > [suːɽ]~[ʂuːɽ]

(5) /skuː/ > [skuː]~[ʂkuː]

- Applying the retroflexion to [ʂ] involves altering the onset with respect to the base form.
- Marslen-Wilson et al. (1996) show that featural changes to the onset lower the ability to associate the form to its base. Speakers will therefore be less accurate in identifying [ʂuːɽ] and [ʂkuː] as tokens of /suːɽ/ and /skuː/ than if no alternation had taken place.
- Additionally, the retroflexed forms [ʂuːɽ] and [ʂkuː] differ in their neighborhood densities:

(6) [ʂuːɽ] *dense neighborhood*

(7) [ʂkuː] *sparse neighborhood*

- Since words in dense neighborhoods are less accurately identified than words in sparse neighborhoods (5.1.1), the retroflexed token [ʂuːɽ] is at a double disadvantage with respect to correct identification.
- [ʂuːɽ] is therefore more prone to not be correctly identified as a token of its base /suːɽ/ than is the case for [ʂkuː].
- In a dynamic and word-specific model of phonology, this entails that [ʂuːɽ] is a less likely production of /suːɽ/ at the next iteration (Wedel 2006)
  - The denser the neighborhood of the retroflexed form, the less likely that word is to undergo retroflexion.

5.3 Hypothesis for Norwegian retroflexion

- If neighborhood density plays a role in Norwegian retroflexion, we expect the following:

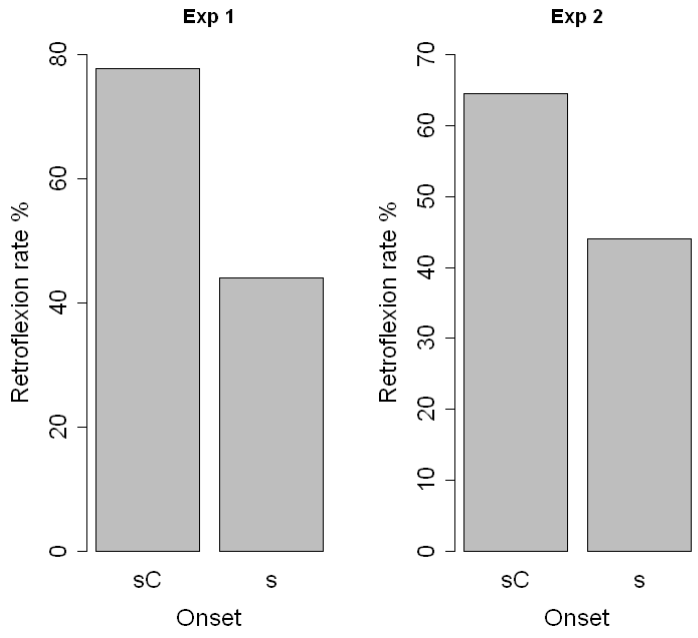
The higher the neighborhood density of a retroflexed token of a word, the less likely that word is to undergo retroflexion

6. Experiments

- *Part 1*
    - 10 Norwegian subjects produced 10 high-frequency monosyllabic words in /s-/ and /sC-/ following a word in /-ɾ/
- *Part 2*
    - The same subjects produced 9 nonce monosyllabic words in /sV/ and /sCV/ following a word in /-ɾ/
- Through multiple reiterations, there were in total 5794 items

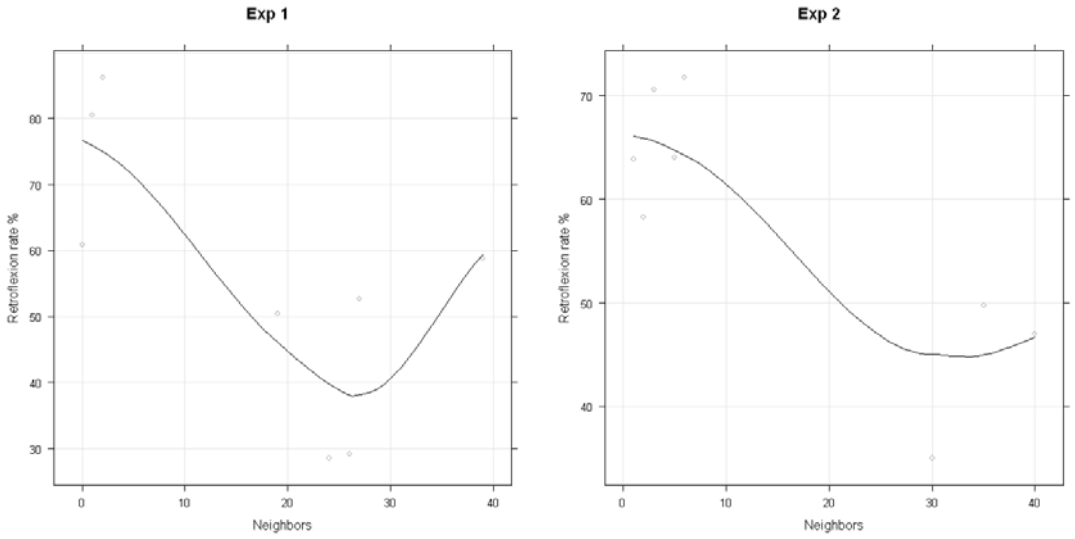
6.1 Results

Onset



- The data were analyzed with linear mixed effects models[1]
- Fixed effect: 'Onset'
- Likelihood ratio test $p < .001$ ***

Neighborhood density



- Fixed effect: 'Neighborhood density'
- Likelihood ratio test $p < .001$ ***

Onset & Neighborhood density

- With both effects added to the model (with residualization), only 'Onset' remains as a significant predictor of retroflexion:
- 'Onset': Likelihood ratio test $p < .05$ *
- 'Neighborhood density': Likelihood ratio test $p > .05$

The phonological factor 'Onset' fares better at explaining the asymmetry in retroflexion than the lexical factor 'Neighborhood density' does

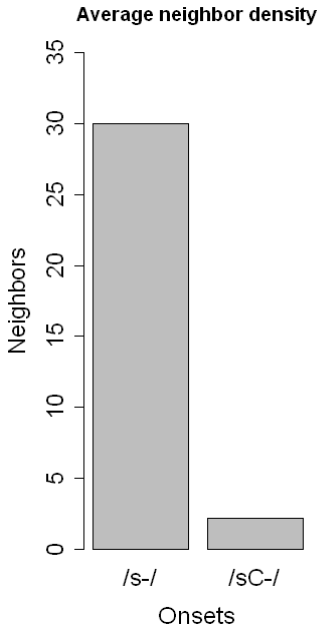
7. Discussion

7.1 Correlation of effects

- Both effects are highly significant tested separately ($p < .001$).

[1] Random effects: a) Word, b) Subject
Fixed effects: a) Lemma frequency, b) The positions of the target item in the text frame, c) The relative position of the text frame in the experiment

- Tested together, 'Onset' becomes less significant ($p < .05$) and 'Neighborhood density' becomes insignificant.
- This follows from the fact that the effects are highly correlated:



Pearson r = -0.94 (Exp 1)
-0.98 (Exp 2)

- The bar plot shows that there are two main groups of neighborhood densities, and that they coincide with the two values for 'Onset'.

7.2 Origin of asymmetry

- Let us assume, as hypothesized in section 5, that a dense neighborhood inhibits retroflex alternation.
- As can be seen in the correlation bar plot, words in /s-/ have a denser neighborhood than words in /sC-/.
- On average, then, words in /s-/ will have less retroflexion than words in /sC-/.
- So far, this is a property of individual words.
- Two factors indicate that such a state will not last:
    1) In production experiments, speakers generalize very quickly from the behavior of individual words to broad phonological classes (Wilson 2006, Nielsen 2008).
    2) As modeled in Wedel 2007, analogical errors will over time force word-specific behavior to give way to more general phonological patterns.
- The strong correlation between neighborhood density (*word-specific*) and onset (*phonology*) would therefore lead us to expect some generalization to occur from the former to the latter.

- As a result, ‘Onset’ might be a better predictor for retroflexion than ‘Neighborhood density’ because that is precisely the phonological generalization speakers have made.

7.3 Why not grammar all the way?

- If a grammatical factor is the best predictor for the asymmetry in retroflexion, then why posit an extra-grammatical origin for it?
- Traditionally, one would seek to account for the grammatical factor of onset in Norwegian by pointing to the fact that /s/~/ʂ/ commonly contrast in simple onsets, but rarely in complex onsets, by employing constraints on contrasts (cf. Flemming 2004).
- Despite the descriptive adequacy of this approach, grammatical behavior triggered by grammar itself is by necessity teleological, and therefore does not provide an explanation for its existence.
- Rooting grammatical patterns in observed effects of lexical processing provides a non-teleological account of their existence.

8. A final caveat

- The experiments reported here were designed to test the effect of the grammatical factor ‘Onset’.
- The effect of ‘Neighborhood density’ was simply tested on the already existing data.
- As a result, ‘Onset’ might be a better predictor than ‘Neighborhood density’ because the items were well balanced for the former, but not so well for the latter.
- A new experiment carefully designed to test the role of neighborhood density will hopefully reveal the true effect of this factor.

9. Conclusion

- Asymmetry in retroflexion of initial /s-/ is tied to the complexity of the onset.
- This effect is best predicted by a phonological factor that directly refers to the onset complexity of the word.
- The onset complexity is tightly correlated with neighborhood density, which is known to affect lexical processing.
- Errors in lexical processing due to the neighborhood effect are therefore posited as the origin of the asymmetry.
- Due to the correlation with onset complexity, this effect has been phonologically generalized to refer directly to the onset.

10. References

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