Variation in Norwegian retroflexion

Sverre Stausland Johnsen

A phonological process in Norwegian takes morpheme-initial alveolar /t d n s/ to retroflex [ʈ ɖ ɳ ʂ] after a morpheme ending in the tap /ɾ/, a process which earlier descriptions in the literature have classified as obligatory. This paper reports on production experiments with both existing and novel words, which show that Norwegian speakers treat retroflexion of morpheme-initial /s/ as optional, and that they are more likely to apply retroflexion to a morpheme in /s-/ when the /s/ is followed by a consonant (/sC-/) than when the /s/ is followed by a vowel (/sV-/).

Keywords Norwegian retroflexion, onset complexity, variation

Sverre Stausland Johnsen, Department of Linguistics and Scandinavian Studies, University of Oslo, Postboks 1102 Blindern, 0317 Oslo, Norway. stausland.johnsen@iln.uio.no

1. INTRODUCTION

A phonological process in Norwegian takes morpheme-initial alveolar /t d n s/ to retroflex [ʈ ɖ ɳ ʂ] after a morpheme ending in the tap /ɾ/, a process which earlier descriptions in the literature have classified as obligatory. This paper reports on production experiments with both existing and novel words, which show that Norwegian speakers treat retroflexion of morpheme-initial /s/ as optional, and that they are more likely to apply retroflexion to a morpheme in /s-/ when the /s/ is followed by a consonant (/sC-/) than when the /s/ is followed by a vowel (/sV-/).

The focus of this paper is to document a specific pattern of retroflexion in Norwegian. For a discussion of what the origin of this retroflexion pattern is, see Stausland Johnsen (2012).

2. NORWEGIAN RETROFLEXION

2.1 Norwegian

'Norwegian' is generally used as a cover term for varieties of North Germanic traditionally spoken within the borders of Norway. There are roughly five million speakers of Norwegian today. The only variety which will be examined in this

paper is the spoken variety used by most speakers in urbanized areas in South-East Norway (for a detailed overview of the phonological properties of this variety, see Kristoffersen 2000). All the Norwegian examples in this paper are based on the production and intuition of the author and his native consultants.

2.2 Retroflexion

Norwegian distinguishes two coronal categories in postvocalic position:

(1) NAME   TRANSCRIPTION   ARTICULATION[1]
    Alveolar   /t d n s/   Laminal alveolar coronal
    Retroflex   /ʈ ɖ ɳ ʂ/   Apical postalveolar coronal

The contrast between alveolars and retroflexes in postvocalic position is illustrated in (2):[2]

(2) /kɑt/   'cat'   /kɑʈ/   'unripe fruit'
    /nøːd/ 'need'   /nøːɖ/ 'nerd'
    /tʉːn/ 'yard'   /tʉːɳ/ 'gymnastics'
    /jœs/   'jeez'   /jœʂ/   'do intentionally'

A morpheme-final apical alveolar tap /ɾ/ deletes when the following morpheme begins with a consonant (Rykkvin 1946; Haugen 1948; Kristoffersen 2000:311ff.):[3]

(3) /ʋintər-føːrə/ → [ʋintəføːrə] 'winter condition'
    /ʋintər-jɑkə/   → [ʋintəjɑkə]   'winter coat'
    /ʋintər-kʉlə/   → [ʋintəkʉlə]   'winter cold'

If the second morpheme begins with an alveolar consonant /t d n s/, the tap /ɾ/ still deletes, as is shown in (3), but the alveolar surfaces as a retroflex [ʈ ɖ ɳ ʂ]:[4]

(4) /ʋintər-tiː/   → [ʋintəʈiː]   'winter time'
    /ʋintər-dɑː/   → [ʋintəɖɑː]   'winter day'
    /ʋintər-nɑt/   → [ʋintəɳɑt]   'winter night'
    /ʋintər-sœʋn/   → [ʋintəʂœʋn] 'winter sleep'

This retroflexion process across morpheme boundaries also takes place when the morpheme boundary is a word boundary. The sentence in (5), for example, will surface with deletion of /ɾ/ before words beginning with a consonant, and with retroflexion of that consonant if it is an alveolar.

(5) /deː æːr ʋintər nɔr dʉː seːr snøː/ → [dɛæʋintəɳɔdʉseːʂɳøː]
    it   is   winter when you see snow

As in Kristoffersen (2000:96f., 316), the discussion in this paper will focus on retroflexion within nominal compounds like those in (4).

3. VARIATION IN NORWEGIAN RETROFLEXION

Previous literature on Norwegian retroflexion describes the retroflexion process as obligatory, absent only when there is a significant intonational or pausal boundary between the morphemes (Eliasson 1986:282; Kristoffersen 2000:316f.; Torp 2007:70). As Kristoffersen puts it, the retroflexion process 'seems to be beyond speakers' active control' (2000:317). This description is generally correct, as retroflexion seems to be obligatory when a morpheme beginning in an alveolar /t d n/ follows a morpheme ending in the tap /ɾ/:[5]

(6) /ʋintər-tiː/ → [ʋintəʈiː]   *[ʋintətiː] 'winter time'
    /ʋintər-dɑː/ → [ʋintəɖɑː]   *[ʋintədɑː] 'winter day'
    /ʋintər-nɑt/ → [ʋintəɳɑt]   *[ʋintənɑt] 'winter night'

On the other hand, when the morpheme begins with an alveolar sibilant /s/, retroflexion seems to be entirely optional:

(7) /ʋintər-sœʋn/ → [ʋintəʂœʋn] ~ [ʋintəsœʋn] 'winter sleep'

Although retroflexion of words in /s-/ is optional, some words in /s-/ appear to undergo retroflexion more readily than others. One factor that seems to contribute to the likelihood of words in /s-/ undergoing retroflexion is what the segment following the /s/ is. Specifically, when the following segment is a consonant, retroflexion to [ʂ] is generally preferred, but when the /s/ is followed by a vowel, retroflexion to [ʂ] is generally not preferred. In (8), the preferred output is indicated with a check mark ✓:

(8) /ʋintər-skuː/ → ✓ [ʋintəʂkuː] ~   [ʋintəskuː] 'winter shoe'
    /ʋintər-suːɽ/ →   [ʋintəʂuːɽ] ~ ✓ [ʋintəsuːɽ] 'winter sun'

Another way to characterize the pattern described above is that retroflexion is more common in complex onsets (when there is more than one consonant at the beginning of the word, i.e. a cluster /sC-/) than in simple onsets (when there is only one consonant, the /s-/). I will therefore refer to the distinction noted in (8) as 'complex onset' vs. 'simple onset'.

4. ONSET COMPLEXITY IN PHONOLOGY

From the pattern noted in Section 3 above, a natural hypothesis would be that the phonological grammar of Norwegian makes direct reference to the onset complexity of words in /s-/, such that retroflexion is applied more often to complex onsets than to simple onsets. This section will briefly illustrate that phonology often makes reference to the onset complexity of morphemes. As a

result, hypothesizing the same for Norwegian should not be considered an unusual approach.

4.1 Onset complexity in Italian

The masculine singular determiner in Italian is /il/ or /lo/ before a noun beginning with a consonant. When this noun has a simple onset in /sV-/, the determiner is /il/, but when the noun has a complex onset in /sC-/, the determiner is /lo/ (Dardano & Trifone 1997:151; Maiden & Robustelli 2007:61):

(9) /il sole/ 'the sun' /lo spekkjo/ 'the mirror'

4.2 Onset complexity in Vedic Sanskrit

Vedic Sanskrit verbs reduplicate their onsets in the perfect tense forms. When the verbal root has a simple onset /sV-/, the consonant /s/ is copied in the reduplicated syllable. The same holds for any simple onset in /CV-/:

(10) ROOT   PERFECT PASSIVE PARTICIPLE
       su-   'press'   *su-ṣv-āṇá-*
       śuc-   'gleam'   *śu-śuc-āná-*
       dā-   'give'   *da-dā-ná-*

When the verbal root has a complex onset in /sC-/, only one of the consonants is copied in the reduplicated syllable, either the /s/ or the following /C/:[6]

(11) ROOT   PERFECT PASSIVE PARTICIPLE
       smi-   'smile'   *si-ṣmiy-āṇá-*
       sthā-   'stand'   *ta-sthā-ná-*

5. EVIDENCE FOR RETROFLEXION IN SIMPLE AND COMPLEX ONSETS

The examples in Section 3 indicate that retroflexion is applied more often to complex /s/-onsets than to simple /s/-onsets. Ideally we want confirmation of this claim from a large body of Norwegian data. Retroflexion is, however, never marked in spelling, and this excludes the use of written corpora. Additionally, there are to date no spoken Norwegian corpora where retroflexion is marked in the transcription, which makes the use of existing spoken corpora less practical. For these reasons, data was elicited directly from Norwegian speakers during a reading task. This experiment and its results are presented in the following section.

Target items			Filler items		
Spelling	Phonemic	Meaning	Spelling	Phonemic	Meaning
<sak>	/sɑːk/	'case'	<dag>	/dɑːg/	'day'
<seng>	/sɛŋ/	'bed'	<kamp>	/kɑmp/	'match'
<sol>	/suːɽ/	'sun'	<navn>	/nɑʋn/	'name'
<sønn>	/sœn/	'son'	<par>	/pɑ(ː)r/	'pair'
<syn>	/syːn/	'vision'	<tre>	/treː/	'tree'
<stat>	/stɑːt/	'state'			
<sted>	/steː/	'place'			
<stein>	/stæjn/	'stone'			
<stoff>	/stɔf/	'material'			
<stund>	/stʉn/	'while'			

Table 1. Experiment A stimuli.

6. EXPERIMENT A: REAL WORDS

6.1 Participants

Ten native speakers of Norwegian with a mean age of 30 years participated in the experiment, six male and four female. Three speakers were visiting students in the Boston area, and the remaining seven speakers participated from their location in Norway.

6.2 Stimuli

The five most frequent monosyllabic nouns in /st-/ and the five most frequent monosyllabic nouns in /sV-/ were chosen as the stimuli. All ten nouns are among the 15 most frequent monosyllabic nouns in /s-/ in the LBK corpus.[7] The onset /st-/ was chosen as the complex onset because it is the most frequent complex /s/-onset in Norwegian. The stimulus set also contained five filler items, which are high-frequency monosyllabic nouns beginning in a consonant other than /s-/. The stimuli are listed in Table 1.

All ten nouns were placed in nominal compounds with a nonce first element <bemmer>, which unambiguously represents /bɛmər/, ending in the retroflex triggering tap /ɾ/. All stimuli were presented to participants in their orthographic representations.

6.3 Procedure

The nominal compounds containing the stimuli each appeared six times within a short frame story, which the participants were instructed to read in a normal, casual manner. The internal order of the frame stories was randomized within participants.
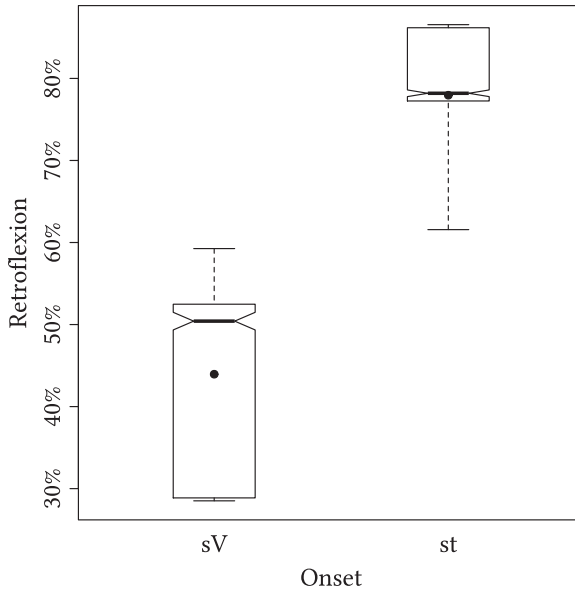
Figure 1. Retroflexion for real words in /s-/.

The participants' productions were digitally recorded. See the appendix for more details.

6.4 Labeling

All recorded tokens of the stimuli were labeled as retroflex or non-retroflex independently by the author and by a phonetically trained linguist who is a native speaker of Norwegian, and who was kept unaware of the purpose and design of the experiment.[8] Only tokens that were labeled identically by both were included in the analysis. Of the total of 2423 tokens recorded, seven were excluded due to erroneous and disfluent production, and eight were excluded due to disagreement between the two taggers. In the end, 2408 trials were submitted for analysis.

6.5 Results

Retroflexion was variably applied to every stimulus word in /s-/. None of these words underwent retroflexion 100% of the time, and none of them consistently escaped retroflexion. The optionality of retroflexion for /s/ is thereby confirmed. As can be seen in Figure 1, retroflexion is considerably more frequent for words in /st-/ than for words in /sV-/, with a mean retroflexion rate of 78% for words in /st-/ and a mean retroflexion rate of 44% for words in /sV-/. A mixed effects logistic regression model

confirms that the difference between /sV-/ and /st-/ is significant ($\chi^2(6) = 230.95$, $p < .0001$). See the appendix for more details.

7. PHONOLOGICAL PRODUCTIVITY

The results reported above in Section 6.5 confirm that retroflexion of /s/ is optional and more common in complex onsets than in simple onsets. These results were obtained using highly familiar words of Norwegian. The possibility always exists that a phonological pattern observed in existing words is there only because these words have been inherited from an older stage of the language when some phonological process was applied to yield that pattern. Put differently, it is not always clear from the behavior of existing words whether this behavior is caused by productive operations in the language or by the inherited properties of these words.

This conundrum can be illustrated with the Norwegian palatalization rule. In Middle Norwegian, /k/ was palatalized before front vowels (Indrebø 1951:230f.). In modern Norwegian, this palatalization product appears as /ɕ/ (Endresen 1991:75f.). From the palatalization rule in Middle Norwegian, there are no native words in modern Norwegian dialects with /k/ before original front vowels, and there is a range of words with a /k/–/ɕ/ alternation between morphologically related forms, as illustrated with a few examples in (12) below:[9]

(12) [k]amb 'comb' (n.)   [ɕ]emba 'comb' (v.)
      [k]oma 'come' (inf.) [ɕ]em   'comes' (pres.)
      [k]u   'cow' (sg.)   [ɕ]yr   'cows' (pl.)
      [k]åt   'happy'   [ɕ]æta   'happiness'

It has not been uncommon to conclude from such examples that there is a productive palatalization process in Norwegian which takes an underlying /k/ to a surface realization [ɕ] before front vowels (Fretheim 1969:87f.; Hovdhaugen 1969/1971:152; Weinstock 1970:586; Standwell 1975:346f.). At the same time, however, it is clear that newer loanwords never undergo palatalization, as seen in (13):

(13) /kidnɑpə/ 'kidnap'   /kiːs/   'man'
      /kymrisk/ 'Welsh'   /kyːprus/ 'Cyprus'
      /kɛɭnər/   'waiter'   /keːbɑb/   'kebab'
      /kœjə/   'hammock'   /køː/   'queue'
      /kæps/   'baseball cap'   /kæjsər/   'emperor'

From the data in (12) and (13) we can conclude that there is no phonologically active palatalization rule in Norwegian (Kristoffersen 2000:112), and that the frequently observed /k/–/ɕ/ alternation is just a lexical property of inherited words.

In the case at hand, we want to be certain that Norwegian speakers apply retroflexion more often to complex /s/-onsets due to a productive phonological

Target items		Filler items	
Spelling	Phonemic	Spelling	Phonemic
<sa>	/sɑː/	<bi>	/biː/
<so>	/suː/	<di>	/diː/
<su>	/sʉː/	<krå>	/kɾɔː/
<sta>	/stɑː/	<my>	/myː/
<sto>	/stuː/	<po>	/puː/
<stu>	/stʉː/	<trå>	/tɾɔː/
<ska>	/skɑː/		
<skå>	/skɔː/		
<sku>	/skʉː/		

Table 2. Experiment B stimuli.

process, and not solely due to the inherited properties of existing words. Since Berko (1958), the standard method applied to identify productive phonological processes has been to investigate whether speakers apply these processes to novel native-like words made up for the experiment. For these reasons, an experiment with nonce Norwegian words in /s-/ was designed. This experiment and its results are reported in the next section.

8. EXPERIMENT B: NONCE WORDS

8.1 Participants

The participants in Experiment B were the same ten native speakers of Norwegian as those in Experiment A.

8.2 Stimuli

Three monosyllabic nouns in /sV/, three monosyllabic nouns in /st-/, and three monosyllabic nouns in /sk-/ were created as stimuli. All words are novel nouns with native-like phonotactics. The onsets /st-/ and /sk-/ were chosen as complex onsets because these are the two most frequent complex /s/-onsets in Norwegian. The stimulus set also contained six filler items, which were novel native-like monosyllabic nouns beginning with a consonant other than /s-/. The stimuli are listed in Table 2.

All nine nouns were placed in nominal compounds with a first element <sommer> /sɔmər/ 'summer', ending in the retroflex triggering tap /ɾ/. The procedure was otherwise identical to that in Experiment A, and the participants' productions were digitally recorded.
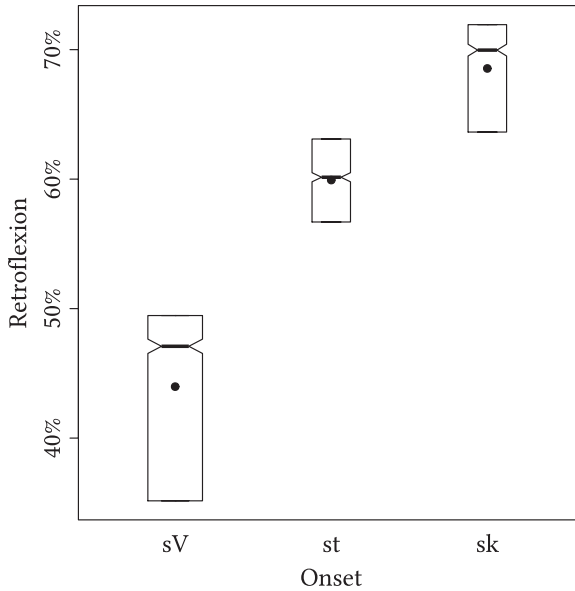
Figure 2. **Retroflexion for nonce words in /s-/.**

8.3 Labeling

All recorded tokens of the stimuli were labeled as in Experiment A. Of the total of 3395 tokens recorded, 17 were excluded due to erroneous and disfluent production, and 38 were excluded due to disagreement between the two taggers. In the end, 3340 trials were submitted for analysis.

8.4 Results

Retroflexion was variably applied to every stimulus word in /s-/, with the retroflexion rate for individual words varying between 35% and 72%. This confirms the finding from Experiment A that retroflexion of /s/ is optional. As seen in Figure 2, retroflexion is less common for words with a simple onset /sV/ than for words with a complex onset /sC/, as in Experiment A, with a mean retroflexion rate of 44% for words in /sV/ and a mean retroflexion rate of 64% for words in /sC-/. Additionally, there is less retroflexion for words with a complex onset /st-/ (mean 60%) than for words with a complex onset /sk-/ (mean 69%). Mixed effects logistic regression models confirm that all observed differences between /sV/, /st/, and /sk/ are significant (14).

(14) ONSET   CHI-SQUARE p
      /sV/ vs. /st/ $\chi^2(3) = 149.46$ $< .0001$ ***
                  /sk/ $\chi^2(1) = 118.59$ $< .0001$ ***
      /st/ vs. /sk/ $\chi^2(1) = 8.58$ $< .01$ **

9. RETROFLEXION OF ALVEOLAR STOPS AND NASALS

According to the native intuition of the present author and his consultants, retroflexion is obligatorily applied to morphemes beginning in alveolar /t d n/ (see Section 3 above). As a quick 'sanity check' that this intuition corresponds well with actual linguistic production, the filler items with a simple alveolar stop and nasal onset from both experiments were also labelled as retroflex or non-retroflex. The retroflexion rate for these items is reported in (15) below.

(15) WORD   ITEM   RETROFLEXION RATE n
      Real   /nɑʊn/   100% $= 235$
      Real   /dɑːg/   98% $= 223$
      Nonce   /diː/   95% $= 276$

In contrast to the items in /s-/, the morphemes beginning in alveolar stops and nasals undergo retroflexion close to 100% of the time, thereby supporting the intuition that these alveolars are required to undergo retroflexion.

10. CONCLUSION

Figures 1 and 2 reveal that real and nonce words behave alike when it comes to retroflexion of words in /s-/, in that both experiments show that retroflexion of /s/ is optional and more likely to apply before a consonant than before a vowel. Experiment B also shows that retroflexion is more likely to apply when this consonant is /k/ than when the consonant is /t/. From this the conclusion can be drawn that the phonological grammar of Norwegian makes direct reference to the phonological makeup of the /s/-onset when it determines whether or not to apply retroflexion to such words.

Combining the patterns of variability in /s/-retroflexion with the (near) obligatory retroflexion applied to words in /t-/, /d-/, and /n-/ (see Sections 3 and 9 above), we can set up the following descriptive hierarchy for the probability of retroflexion to alveolar onsets:

(16) /t/, /d/, /n/ > /sk/ > /st/ > /sV/

The hierarchy in (16) illustrates the fact that the retroflexion rate is the highest for onsets in /t-/, /d-/, /n-/, followed by a lower retroflexion rate for /sk-/, and so on.

The aim of this article has been to support the hypothesis that retroflexion of /s/ is optional in Norwegian, and that the variability of /s/-retroflexion largely depends on the segment following the /s/. A question which therefore lies outside the scope of this article is where the retroflexion pattern in (16) comes from. This question is the focus of Stausland Johnsen (2012), where a perceptual experiment reveals that the perceived distance between an alveolar and a retroflex is inversely related to the retroflexion hierarchy in (16). In other words, the perceived distances between alveolar [t d n] and retroflex [ʈ ɖ ɳ] are the smallest, and the perceived distance between alveolar [s] and retroflex [ʂ] before a vowel is the largest. For a fuller discussion of how this correlation between perception and phonology can best be explained, the reader is referred to Stausland Johnsen (2012).

ACKNOWLEDGMENTS

APPENDIX

The frame story in Experiment A was written in such a way that it gave no semantic content to the first element of the nominal compound, the nonce word <bemmer>. This was to prevent the possibility that the semantic and pragmatic plausibility of the compound could affect the likelihood of retroflexion. To ensure that the participants treated the words in /s-/ as the intended high-frequency nouns (and not as coincidental homonyms), each frame story was introduced with an illustration of the /s/-word appearing in that frame story, as seen in Figure A1.
The Norwegian text in Figure A1 translates into English as follows:

> In Wonderland there is a wizard named Bogo. With his magic, he can create whatever he pleases from absolutely nothing. Bogo wants to create a new *sol* made from *bemmer*. He is thinking about how to go about creating a *bemmersol*, a very nice *bemmersol* at that. Bogo creates a *bemmersol* by saying 'Puff! Come, *bemmersol*!'. Now Bogo has a *bemmersol*, and he is very happy that he has acquired a *bemmersol*.

The frame story in Experiment B gave no semantic content to the nominal compound other than being an object suitable for use during the summer (Figure A2). Although some of the phonetic strings functioning as novel nouns in this experiment appear elsewhere in the language as verbal forms (e.g. /sɑː/ is the preterite of /siː/

I Eventyrland sitter trollmannen Bogo. Med magien sin kan han lage seg akkurat hva han vil ha ut av

absolutt ingenting.

Ei sol
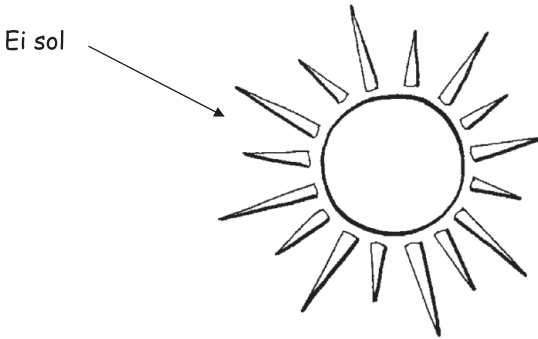
Bogo vil konstruere ei ny sol laga av bemmer. Han tenker på åssen han skal få laga ei bemmersol, ei

veldig fin bemmersol. Bogo lager ei bemmersol ved å si "Poff! Kom, bemmersol!". Nå har Bogo ei

bemmersol, og han er veldig glad for at han har fått seg ei bemmersol.

Figure A1. Experiment A trial.

Om sommer'n er det perfekt å bruke et su, så i mai går jeg ut i garasjen og henter sommersuet mitt. Det

er et nydelig sommersu, nesten like fint som det sommersuet bestemora mi hadde. Jeg setter

sommersuet i hagen. Jeg laga sommersuet sjøl for mange år sida. Det er ikke lett å lage sommersu, men

det er det beste sommersuet jeg har hatt.

Figure A2. Experiment B trial.

'say'), the frame story immediately introduced these words as representations of tangible objects.

The Norwegian text in Figure A2 translates into English as follows:

It's great to use a *su* in the summer, so when May comes, I go and get my *summersu* from the garage. It's a wonderful *summersu*, almost as nice as the *summersu* that my grandma had. I put the *summersu* in the back yard. I made the *summersu* myself many years ago. It's not easy to make a *summersu*, but it's the best *summersu* I've ever had.

The three participants in the Boston area read the frame stories from printed copies, whereas the seven participants in Norway read from their own computer monitors.

All participants were instructed to read each page with frame stories four times before proceeding to the next page. A pilot study revealed that speakers often produce careful speech at the beginning of a reading task, at which register retroflexion is almost always absent. Since such speech is of no interest in this study, each participant's production up until the first instance of applied retroflexion was treated as a warm-up to the experiment, and the frame stories contained in the warm-up were then repeated at the end of the experiment.

The productions from two participants were recorded in mono using a KSM27 Shure microphone in a sound-attenuated booth. The signal was amplified through an M-AUDIO Firewire 410 amplifier and recorded digitally with Audacity software (Audacity Team 2006) in .wav format at a sampling rate of 44.100 Hz on an iMac7,1 Macintosh computer. One participant was recorded in mono in a quiet room using an MXL M.A.R.K. microphone, and the signal was recorded digitally with a PMD660 Professional Marantz recorder in .wav format at a sampling rate of 44.100 Hz. Seven participants were recorded in mono in quiet locations with the Voice over Internet Protocol software Skype 4.0 (*Skype* 2003–2009) and Skype Call Recorder 0.7 (Nikiforov 2009) in .mp3 format at a bit rate of 128.000 bit/s and a sampling rate of 44.100 Hz.

In the mixed effects logistic regression models, the dependent variable is the presence or absence of retroflexion for each item produced by a participant. The independent variable of interest here is Onset, which classifies the stimulus items as having an onset in /sV-/, /st-/, or /sk-/. Other independent variables code for vowel features of the stimuli, the position of the stimuli within the frame story, the position of the frame story within the experiment, and, for the real words in Experiment A, the lexical frequency of the stimulus words in the LBK corpus (see Note 7). The models were fitted with the *glmer()* function from the *lme4* package (Bates, Maechler & Bolker 2012) in R (R Core Team 2012), with random intercepts for words and participants (Baayen, Davidson & Bates 2008), using the method of backward elimination (Draper & Smith 1998:339f.; Faraway 2005:131f.). Under this approach, an initial model with all variables and their interactions is built, and then the least significant term is removed from the model, as diagnosed by the *dropterm()* function from the *MASS* package (Venables & Ripley 2002). A model without this term is fitted, and this reduction continues until no insignificant terms remain. The significance of the variable Onset is determined by a likelihood ratio test (Hilbe 2009:81f.). Separate models were built for each of the three comparisons reported in Experiment B.

NOTES

1. For articulatory studies of these segments, see Foldvik 1988a, b; Simonsen & Moen 2004; Simonsen, Moen & Cowen 2008; Moen & Simonsen 2011.

2. It was not uncommon in the 1960s and 1970s to analyze morpheme-internal retroflexes as derived from underlying consonant sequences (see e.g. Hovdhaugen 1969/1971:147; Endresen 1974:75, a view that is less common today (see Kristoffersen 2000:88f.; Stausland Johnsen 2012:127). The difference between these two approaches has no bearing on the discussion in this paper.

3. For articulatory studies of the tap, see Foldvik (1974, 1977); Moen et al. (2003); Knutsen (2006).

4. This retroflexion process was first described by Brekke (1881:18ff.); Storm (1884:96f.); Western (1889:275). See Kristoffersen (2000:96f.) for a recent description.

5. In some marginal cases, retroflexion can be absent when several conditions are met: (i) the word ending in /-ɾ/ is unstressed; (ii) the tap /ɾ/ is in an unstressed grammatical suffix; and (iii) the sequence /ɾ + alveolar/ is in a high-frequency collocation. One such example that appears in the corpus study by Olsen (2011) is /ˈtrædʊə kruːnər ˈtiːmən/ → [ˈtrædʊə kruːnə ˈtiːmən] 'thirty kroners an hour', where /kruːnər/ 'crown-PL' is unstressed and with /-ɾ/ as the plural suffix. Since this paper only deals with nominal compounds, the /-ɾ/ will in our cases always be part of the stem.

6. For the formation of these perfect tense forms, see Whitney (1889:222f.); Macdonell (1910:363f.). Other phonological changes also apply to the forms illustrated in (10) and (11): the *s* becomes a *ṣ* after high vowels *i* and *u*, high vowels *i* and *u* become glides (*i*)*y* and (*u*)*v* before another vowel, and the aspirated stop *th* dissimilates to *t* when there is another aspirated stop in the onset of the next syllable (Whitney 1889:44, 61; Macdonell 1910:23). These changes are not relevant to the discussion here.

7. Lexicographic corpus for Norwegian Bokmål: http://www.hf.uio.no/iln/tjenester/kunnskap/sprak/korpus/skriftsprakskorpus/lbk/.

8. All tokens with an alveolar realization were labeled 'non-retroflex', irrespective of whether the underlying /ɾ/ had been completely deleted (e.g. [bɛməsɑːk]) or articulatorily reduced (e.g. [bɛməˠsɑːk]). This was mainly for practical purposes, as it proved difficult to distinguish /ɾ/-deletion from /ɾ/-reduction, a problem previously pointed out by Haugen (1948:121). Since this paper focuses on the application of retroflexion and not on the magnitude of reduction to the /ɾ/, any acoustic or articulatory study of /ɾ/-reduction must be left for future research.

9. The orthography in these examples follows the landsmål standard, which is based on the modern Norwegian dialects (Aasen 1873). The bracketed phonetic transcriptions are based on the spoken Norwegian variety treated in this paper (see Section 2.1).

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