

## The role of the vowel context in the differentiation of French /sʃ/ and /ʃs/ sequences

Oliver Niebuhr, Christine Meunier, Leonardo Lancia

Laboratoire Parole & Langage, CNRS UMR 6057, Université de Provence, Aix-en-Provence

It is well known for English and German that alveolar sibilants can be adjusted to the place to articulation of following postalveolar ones across word boundaries. For example, realizations of /sʃ/ in the word pairs “nice shoes” or “das Schaaf” (‘the sheep’) can approximate a single [ʃ:] sound. This phenomenon may be conceptualized as a process of regressive place assimilation. It is gradual rather than categorical. So, while it is possible that the process creates an output for /sʃ/ which is confusable with the phonetic manifestation of a sequence of two postalveolar sibilants (i.e. /ʃʃ/), it can also result in temporally and spectrally intermediate patterns. Recently, Niebuhr et al. (2008) found the same kind of post-lexical, gradual place assimilation towards postalveolar in the sibilant sequences of French. However, different from English and German, this process does not only occur regressively, but also progressively. For example, the /sʃ/ and /ʃs/ sequences in “couches sous” (‘sleep under’) and “classe chargée” (‘crowded class’) can both become similar to or even converge in a single [ʃ:] sound with regard to both temporal and spectral patterns. So, French sibilant sequences may not only allow for the possibility that a mixed sequence with an alveolar and a postalveolar sibilant is confused with a solely postalveolar sequence as in English and German. Single [ʃ:] sounds can further represent two different kinds of mixed sequences, /sʃ/ and /ʃs/.

However, to what extent does this phonetic ambiguity pose a problem for the listener? Apart from higher-level semantic effects in speech perception (e.g., Ganong 1980), it is important to note that the ambiguity refers to the sibilant section itself. It is well known from a number of studies that phonological processes like assimilation and elision leave phonetic traces in the surrounding sounds. In German, for example, the elision of a /t/ results in a fronting of an adjacent /k/, and the elision of the palatal syllable “-lich” in the word “eigentlich” causes a lengthening and fronting of the phonetically similar glide in the initial diphthong /aɪ/ of “ei-“ (Kohler 1976; Niebuhr 2008). Nolan (1992) found for English that word-final /d/s which were completely assimilated to following word-initial /g/s (in terms of EPG patterns) were still identified as /d/s by his subjects. He ascribed this effect to differences in the preceding vowel. Starting from this interesting observation, which was not further pursued so far, the present study investigates whether the vowels preceding the assimilated /sʃ/ and /ʃs/ sibilant sequences in French show differences in phonetic details that can be used by listeners to identify the even those following sibilant sequences as /sʃ/ or /ʃs/ that are ambiguously realized as [ʃ:].

The study is based on a set of pseudo names that consist of pairs of monosyllabic first and last names with a CVC.CVC structure. The /sʃ/ and /ʃs/ sequences are formed across the boundary of the first and last name (C.C), and they are framed by the symmetrical vowel contexts /a\_a/, /i\_i/, and /u\_u/. The vowel contexts start with and end in voiced labial consonants. The resulting names are embedded into the constant sentence frame “J’ai vu \_\_ hier” (‘I’ve seen \_\_ yesterday’). The test sentences were repeated five times in a randomized order and read in an informal fashion as fast as possible by 5 female native speakers of French. An acoustic analysis of /sʃ/ and /ʃs/ yielded significant differences neither in the overall duration nor in centre-of-gravity values, i.e. the sibilant sequences were all comparably realized as [ʃ:]. At the same time, however, the vowels preceding /ʃs/ were produced significantly longer, breathier, softer, and with a more peripheral quality, compared with the ones preceding /sʃ/ (cf. Figure 1-4). Furthermore, we have first evidence from initial perceptual testing that the subjects are able to use these phonetic details to identify the sibilant sequences as /sʃ/ or /ʃs/. Overall, the acoustic and perceptual findings underline that assimilation is more adequately described as a (gradual) process that does not lead to a local substitution, but to a global (temporal) re-organization of distinctive features and that hence does not necessarily lower the information value of the speech code.

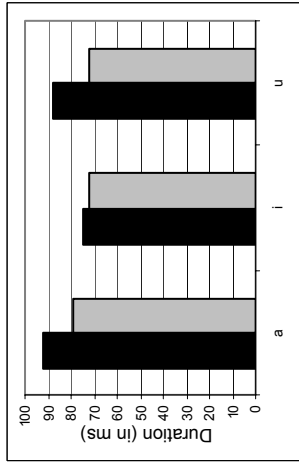


Figure 1. Average durations across all 5 speakers (n=20) of the /a/ (left), /i/ (middle), and /u/ (right) vowels that preceded the /sʃ/ and /ʃs/ sibilant sequences (grey and black bars, in ms). Across all speakers and vowel contexts, a t test yielded that the vowels before /ʃs/ are significantly longer than the vowels before /sʃ/.

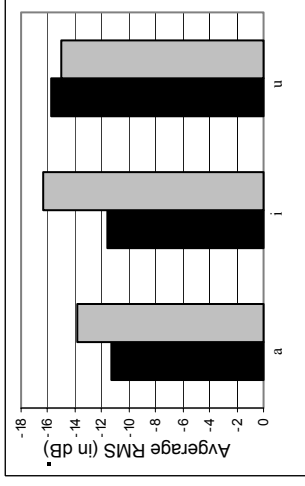


Figure 2. Average acoustic energy (root mean square, RMS in dB) across all 5 speakers (n=20) of the /a/ (left), /i/ (middle), and /u/ (right) vowels that preceded the /sʃ/ and /ʃs/ sibilant sequences (grey and black bars). Across all speakers and vowel contexts, a t test yielded that the vowels before /sʃ/ have a significantly higher average RMS (i.e. they are louder) than the vowels before /ʃs/.

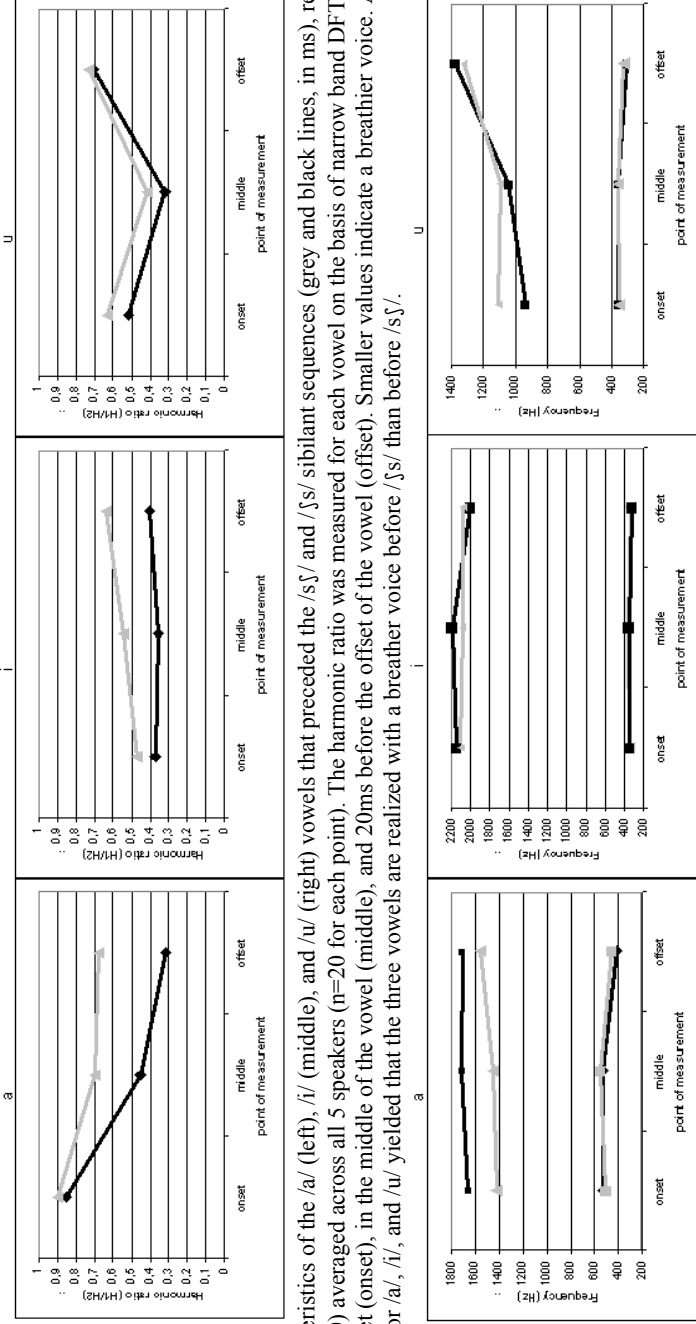


Figure 3. Voice quality characteristics of the /a/ (left), /i/ (middle), and /u/ (right) vowels that preceded the /sʃ/ and /ʃs/ sibilant sequences (grey and black lines, in ms), represented by the harmonic ratio H1/H2 (cf. Klatt and Klatt 1990) averaged across all 5 speakers (n=20 for each point). The harmonic ratio was measured for each vowel on the basis of narrow band DFT spectrograms at three points in time: 20ms after the vowel onset (onset), in the middle of the vowel (middle), and 20ms before the offset of the vowel (offset). Smaller values indicate a breathier voice. Across all speakers and all points in time, separate t tests for /a/, /i/, and /u/ yielded that the three vowels are realized with a breathier voice before /ʃs/ than before /sʃ/.

Figure 4. F1 and F2 formant patterns (in Hz) of the /a/ (left), /i/ (middle), and /u/ (right) vowels that preceded the /sʃ/ and /ʃs/ sibilant sequences (grey and black lines, in ms), averaged across all 5 speakers (i.e. n=20 for each point). The formant values were measured for each vowel on the basis of broadband LPC spectrograms at three points in time: 20ms after the vowel onset (onset), in the middle of the vowel (middle), and 20ms before the offset of the vowel (offset). Across all speakers and all points in time, separate t tests for /a/, /i/, and /u/ revealed differences in the F2 levels that are higher for /a/ and /i/ and lower for /u/ before /ʃs/.

## References

Ganong W. (1980). Phonetic categorization in auditory word perception. *Journal of Experimental Psychology* 6, 110-125.

Klatt, D.H. and Klatt, L.C. (1990). Analysis, synthesis, and perception of voice quality variations among female and male talkers. *JASA* 87, 820-857.

Kohler, K.J. (1976). Die Instabilität wortfinaler Alveolarplosive im Deutschen: eine elektropalatographische Untersuchung. *Phonetica* 33, 1-30.

Niebuhr, O., Lancia, L., Meunier, Ch. (2008). On place assimilation in French sibilant sequences. *Proceedings of the 8th ISSP, Strasbourg, France*, 221-224.

Niebuhr, O. (2008). Identification of highly reduced words by differential segmental lengthening. *Talk given at the first Nijmegen speech reduction workshop, Nijmegen, The Netherlands.*  
<http://www.ipds.uni-kiel.de/on/>

Nolan, F. (1992). The descriptive role of segments: evidence from assimilation. In D.R. Ladd & G.J. Docherty (Eds.) *Papers in Laboratory Phonology 2* (pp. 261–280). Cambridge: CUP.