# Realizations of French voiced fricatives by German learners as a function of speaker level and prosodic boundaries

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## ABSTRACT

We analyzed the realizations of French voiced fricatives /z,ʒ/ by German learners of French as a function of learners' levels and prosodic boundaries. Fricatives are embedded in sentences and appear in final position of an accentual group, but not in sentence final position. Results showed that the performance of the speakers is linked to the way they realized boundaries. In particular, we observe that advanced speakers preferred to realize no pause after the fricatives, and that, in this intervocalic context, these speakers produced more voiced fricatives than beginners.

**Keywords**: Phonetic transfer, fricatives, voicing neutralization, prosodic boundaries, German/French.

## 1. INTRODUCTION

We investigate a typical example of L1-L2 interference concerning the realization of the French voiced fricatives /z, ʒ / in final position by German learners of French. In German, the opposition between voiced and unvoiced obstruents (fricatives and stops) is neutralized in final position in favour of the realization of unvoiced consonants [1], whereas in French the voicing feature is distinctive in final position. As an example, the German word "Motiv" (motive) is pronounced /motif/. This difference between both systems is known to be a source of error for German speakers, who tend to produce unvoiced obstruents in final position when speaking French instead of the expected voiced consonants. Of course, German non-native realizations should be highly dependent upon speaker level, and we expect advanced speakers to make more « French-like » realizations than beginners. But other factors should also be taken into account to explain speakers' realizations. Indeed, in languages with voicing neutralization in final position, neutralization appears to be often incomplete [2] and the extent of this phenomenon (the incomplete neutralization) was found to be dependent on sentence position, phonetic environment, orthography and speaking styles, among other factors (see Kleber et al [3] for a review). Kuzla *et al* [4] also showed prosodic effects on the duration and amount of glottal vibration in German word-initial fricatives /f,v, z/ in assimilatory and non-assimilatory devoicing contexts

In this study, we analyzed the realizations of voiced fricatives which are embedded in sentences and appear in final position of an accentual group but not at sentence final position. We paid a special attention to the way speakers realized the boundary at the vicinity of the fricative and discussed the links between the boundary type, fricative voicing and speaker level. A pilot study on a preliminary version of the IFCASL corpus was realized for the consonant /ʒ/ in sentence final position [5].

The voicing feature, which makes a phonological contrast between obstruents sharing identical features but the voicing one (i.e. /f-v/, /s-z/, /ʃ-ʒ/, for fricatives) does not rely only upon the presence or absence of voicing –the articulatory phenomenon corresponding to vocal fold vibration and generating periodicity in the acoustic signals. Other articulatory correlates, such as articulatory strength (associated to the fortis/lenis distinction, and very important in German stop production), play also a role in the categorization of both kind of consonants [6].

Many acoustic cues are associated to the voicing contrast [7] [8]. We chose to begin this study with the analysis of the periodicity of the signal during the production of the fricatives, i.e. the acoustic cue corresponding to the vibration of the focal folds (that is voicing, with the articulatory acceptation of the term). Other cues, such as the duration of the preceding vowel –difficult to interpret here since it codes both the end of an accentual group and the voicing feature- and intensity will be the object of a next study. As native and non-native speakers recorded the sentences, German realizations has been systematically compared to French ones.

## 2. EXPERIMENTAL PROTOCOL

### 2.1. Corpus

We extracted a set of French sentences containing fricatives in final position of a group of words (an accentual group, in French) from a bilingual corpus which was recorded by French learners of German and German learners of French in their native and second languages [9]. This corpus has been built under the framework of the IFACSL ANR project (www.ifcasl.org), and was devoted to the analysis of French/German phonetic interferences.

The subjects read the sentences in a quiet room from the screen of a Windows laptop, with a headset microphone (AKG C520) connected to an Audiobox (M Audio Fast track). The gain was automatically controlled during the recording session. Subjects could listen to their recordings after each sentence and decide whether or not they wanted to pronounce again the sentence. Fourty German learners of French and fourty French speakers recorded the corpus. The non-native speakers were classified by German teachers of French in three categories: beginners, intermediate and advanced, corresponding to A, B and C levels, respectively.There was 15 beginners, 14 intermediate speakers than 12 advanced ones.

We analyzed the fricatives /z/ and /ʒ/ embedded in sentences. There was one sentence per fricative, and each sentence was uttered once by each speaker. Both sentences were made up of three noun phrases and a verb phrase in that order: NP1 VP NP2 NP3, where NP1 was a subject, NP2 a direct object and NP3 an adverbial phrase beginning with a preposition. The fricative was at the end of the last word of NP2, preceded by the vowel /a/ and the preposition (i.e. the word following the fricative) always began with the vowel /a/. The first sentence was “Mon ami a perdu ses bag**ages à** la gare” (My friend lost his luggage at the railway station), and the second one “Les élèves doivent cocher la bonne c**ase a**vec un feutre” (Pupils had to tick the right case with a felt pen) . The standard pronunciation for the fricative /ʒ/ and its context is either /aʒa/, /aʒ#a/, or, although less frequent, /aʒə#a/ (same sequences for /z/). There was one repetition of each sentence by each speaker, which gives a total number of 160 sentences.

### 2.2. Segmentation

The vowel preceding the fricative, the fricative in final position, the first vowel (/a/) of the following word, as well as all the possible phonetic events between the fricative and the following word have been segmented manually with Praat by the author.

We observed the following possible events: a schwa [ə], a silence [#], a glottal stop [ʔ], aspiration [h], as well as the presence of very weak voiced segments at the end of the fricative, noted [hh].

The distinction between schwas and weak periodic events has been made on the following basis: segments which were less than 30 ms, and have no visible formant structure were not classified as schwas.

We observed a special sequence, produced by non-native speakers: a schwa directly followed by the vowel /a/. In almost all cases, at least one of both vowels was creaky. It was sometimes hard to distinguish this sequence from a single /a/; criteria such as duration and formant transitions were used to differentiate these events.

### 2.3. Boundary types

From observations made during the segmentation of the fricative and its neighbouring segments, we considered four types of boundary:

1) the fricative is directly followed by the following vowel, as in /aʒa/,

2) the fricative is followed by a schwa, and a pause, as in /aʒə#a/, the pause being either a silence, either an aspiration, or a glottal stop,

3) the fricative is followed by a pause (silence, glottal stop, or aspiration), as in /aʒ#a/

4) the fricative is followed by a schwa and then by the vowel /a/, as in /aʒəa/. This sequence has been observed for non-native speakers and the vowels after the fricative were often creaky.

For this preliminary work, we took into account neither [hh] segments nor the presence of creaky voice in vowels in the group constitution.
The sentences have been split into four groups as a function of their boundary type : G1, G2, G3 and G4; the number assigned to each group matching the rank of the boundary type in the above list.

### 2.4. Acoustic cues

The periodicity has been estimated by the Praat "Voicing Report" function which provides the fraction of locally unvoiced frames (we considered the fraction of locally *voiced* frames in our analysis). The estimation of periodicity during fricatives (sounds with often intense noises) is especially difficult and we decided to check the results manually, and corrected them if necessary.

## 3. RESULTS AND DISCUSSION

First, we should precise that, in all the data given in this section, results for /z/ and /ʒ/ have been mixed up. The fractions of locally voiced frames, hereafter referred to as voicing fractions, during the fricative production have been split into six categories, depending on whether: the fricative was fully unvoiced (fraction equal to 0%), the fraction fell in one the four following intervals: ]0,25], ]25-50],]50,75], ]75,100[, or the fricative was fully voiced (100%). We used the Pearson's chi-squared test analysis to compare the results.

In our analysis, we considered not only the whole voicing distribution (i.e. the number of elements in each of the six categories) but also voicing ditribution in larger intervals (englobing the whole fricative duration). More precisely, we compared the number of elements in the [0-25] *vs*. ]25-100] intervals (to compare the number of "poorly" voiced consonants *vs* others), in the [0-50] *vs*. ]50-100] intervals (to compare the number of consonants which were predominantly voiced or not), and we also tested the number of fully voiced *vs* non fully voiced consonants (less than 100% *vs*. 100% voiced consonants).

**Periodicity**. Figure 1 shows the distribution of voicing fractions as a function of the native language of speakers. Differences between French native and German non-native speakers were highly significant on a statistical point of view (p-value < $10^{-6}$, when we consider the 6 categories of voicing), French speakers exhibiting, as expected, more voiced fricatives than German non-native speakers. All pairwise comparisons between two intervals, showed significant differences between French and German speakers, French fricatives being less "poorly" voiced, more predominantly voiced, and more fully voiced than German fricatives (p-value < $10^{-3}$ , in all cases). Such results are in agreement with those of [5].

Concerning the distribution of voicing fractions as a function of speakers' levels (Figure 2), results were rather surprizing. Indeed, we expected statistically more "voiced" consonants for more advanced speakers, but there was no statistical difference when we consider all the levels (3) and all the voicing categories (6). We found only one statistically significant effect (p-value <0.02), which applied to the number of elements in the [0-25] *vs*. ]25-100] intervals for advanced learners (C level) and beginners (A level), C-level speakers having less "poorly" voiced fricatives than beginners.

**Boundary types**. Table 1 shows how speakers realized the boundary at the vicinity of the consonant. We considered four categories, G1, G2, G3 and G4, as explained in section 2.3. Once again, differences between French and German speakers (columns 5 and 6) were very clear and highly significant (p-value inferior to $10^{-8}$ when all groups are taken into account). If we kept only the two most important groups, G1 and G3, we observed a strong difference (p-value < $7\text{x}10^{-4}$ ) between French and German choices concerning the prosodic structures: there is 73% of G1 boundaries *vs* 12 % of G3 boundaries for French speakers, and 35% of G1 boundaries vs 42% of G3 boundaries for German). Hence French speakers produced more boundaries with no pause between the fricative and the following word (G1).

Boundaries varied also as a function of speakers' levels (p-value < 0.03, for the four groups and the three levels). Let us consider advanced speakers and beginners, to maximize the differences between speakers, and the most important groups in terms of numbers, G1 and G3. We can observe that the difference between G1 and G3 was more important for advanced speakers than beginners (p-value < 0.02). Advanced speakers chose more G1 realizations, the most frequent structure chosen by French speakers.

**Periodicity and boundary types**. Let us now consider the distribution of voicing fractions as a function of G1 and G3 boundary types for German speakers (Figures 3, 4). We first observe that, as might be expected, fricatives in intervocalic position (G1) were more voiced than fricatives appearing before a pause (G3), whatever the comparison made (e.g. p-value is inferior to $4\text{x}10^{-3}$, if we compare fully voiced to non fully voiced consonants, all levels confounded). If we consider the results as a function of the speakers' levels, we found statistically significant differences between the distributions observed for G1, but not for G3. In particular, we found that, in G1, the number of "poorly" voiced consonants with respect to more voiced consonants (in the [0-25] *vs*. ]25-100] intervals) was more important for beginners than for advanced speakers (p-value < $3\text{x}10^{-3}$ ). In other words, this means that, in intervocalic position, advanced speakers produced relatively more voiced consonants than beginners. In G3, i.e. before a pause, where there is less voiced consonants than in G1, our data did not allow us to find difference between beginners and advanced speakers.

**Discussion**. Results show that the way speakers realized boundaries at the vicinity of the consonant varies with their level (advanced speakers realized relatively more G1 boundaries than beginners did), and that advanced speakers tend to perform better in G1 realizations than beginners.

Let us recall that we found few statistical differences between speakers' levels, when all groups are confounded (Fig.2). One possible explanation of this result, in addition to the lack of differences within G3, might be the number of schwas realizations after the fricative (G2 and G4 boundary-types), relatively important for A speakers. The presence of a schwa after the fricative (may be due to the influence of German orthography) tends to favour the presence of voicing. More data would be necessary to confirm this explanation. However, it appears that the way speakers realized boundaries at the vicinity of the consonant is linked to their performance, and should be taken into account to evaluate it.

## 4. CONCLUSION

We analyzed the realizations of French voiced fricatives /z,ʒ/ embedded in sentences and appearing in final position of an accentual group, as a function of German speakers' levels and boundary types. Results showed that the performance of the speakers should be explained as a function of the way they realized boundary types. In particular, we observe that advanced speakers preferred to realize no pause after the fricatives, and that, in this intervocalic context, these speakers produced more voiced fricatives than beginners.

We will complement this study by the analysis of new cues, such as the duration of the preceding vowel and the intensity of the noise. We also plan to compare German realizations with French unvoiced fricatives, present in IFCASL corpus in nearly identical contexts.

Table 1 Percentages of realizations of G1, G2, G3 and G4 boundaries, as a function of German non-native speakers' levels (A, B, C), and speakers' first language (G for German and F for French)

| | A | B | C | G | F |
|---|---|---|---|---|---|
| G1 | 21% | 28% | 58% | 35% | 73% |
| G2 | 7% | 12% | 4% | 8% | 9% |
| G3 | 54% | 44% | 25% | 42% | 12% |
| G4 | 18% | 16% | 13% | 16% | 0% |

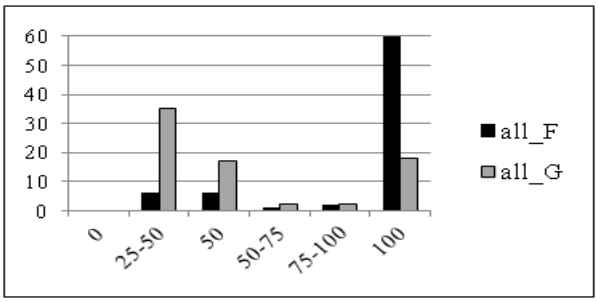


Figure 1 Distribution of voicing fractions for French (F) and German (G) speakers.

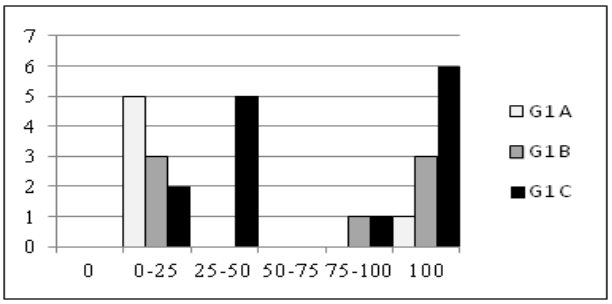


Figure 2 Distribution of voicing fractions for advanced (C), and intermediate speakers (B) as well as beginners (A)

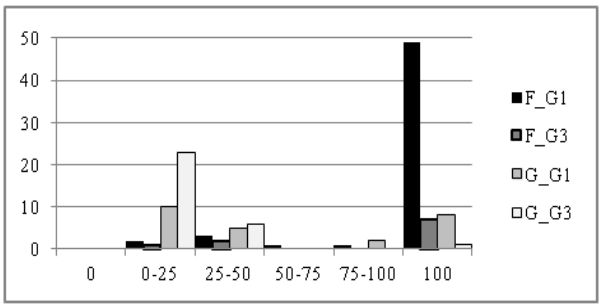


Figure 3 Distribution of voicing fractions for G3 boundary-type, as a function of advanced (C) and intermediate speakers (B) as well as beginners (A

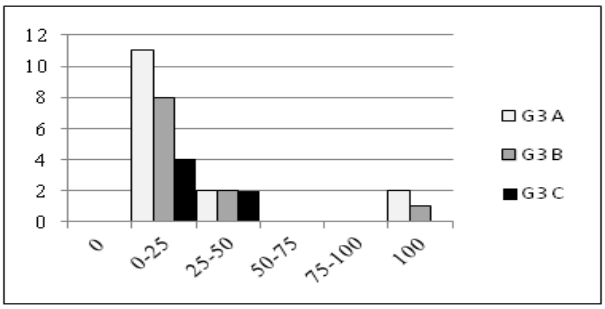


Figure 4 Distribution of voicing fractions for G1 boundary-type, as a function of advanced (C) and intermediate speakers (B) as well as beginners (A)

## 7. REFERENCES


[1] R. Wiese, The Phonology of German, Oxford: Clarendon Press, 1996.

[2] R. Port et P. Crawford, «Incomplete neutralization and pragmatics in German,» *Journal of Phonetics,* vol. 17, pp. 257-282, 1989.

[3] F. Kleber, T. John and J. Harrington, "The implications for speech perception of incomplete neutralization of final devoicing in German," *Journal of Phonetics,* vol. 38, pp. 185-196, 2010.

[4] C. Kuzla, T. Cho et M. Ernestus, «Prosodic strengthening of German fricatives in duration and assimilatory devoicing,» *Journal of Phonetics,* vol. 35, pp. 301-320, 2007.

[5] C. Fauth et A. Bonneau, *L1-L2 interference: the case of devoicing of French voiced obstruents in final position by German learners - Pilot study.*, Dagstuhl – Germany, 2014.

[6] S. Fuchs, J. Brunner et A. Busler, «Temporal and spatial aspects concerning the voicing contrast in alveolar and postalveolar fricatives,» *Advances in Speech-Language Pathology,* vol. 9, n° %11, pp. 90-100, 2007.

[7] L. Lisker et A. Abramson, «A cross-language study of voicing in initial stops,» *Word,* pp. 384-422, 1964.

[8] M. Jessen, "Phonetic implementation of the distinctive auditory features [voice] and [tense] in Stop consonants," in *Recent developments in distinctive feature theory*, T. Hall and U. Kleinhenz, Eds., Berlin, Mouton de Gruyter, 2001.

[9] C. Fauth, A. Bonneau, O. Mella, B. Andreeva, V. Colotte, D. Fohr, D. Jouvet, B. Moebius and J. Trouvain, "Designing a bilingual speech corpus for french and German language learners," in *LREC*, Reykjavic, 2014.


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