

## Perceptual sensitivity to cross-linguistic timing differences in consonant clusters

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Languages differ not only in their phonotactics but also in the phonetic implementation of consonant clusters. The degree of overlap with which consonant clusters are produced differs between languages. For instance, German consonant clusters are produced with relatively high overlap (Bombien, Mooshammer, & Hoole, 2013) and Georgian ones with less overlap (Chitoran, Goldstein, & Byrd, 2002). This study aims to examine perceptual sensitivity to these cross-linguistic timing differences in consonant clusters. More specifically, this study investigates whether French native listeners are sensitive to differences in cluster timing between Georgian (low overlap) and German (high overlap).

To that end, native speakers of French were tested in an AXB similarity judgment test using consonant clusters produced by German and Georgian speakers. Stimuli were /bla, gla, gna/ syllables recorded by 10 Georgian and 10 German native speakers, along with EMA. All three clusters /bl, gl, gn/ are attested word onsets in German, Georgian, and French, with /gn/ being marginal in French. For each of the three clusters, 30 AXB triplets were created in the following fashion. First, two high overlap German tokens and two low overlap Georgian tokens were selected to serve as A and B. Xs with varying degrees of overlap were chosen from the rest of the recordings. In each AXB triplet, A and B were closely matched in terms of their pitch range, pitch contour, and the duration of /a/ vowel. Overlap was defined articulatorily based on EMA measures, as duration from C1 nucleus offset to C2 nucleus onset: the longer that duration is, the less overlapped the consonants are. For one half of the AXB triplets, A is low overlap Georgian and B is high overlap German. For the other half, the order is the opposite.

The participants were 21 self-identified native speakers of French (mean age = 24.1, s.d. = 3.4), currently living in Paris, France. Participants heard a total of 180 AXB triplets (90 triplets repeated twice) in a randomized order. Participants were asked to choose whether X is more similar to A or B using the button box. Each new triplet was played one second after the participant hit the button for the previous item. Participants' responses were statistically analyzed using a series of generalized mixed effects models.

Results showed that French listeners are sensitive to timing differences between long lag Georgian clusters and short lag German clusters. When the timing lag value of X is closer to A, participants were more likely to choose A ( $\beta = 0.45, p < 0.00001$ ). Listeners' sensitivity was also influenced by the types of clusters: listeners were more sensitive in /bla/ than they were in /gla/ ( $\beta = 0.63, p < 0.01$ ) and in /gna/ ( $\beta = 0.76, p < 0.01$ ), without a significant difference between /gla/ and /gna/. Burst duration of C1 was also included in the statistical model, and was a significant predictor for the listeners' response for /gla/ ( $\beta = 0.34, p < 0.05$ ), but not for /bla/ ( $\beta = 0.13, p = 0.24$ ) or /gna/ ( $\beta = 0.10, p = 0.52$ ). Adding epenthetic vowel duration (acoustically measured from the stimuli) did not improve the model ( $\chi^2(4) = 5.44, p = 0.24$ ).

The current findings demonstrate that adult listeners are sensitive to cross-linguistic differences in consonant cluster timing of two non-native languages. This, arguably, suggests that adult listeners are capable of discerning non-native sub-phonemic details while, at the same time, their perception of consonant clusters is mediated by native phonotactics. Furthermore, listeners' similarity judgments seem to be influenced by articulatory timing (duration from C1 nucleus offset to C2 nucleus onset) rather than acoustically measured epenthetic vowel, suggesting that epenthetic vowel is not a strong perceptual cue for the French listeners in this task.