Probing the representation of temporal structure in speech using auditory feedback manipulation

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Compared to real-time manipulation of formants, much less is known about whether subjects' sensitivity to discrepancies between predicted and actual feedback extends to the temporal structure of speech. Here we follow an approach pioneered by Cai et al. (2011; see also Tourville et al., 2013). Unlike their study, which used very vocalic material, we explore here the possibility of applying temporal perturbations to different locations in the syllable in items with complex syllable structure. We refer to the key experimental conditions as the onset and coda conditions. In the onset condition, using the German word "*Schnecken*", the onset consonants /**ʃn**/ of the first syllable were stretched by 50%, and the following vowel correspondingly compressed, so that the overall duration of the word remained unchanged. In the coda condition, using the word "*Menschen*", the vowel in the first syllable was stretched by 50%, and the coda consonants /**nʃ**/ compressed. Based, among others, on considerations in the coupled-oscillator model of syllable structure (Goldstein & Pouplier, 2014) we hypothesized that the onset manipulation would lead to clearer responses.

As a further new feature we used a paradigm in which the perturbation was designed to become predictable for the subjects over the course of the experiment, i.e. following a baseline phase the perturbation was gradually increased over a ramp phase (this in turn followed by a hold phase with maximum perturbation, and an after-effect phase with normal feedback). This was designed to determine whether subjects are in principle able to compensate for a temporal perturbation by adjusting the durations of the perturbed segments themselves. Thus analysis focussed on segmental durations in the hold phase vs. the baseline phase.

In the onset condition (initial cluster stretched, following vowel compressed) there was no difference in the duration of the initial cluster for hold versus baseline phase. However the vowel was very clearly longer in the hold phase (by about 40ms). In the coda condition (vowel stretched, coda cluster compressed) there was no change in the vowel duration from baseline to hold phase. As in the onset condition the compressed segment was lengthened in the hold phase, but the effect was much weaker, i.e. only about 17ms. Moreover, in the onset condition a small but significant lengthening of the vowel was retained in the after-effect phase, but in the coda condition there was no evidence at all that the coda-cluster lengthening was retained in the after-effect phase.

Overall then the results indicate that subjects may be more sensitive to perturbations in the syllable-onset than the syllable-coda, but this will require confirmation with further experiments, since the perturbation scheme used here also turned out to result in greater perturbation in absolute terms in the onset condition. The fact that compensatory responses exclusively involved lengthening of compressed segments (rather than compressing of lengthened segments) suggests possible differences in the representation of temporal compared to spatial (formant) structure, for example a greater relevance of relative rather than absolute patterns in the temporal case. We are currently planning to investigate even more fine-grained temporal manipulations for evidence of adaptive responses, for example stretching C1 and compressing C2 within a cluster.

References

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