Monitoring speech timing via auditory feedback in French

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Introduction: Understanding the representations of speech sounds and their flexibility is key for investigating how speakers interact with their linguistic environment and ultimately engage in sound change. In this study, we test the malleability of temporal parameters in French with temporal auditory feedback (AF) perturbations of singleton onsets, vowels and singleton codas comparing musicians and non-musicians. In AF perturbations, speakers hear their own speech via headphones while the speech signal is altered in (almost) real-time. When speech is temporally stretched or compressed in the AF, speakers mostly compensate in the opposite direction of the shift [1-3] similar to spectral AF perturbations [4]. However, such responses could not be found unrestrictedly across varying speech material and languages. Especially shortening responses to a stretching in perturbation could rarely be observed. Consequently, a variety of factors that may influence a compensatory temporal response were suggested, such as position within the syllable [1]; crossing of phoneme boundaries [2, 5]; or the stress pattern of the observed language [6]. In addition, individual capacities in motor variability and auditory acuity (as for example acquired in musical education) were shown to affect responses. Speakers with higher auditory acuity compensated more to ongoing perturbations (online compensation/reactive feedback control) and speakers with higher general motor variability adapted more, i.e. they kept their adjustments to the perturbation as an update of their representation [7]. Apart from the individual capacities, all of these factors are dependent on the phonemic system of the given language, and have so far been explored in German [1, 3, 6] and English [2, 5, 8], which are both considered stress-timed languages. To gain a better understanding of cross-language similarities of temporal representations in speech, it is crucial to investigate languages with different prosodic and rhythmic structure. Accordingly, we focus here on French, which is traditionally regarded as syllable-timed.

Methods: In Montréal, two groups of participants (20 musicians and 18 non-musicians, matched in age) completed a real-time temporal AF adaptation paradigm with two conditions by reading the sentence "J'épèle [target word] lundi". In the target word "soute" (/sut/), the onset /s/ was stretched and the /u/ compressed (onset condition), and in the target word "tousse" (/tus/), the /u/ was stretched and the coda /s/ compressed (coda condition). If monitoring speech timing in syllable-timed and stress-timed languages is similar, we expect less compensatory shortening to the stretched onset (onset condition) than to the stretched vowel (coda condition), similar to the findings in [1] (H1). This effect could be attributed to a suggested greater articulatory stability and lower malleability of syllable onsets in production [1, 9]. Between the groups, we expect stronger compensatory responses in musicians than in non-musicians, under the assumption that musicians engage more efficiently in sensorimotor integration (H2). Durations of the sounds /s/ and /u/ were fed into linear mixed-effects models estimating the contrast of Hold phase productions (maximum perturbation) and Baseline (no perturbation).

Results: The results show an overall pattern of non-musicians lengthening all four segments of interest regardless of perturbation direction, while musicians do not respond significantly to the stretched first segments (/s/, onset condition; /u/, coda condition) but compensatorily lengthen the respective compressed second segment (Fig. 1). Thus, the data do not support H1: Unlike in [1], compensatory shortening responses could not be observed at all. Regarding H2, we found that non-musicians responded more generically by lengthening all segments, while musicians showed a non-significant response rather than following the perturbation. The lack of significant responses in musicians is therefore interpreted as an effort to not generically slow down. These and further results (e.g. for the Aftereffect phase) will be discussed in more detail at the conference, together with the possible role of language-specific phonotactic and rhythmic structures for compensatory responses.

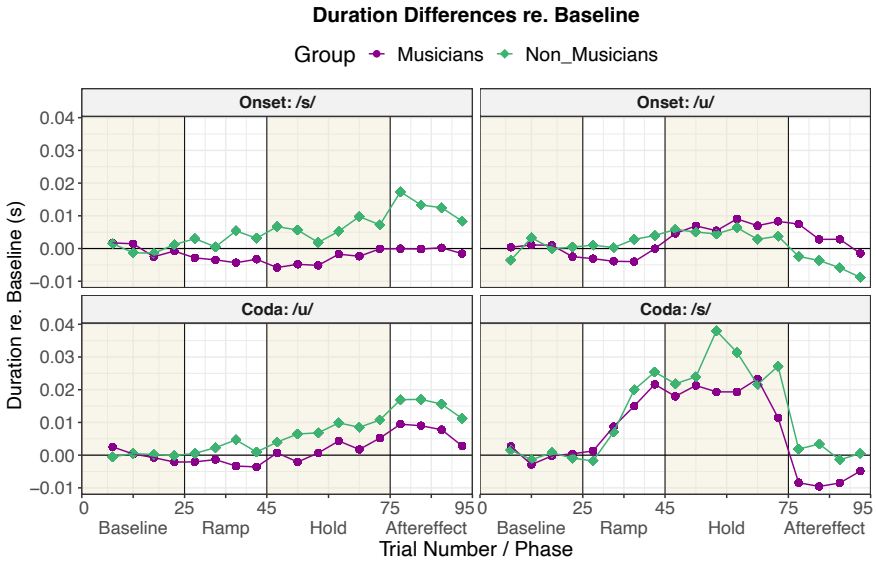

Fig. 1. Duration differences (production) relative to the Baseline mean (0) over the course of the experiment binned per 5 trials for musicians and non-musicians. Baseline and Hold phase marked. Onset condition in the upper panels and Coda condition in the lower panels. Stretched sounds in the left panels, compressed sounds in the right panels. Thus, compensatory responses are indicated by negative values in the left panels and positive values in the right panels.

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