Vowel Perception in Congenital Amusia

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Congenital amusia is a disorder that negatively influences pitch and rhythm perception ([1]) and it is not caused by a hearing deficiency or brain damage. While congenital amusia had long been reported to affect only the musical domain ([1, 2]), several studies have shown that amusics also have impaired perception of intonation (e.g. [3]) and linguistic tones (e.g. [4]).

In the present study we tested whether congenital amusia also has an influence on linguistically relevant cues other than pitch by investigating the discrimination of German front mid vowels /ɛ/, /ɛ:/, /e/ and /e:/ (where /ɛ:/ and /e/ are of low frequency, the latter being a loan phoneme). We assessed amusics' behavioural and electrophysiological responses, more specifically the Mismatch negativity (MMN), which is a component evoked by unconscious change detection in the auditory signal (e.g. [5]).

We tested 11 congenital amusics diagnosed with the MBEA (8 female; mean age 34.09 years) ([6]) and 11 controls matched for age, gender, years of education and years of music education (8 female; mean age 32.45 years). All participants were right handed, had normal hearing and had German as native language. Our stimuli were isolated synthetic vowels created by Klatt synthesis (in Praat; [7]), varying in either durational or spectral properties (F1 and F2 varied together), which resulted in four continua with seven steps, see Figure 1. We used synthesized vowels to ensure very tightly controlled stimuli ([8]), while at the same time, we tried to keep them as naturally sounding as possible by adding a falling-rising pitch contour and amplitude, and eight additional formants. We decided to use mid vowels to avoid periphery effects ([9]), and to utilize vowels that are close to each other in their height and front-back dimension in the vowel space, but that differ in quality and/or quantity.

In the behavioural study we employed an ABX task, where two adjacent corner vowels in Figure 1 (left panel) were used as A and B, and X could either be one of these or one of the five stimuli in between. The stimuli were presented with an inter-stimulus interval (ISI) of either 0.2 s or 1.2 s.

The stimuli in the EEG study were presented in a multi-deviant oddball paradigm in four blocks. In each block, one of the four high front vowels (the corner vowels in Figure 1) was the standard and occurred 85% of the time, while the other three served as deviants, each occurring 5% of the time. This resulted in 16 event-related potentials (ERPs) per participant: 4 standards and 12 deviants. The inter-stimulus interval was varied randomly between 400 ms and 600 ms to avoid entrainment effects.

For the behavioural data, we calculated a linear mixed model (*lmer* in R; [8]) with subject as random effect, and group (amusics vs. controls), ISI (0.2 s vs. 1.2 s) and cue (duration vs. formant frequency) as fixed factors. We found main effects of group ($t(20)=2.28$, $p=0.033$), ISI ($t(1028)=7.69$, $p<0.001$), and cue ($t(1028)=8.24$, $p<0.001$). As expected, amusics performed worse than controls. Furthermore, short ISI resulted overall in worse performance, and a difference in duration was overall harder to detect than a difference in formant frequency.

For the MMN data, we used a linear mixed model as well. We found significant main effects for group ($t(23.7)=-2.43$, $p=0.023$): amusics (M=-2.67) had a smaller MMN than controls (M=-3.35), visible in Figure 1, right panel. In addition we found a main effect for cue ($t(2351.8)=-6.14$, $p<0.001$) and a significant interaction between group and cue ($t(2351.8)= 3.85$, $p<0.001$): durational differences were harder to detect, especially for amusics.

Our study shows that congenital amusia does not only affect the perception of pitch in music and language but also the perception of vowel contrasts, therefore having more far-reaching consequences for speech perception than previously assumed. Not only was the behaviour of amusics shown to be affected, we also found differences in the MMN, reflecting differences in early auditory change detection.

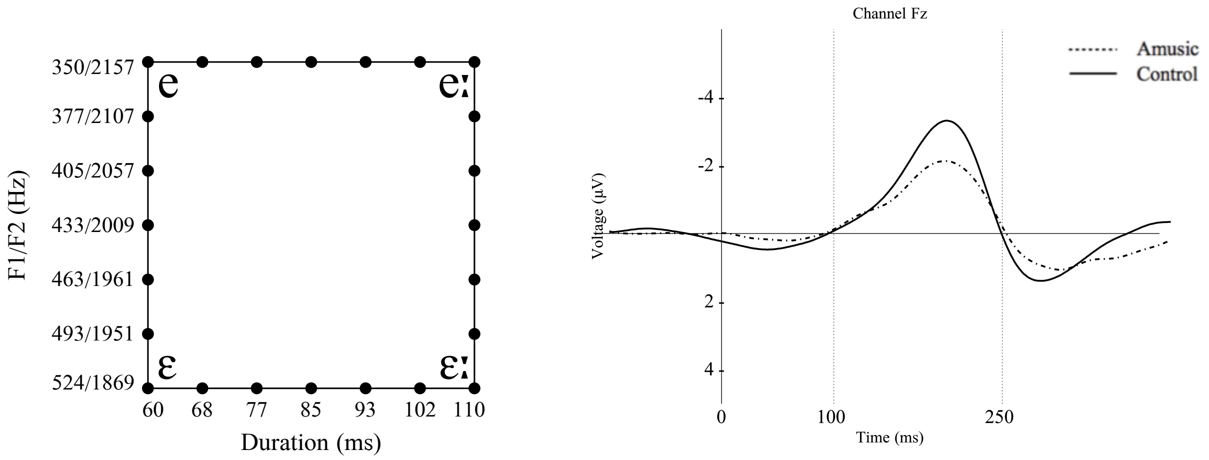

Figure 1: Left: The spectral and durational values of the stimuli on the four continua.
Right: grand average difference waves plotted at Fz for amusics and controls.

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