Music Listening in Electric Hearing

- designing and testing two novel EEG paradigms for measuring music perception in cochlear implant users

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Introduction

With the considerable advances made in cochlear implant (CI) technology with regards to speech perception, it is natural that many CI users express hopes of being able to enjoy music. For the majority of CI users, however, the music experience is disappointing and their discrimination of musical features as well as self-reported levels of music enjoyment is significantly lower than normal-hearing (NH) listeners (1,2). Therefore, it is important that ongoing efforts are made to improve the quality of music through a CI.

To aid in this process, the aim of this study is to validate two new musical EEG-paradigms: 1) a no standards mismatch negativity (MMN)-paradigm and 2) a free-listening paradigm, presenting real musical pieces.

In a wider perspective, the study aims to investigate whether a novel sound processing strategy implementing output compression may be beneficial for music listening with a CI, as compared to front-end automatic gain control strategies. Due to few CI participants, only preliminary data are presented here.

Methods

EEG paradigms

1. The MMN-paradigm is built upon a musical multifeature (MuMuFe) paradigm developed by Vuust et al. (3). It integrates a new approach introduced by Kliuchko et al. (in preparation) in which only deviants and no standard stimuli are presented. Deviants in pitch, timbre, intensity and rhythm are embedded in a Alberti bass pattern and are randomly presented at four levels of magnitude: small (S), medium (M), large (L) and extra large (XL) (figure 1.)

2. The free-listening approach is based on a new methodology introduced by Poikonen et al. (4). Using the Music Information Retrieval (MIR) toolbox (5) it is possible to investigate the relation between extracted musical features such as Spectral Flux, a measure of change in loudness and pitch or timbre, and ERP responses (figure 2.)

Neither of the two approaches have previously been tested on CI-users.

Behavioural test

A 3-AFC test, testing behaviourally discrimination of the same music parameters and levels of magnitude as presented in the MMN-paradigm.

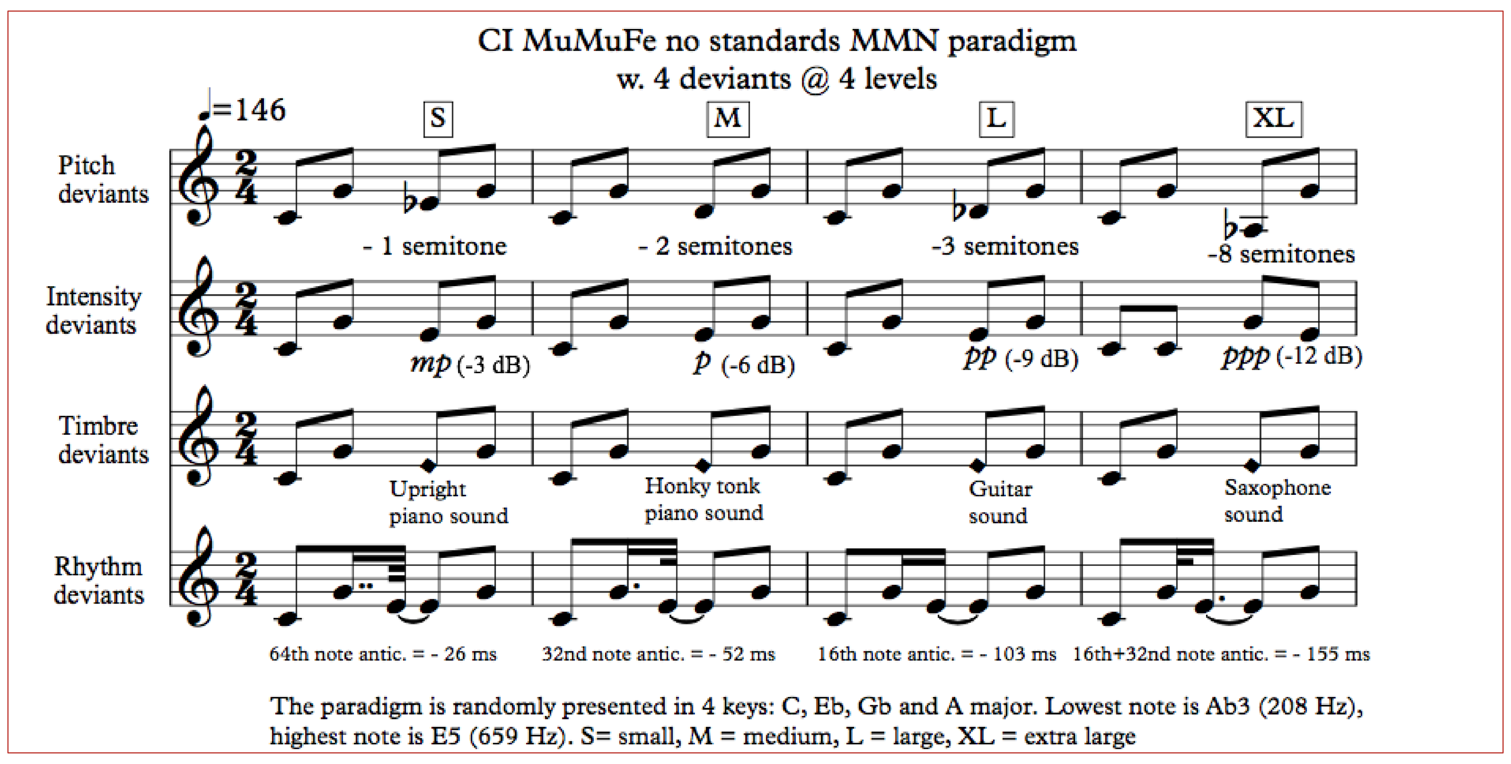

Figure 1. CI MuMuFe no standards MMN paradigm

Experimental Groups

1. Recently operated CI-users
   (N= 4; age range: 53-74 y)
2. Experienced CI-users
   (N=6; age range: 49-69 y)
3. NH controls
   (N=10; age range: 55-67)
4. NH young
   (N=16; age range: 21-31 y)

Figure 2. Free-listening paradigm

To investigate brain plasticity and development in music discrimination abilities, recently operated CI-users will be tested twice: within three weeks of switch-on and after three months.

Results

MMN paradigm

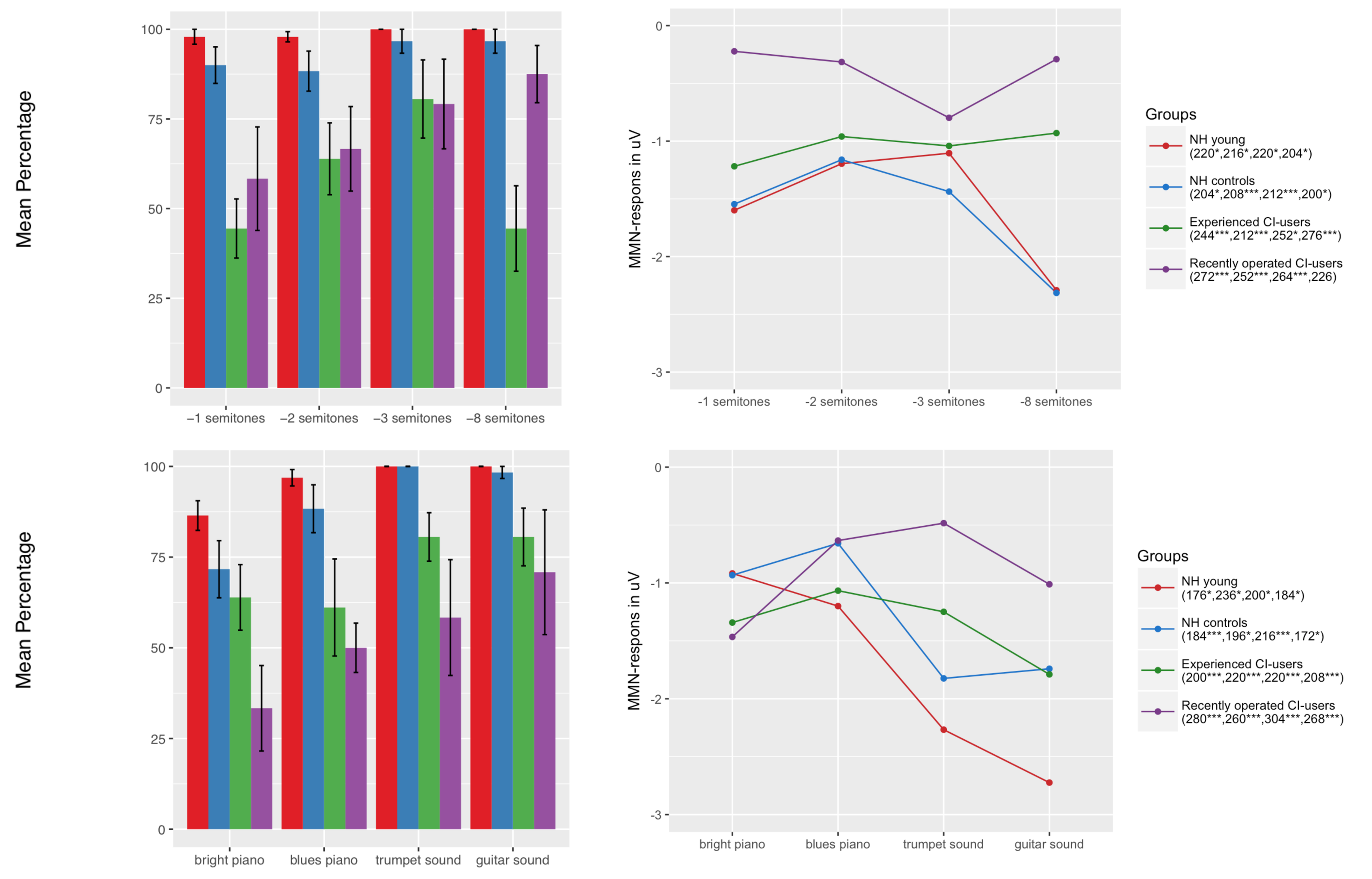

Figure 3. Left: Mean percentage correct scores from the AFC test. Error bars indicate +/- one SE. Right: Peak MMN responses of the Pitch and Timbre deviants from the MMN paradigm. Latencies (in ms) and significance levels are given in parentheses.

Free-listening

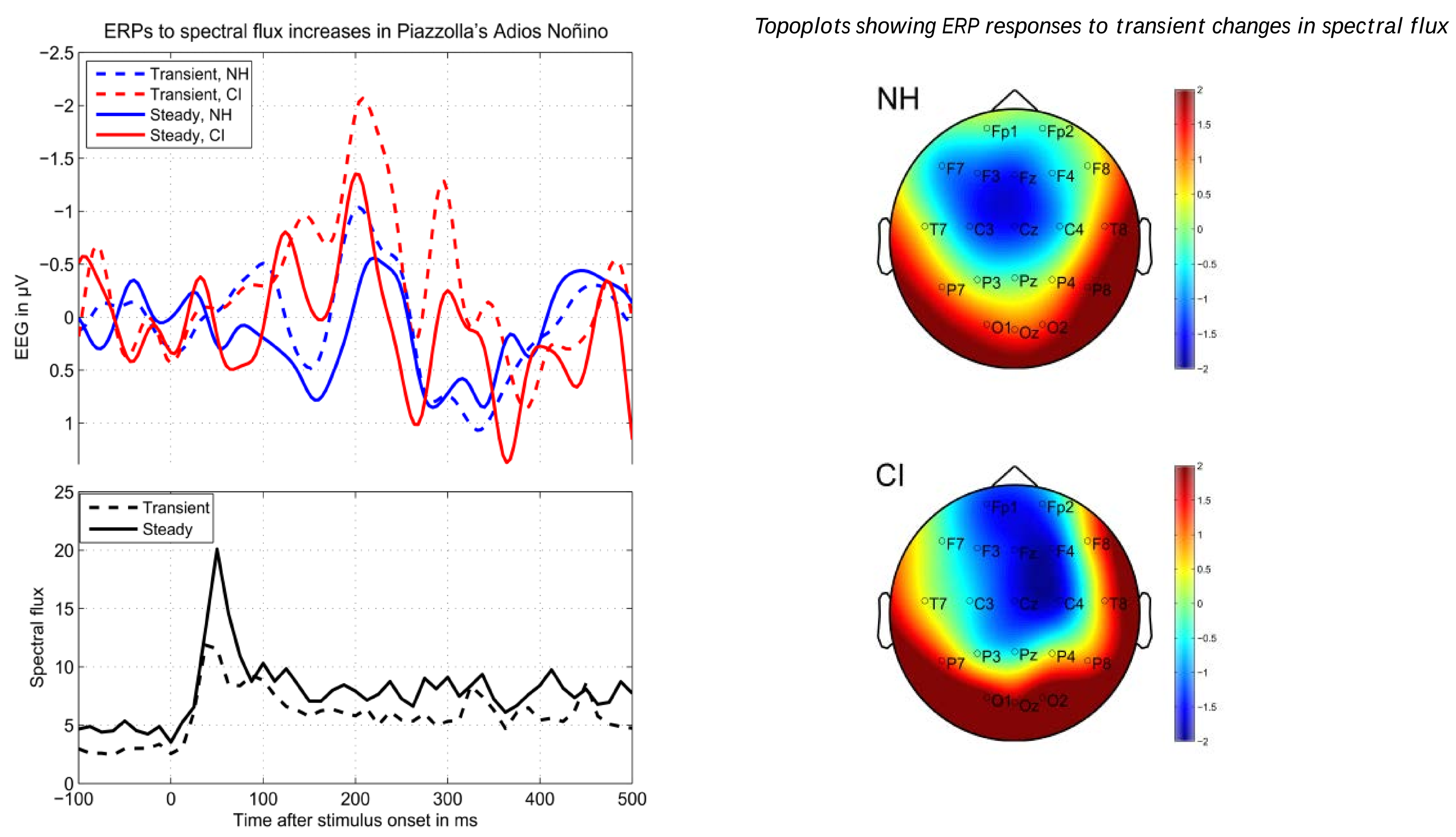

Figure 4. ERP responses from CI users and NH controls listening to tango music showing the average across 10 EEG responses to increases in the musical feature Spectral Flux.

Discussion

NH listeners produce behavioral scores that are significantly higher than those of the CI-users. CI-users score above chance and generally in accordance with levels of deviation. Unexperienced CI users score on level with experienced CI users for pitch but poorer for timbre.

Overall, the MMN-paradigm elicits significant responses in all participants and MMN strength seems to correspond well with the levels of deviation, especially for NH. Experienced CI-users show MMN-responses with higher amplitudes and shorter latencies than the recently operated, and for some deviants they seem to be on level with the NH controls.

In the free-listening paradigm, experienced CI-users show higher auditory evoked potential (AEP) amplitudes than NH controls (top plot). This presumably reflects higher prediction error in CI compared to NH. Also, transient acoustical changes elicit higher AEP amplitudes than steady changes in both NH and CI.

To sum up, our results indicate that both paradigms work according to our hypotheses. However, more participants and more analyses are needed to make firm conclusions.

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