CLINICAL APPLICATIONS OF MUSIC

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We can work it out - perception and discrimination of music in experienced and recently implanted CI users

Try to see it my way,
only time will tell if I am right or I am wrong
(Lennon/McCartney 1966).

A longstanding relationship

One significant aspect of MIB's engagement in clinical applications of music is the study of how music plays a role in the lives of patients with profound hearing loss who have received a cochlear implant (CI). Previously, we examined the effect of musical ear training in pediatric, adolescent and adult CI-users as well as music listening habits, music enjoyment and quality of life in experienced CI-users (see MIB's annual report 2016 p. 39-42). The study of brain plasticity and neural discrimination of features of music formed part of these studies, initially using PET[1], but recently also using EEG, measuring the Mismatch Negativity (MMN) response[2,3].

A new paradigm

In a cooperation with the Danish CI manufacturing company Oticon Medical we have developed a novel MMN 'Musical Multifeature' paradigm (CI MuMuFe) to be used both in CI research and in clinical context. The paradigm integrates only deviants and presents no standard stimuli. Deviants in pitch, timbre, intensity and rhythm are embedded in an Alberti bass pattern and presented randomly at four levels of magnitude (S, M, L & XL; see MIB's annual report 2016, p. 42). Here we report preliminary results from experienced and recently implanted CI-users at the group level as well as in individuals.

A brief overview

Eleven experienced CI users (CIex), 11 recently implanted CI users (CIre) and 14 normally-hearing (NH) controls underwent EEG-recording while subjected to the CI MuMuFe paradigm. To monitor the CI adaptation process, CIre were measured twice: shortly after switch-on (T1) and after three months (T2). In addition, all participants completed a behavioral discrimination test.

Account of highlights

a) CIex vs NH

Across levels, the CI MuMuFe paradigm elicited significant MMN responses to all deviants in NH controls and to all deviants in the CIex group except for the rhythm S and timbre M deviants. In NH listeners, MMN amplitudes for the intensity deviant were significantly lower than for pitch and timbre deviants. In CIex, MMN amplitudes did not differ significantly between any of the deviants. Furthermore, across deviants, the overall relationship between MMN amplitudes and deviation magnitude was consistent, a trend also reflected in behavioral measures (see fig 1).

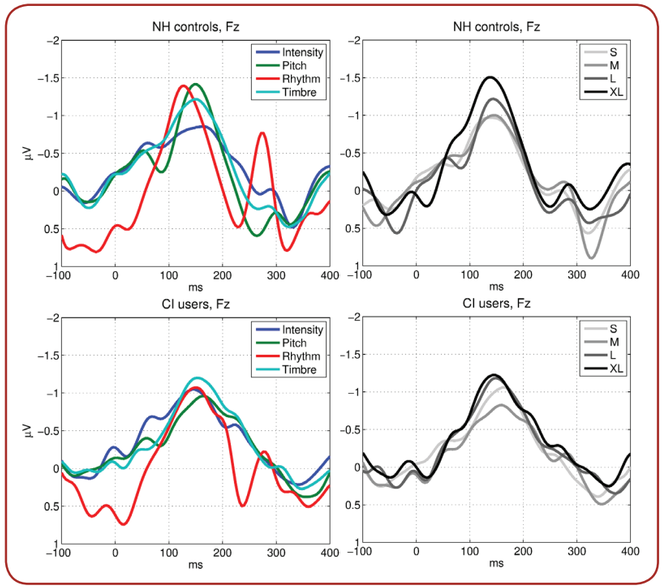

Figure 1. Left: MMN difference waves for all four deviants across levels in the NH (top) and CIex groups(bottom); right: MMN difference waves across deviants as a function of deviation magnitude levels.

While NH controls showed a differentiated discrimination of the pitch deviant, CIex showed no discrimination between any pitch levels. By contrast, the CIex group showed an abnormally higher MMN amplitude in response to the brighter timbre deviant S than the darker variation M, not observed in NH. Similarly, for rhythm, the CI users' response to the L deviant was abnormally higher than to S, M and XL.

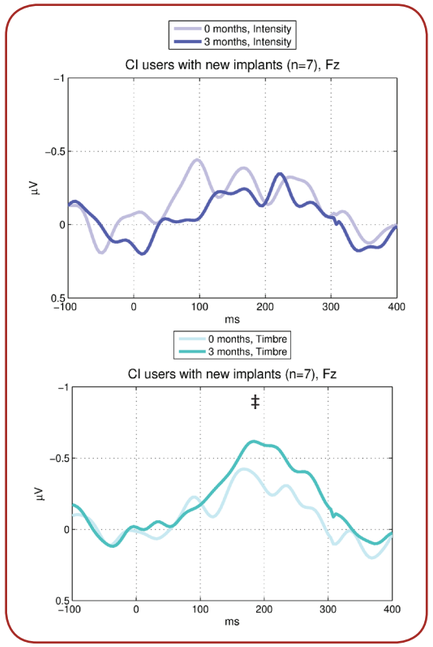

Figure 2. CIre difference waves illustrating the negative ERP responses to the intensity (top) and the timbre deviants (bottom) at T1 and T2.

b) CIre

The CIre-group displayed MMN-like negative ERPs for all deviants, even after a short duration of experience. For pitch and timbre especially, the T2 amplitudes of these ERPs indicated a strong effect of time. This may suggest that the auditory training linked to the adaptation process is manifested stronger in the discrimination of the spectrally complex rather than in the more basic features of music (see fig 2).

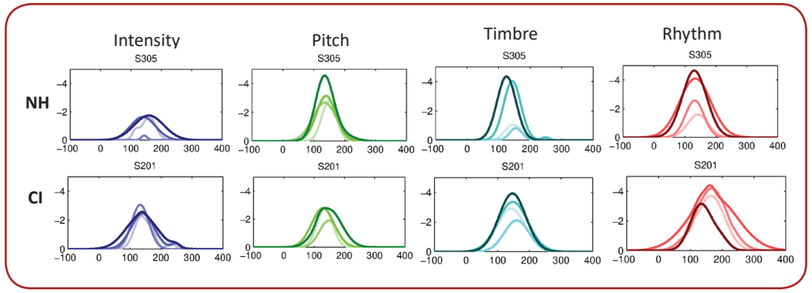

Figure 3. MMN responses to the CI MuMuFe paradigm in a single NH (top) and a single CIex listener, xtracted by SCA.

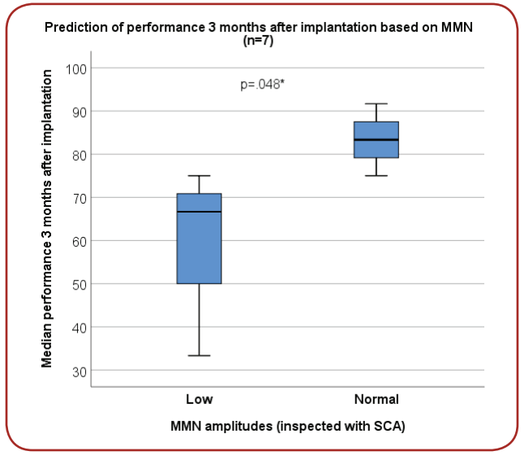

Figure 4. Box plot showing the relationship between low and normal MMN amplitudes and behavioral hit rates in the CIre group.

A single case

Spike density component analysis (SCA) is a novel methodology for analyzing MMN data, developed at MIB in 2018[4]. The method has proven particularly useful in analyzing single subject MMN responses. Results extracted in a single CIex and a NH control, respectively, are shown in fig 3.

A close connection

Prediction of CI outcome. Using the SCA method, we categorized MMN amplitudes from individual CIre participants according to strength and correlated with behavioral performance. The analysis revealed a strong relationship between MMN amplitude and behavioral hit rates, indicating the method's potential to predict CI performance (see fig 4).

In one single subject, we observed abnormally low MMN amplitudes as well as poor behavioral performance. Subsequently, we learned that the patient had been reimplanted due to a physiological change in the inner ear. Such an association suggests the potential of both the paradigm and the SCA as tools for objective diagnostic and prognostic measures in a clinical context.

A final wrap-up

The preliminary findings of this study are encouraging. Despite a high complexity, the CI MuMuFe paradigm may provide objective and detailed evidence of CI users' musical discrimination abilities. Furthermore, in naïve CI users, the paradigm traces basic advances in detection of complex musical features, reflecting functional changes in the auditory system.

Finally, applying the SCA approach, the paradigm may provide identification of reliable MMN-responses in individual CI patients. The latter is an encouraging indication of the potential application of the new methodologies as prognostic and diagnostic tools in clinical settings. With presumed inclusion of future new CI users, we anticipate further support of our findings.

Acknowledgement

Recruitment, scheduling, EEG-recording and testing of participants was carried out by research year student Anne Sofie Friis Andersen and research assistants Alberte Seeberg and Monica Ipsen.

Parts of this study were presented at MMN 2018 in Helsinki and the Oticon Medical Scientific Meeting in Copenhagen, 2018 and will be reported in[5].

References

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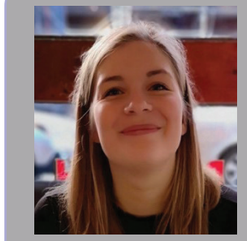
5.] Friis Andersen, AS*, Petersen, B*, Højlund A, Trusbak Haumann N, Dietz M, Michel F, Ovesen T, Kamaric Riis S, Brattico E, Vuust P. The CI MuMuFe - a new MMN paradigm for measuring music discrimination in electric hearing (In preparation). (* shared first authorship)



Alberte Baggesgaard Seeberg is enrolled in the BSc programme 'Cognitive Science' at Aarhus University. In 2018, Alberte has been involved in MIB's study on Music and CI .

For her BA thesis, Alberte incorporated and analyzed anonymized data, collected in discrimination tests and questionnaires from experienced and recently implanted CI users. The following summarizes some of her findings.

1. Age at CI-implantation seems to correlate negatively with discrimination performance. This could indicate that the plastic changes taking place post-implantation occur faster in the brain of people implanted at a younger age.
2. Poorer performance is associated with a longer duration of deafness. This is particularly true for recently implanted CI-listeners, suggesting that the amount of years with hearing loss influences the time it takes to regain the ability to discern between different properties of sounds.
3. Time spent listening to music is significant to performance. If this is true, CI users could benefit from musical training programs post-implantation, increasing their ability to perceive and enjoy music.