CLINICAL APPLICATIONS OF MUSIC

Line Gebauer

Music interventions – how does music do its magic?

Music can do more than just lift your spirit - its impact on our body, brain, and emotions has great potential for the development of music interventions for a range of clinical conditions. These effects are a central research interest to Center for Music in the Brain (MIB). At the moment, there is an increasing interest in the use of music in clinical contexts from pain management to sensori-motor rehabilitation and improved sleep quality across the health sector, research community, and industry as highlighted by the novel initiative ”Music and Health” from the Danish Composers’ and Songwriters’ Association, which will be launched in 2017. The goal of MIB is to conduct research identifying evidence-based music interventions and to document the underlying mechanisms behind the putative positive effects of music.

Currently MIB researchers are working on a number of clinical projects related to: patients with cochlear implants (Asst Prof Bjørn Petersen, PhD student Cecilie Møller, PhD student Stine Derdau, Research Year Student Anne Sofie Andersen), pain management (Dr Eduardo Garza-Villarreal, Asst Prof Christine Parsons and PhD student Sigrid Juhl Lunde), neurodevelopmental disorders (Assoc Prof Line Gebauer, Research Interns Rasmine Holm Mogensen and Maja Hedegaard), dementia (PhD student Kira Jespersen, Assoc Prof Line Gebauer, Research Intern Maja Hedegaard), and sleep improvement (PhD student Kira Jespersen). Furthermore, Margrethe Langer Bro in collaboration with Peter Vuust is studying the effect of live music interventions on cancer patients undergoing chemotherapy in a large study funded by ‘Kræftens Bekæmpelse’.

In 2016 MIB, in collaboration with DTU, received funding from Innovation Fund Denmark to undertake a study on music interventions for sleep problems in patients suffering from dementia. Besides this, the Tryg Foundation funded a project on the impact of singing on Chronic Obstructive Pulmonary Disease (COPD) which is to be undertaken by Mette Kaasgaard, who will begin her PhD in 2017 in a collaboration between MIB, Dr Ole Hilberg at Vejle Sygehus, and Dr Uffe Bødtger, Assoc. Professor at University of Southern Denmark.

MIB PhD student Stine Derdau and former MIB researcher Mads Hansen preparing a participant for the MuMUFE CI MMN paradigm.

Photo: Bjørn Petersen

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Bjørn Petersen

The Sound of ~~Silence~~ Music

A paradox?

At a first glance, a coupling between music and hearing loss (HL) may appear rather paradoxical. Music has, however, historically been part of the lives of at least some deaf persons. The famous composer Ludwig van Beethoven composed his 9th symphony, despite a profound HL – based on well-established internal representation and musical imagination. Two hundred years later Evelyn Glennie, who is profoundly deaf, leads a career as a professional classical percussion soloist, relying on vibration cues from her bare feet. In the 70s and 80s, Danish music therapist Claus Bang included drumming in his work with deaf and hearing-impaired children. If unable to hear, the children could still make music together through visual cues and low-frequent vibrations. One of MIB’s most important clinical research areas concerns music in the lives of persons who are deaf but able to hear by means of a cochlear implant (CI), an area of research that has gained wide global attention and in which MIB is at the forefront. As it appears, the phenomenon is not too unrealistic, let alone paradoxical.

Electric ears

The CI is a neural prosthesis that allows individuals with severe to profound HL to gain or regain the sense of hearing. Basically, a sound processor transforms acoustic signals into electric impulses, which are delivered to an electrode array implanted within the cochlea. A rise in bilateral implantation together with technological refinements have improved implant outcomes, allowing adults with a postlingual HL to restore speech comprehension and congenitally deaf children to acquire spoken language. Correspondingly, the number of CI surgeries has risen exponentially and today more than 350,000 CI recipients worldwide use the device in their daily communication[1].

Technological amusia

Despite this immense technological and medical achievement, CI users face several limitations in their auditory perception. This is particularly true for perception of music which is severely compromised by the degraded spectral and temporal resolution of the implant. The American CI recipient and author Michael Chorost has compared his music listening experience to “walking colour-blind through a Paul Klee exhibit”. To some it may well be far worse which is suboptimal, since music in many cases has been an essential part of their cultural and social life.

Looking back

In 2007, reports of local “super listeners” who had regained their music enjoyment through repeated playback of the same well-known album, and who at the same time exhibited excellent speech perception, came to the attention of MD and then PhD student, now deceased, Malene Vejby Mortensen. This inspired her and Peter Vuust to propose the hypothesis that musical ear training might be a way to strengthen not only perception of music but also perception of speech.

The hypothesis was based on two rationales. First, music and language rely on processing of fundamental aspects of sound, such as pitch, timing and timbre, and recent studies have shown that complex music tasks activate brain areas associated with language processing[2]. Thus, improved perception of music could generalize to linguistic skills, in particular perception of prosody. Second, adaptation to the CI is based on residual cortical plasticity in auditory brain regions which again may allow for further advances in performance, as a result of systematic training efforts.

Three experiments and a survey
In three different studies, we tested this hypothesis. 1) A longitudinal study involving recently implanted adult CI users (N=18; age: 21-73 years), 2) a short intensive study involving prelingually deaf adolescents (N=21; age: 16-18 years) and 3) a 3-month study with preschool children (N=21; age: 3-6 years) with CIs. In all three studies, the musical ear training had active music making, rather than passive listening, as the main components. In addition to the obvious beneficial rewarding and enriching effects such activities create, the reason for this was a wish to create and maintain motivation. Judging from the compliance of the participants, this was a wise strategy; in all three studies, all participants completed the programme. Alongside the training experiments we carried out a comprehensive survey (N=163). Our aim was to gather information about music listening habits, music enjoyment and quality of life (QOL) from a large, representative sample of adult CI users.

Highlights from the four studies include:
a) The music training had a significant effect on CI users' overall music discrimination skills. In particular, discrimination of rhythm, melodic contour and timbre showed a significant progress. By contrast, discrimination of pitch was poor and unaffected by training. This pattern was reflected also in MMN results done with EEG and emphasizes both the strengths and limitations of the implant and the learning potential.
b) According to feedback and observations, musical activities with a vocal aspect, such as singing and rapping, appeared particularly motivating and fruitful. This highlights the potential effect of music training on both impressive and expressive skills. Full circle.
c) Despite the technical disadvantages of the CI, a large majority of CI listeners listen to and enjoy music ranging from modest satisfaction to great enthusiasm; adolescents even listen at levels that are comparable to NH peers. In addition, average ratings for the quality of the sound of music with the implant was much higher in adolescents than in adults, indicating a strong psychological factor (Fig 1). Adults may tend to make comparisons with long lost music memories. Adolescents have only

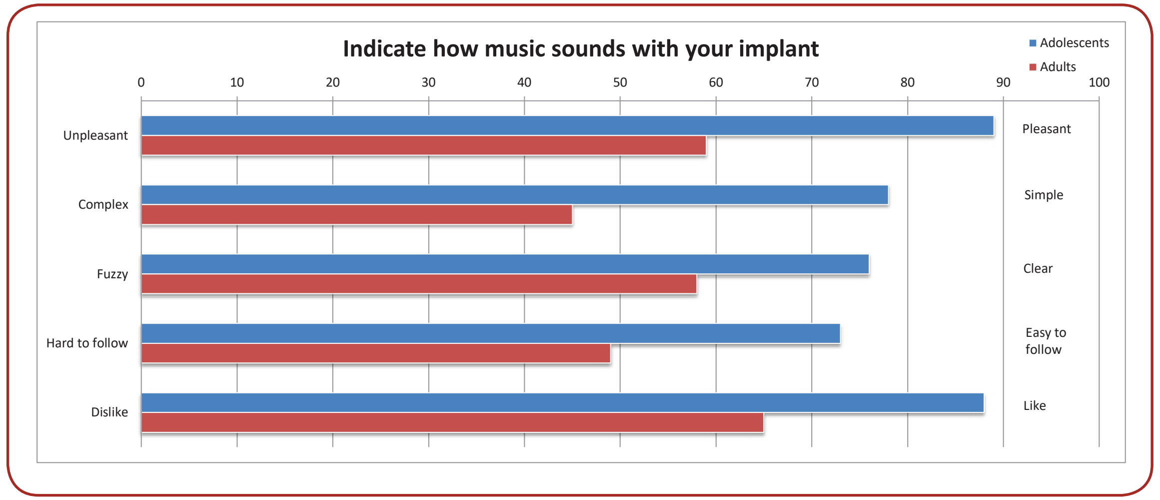

Figure 1: *Adolescent (blue) and adult ratings of the quality of the sound of music through their CI as indicated on a VAS scale of 0-100 with bipolar adjective descriptors. The average rating was 55 for adults and 81 for ados.*

heard sound through the implant and make their judgement without such reference. For details, see[3-7].

Looking forward
MIB's involvement in CI and music research has resulted in a line of new studies.

Music training app. The study with adolescent CI users suggested that our computer-based training applications had too little to offer in terms of motivation and excitement. Subsequently, this led to the development of a novel music training app for smartphone, Musicity (Fig 2), which is part of PhD student Stine Derdau Sørensen's work. The app uses a gamified approach which implies that users will be able to level-up, according to their performance, thus supposedly increasing motivation and, evenly important, training intensity. The app so far contains five different musical ear training games and has been tested by many different target groups, including approx. 3,000 school children as part of the nationwide Mass Experiment. The aim is that with this app, CI users worldwide will be able to improve their music discrimination skills and in the process potentially enhance their music enjoyment too[8].

Effect of sound compression. MIB's expertise in objective measurements in CI users done with EEG has led to a new study in cooperation with the Danish CI manufacturer Oticon Medical. The main goal is to examine the possible beneficial effect on CI users' music perception from a novel

Figure 2: *The front screen of the music training app Musicity, created and designed by MIB PhD student Stine Derdau Sørensen.*

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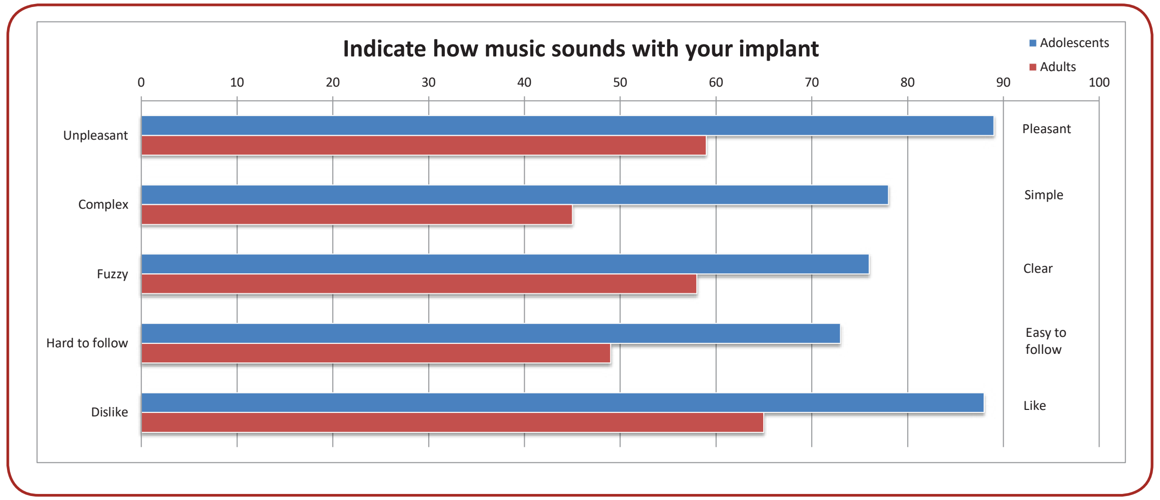

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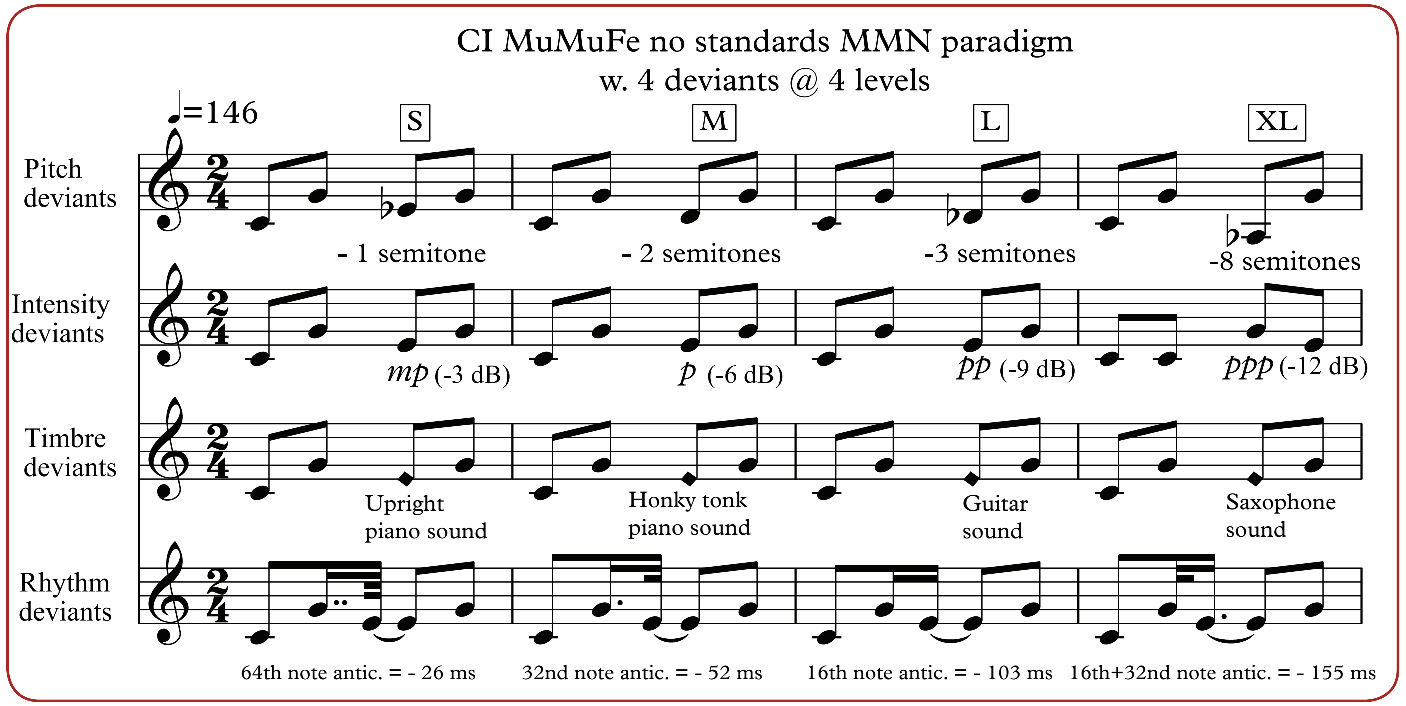

Figure 3. The modified CI MuMUFE MMN paradigm. *The paradigm presents 4 different deviants in up to 4 levels of magnitude: Pitch (-1 ST, -2ST, -3ST, -8ST), Intensity (-3 dB, -6 dB, -9 dB, -12 dB), Timbre (rock bright piano, ragtime piano, guitar, saxophone) and Rhythm (-26 ms, -52 ms, -103 ms, -155 ms). The paradigm is randomly presented in 4 keys: C, Eb, Gb and A major. Lowest note is Ab3 (208 Hz), highest note is E5 (659 Hz). S=small, M=medium, L=large, XL= extra large. Antic.=anticipation.*

sound compression strategy, which leaves room for a wider dynamic range as compared to the typical automatic gain control. An equally important goal is to validate two new EEG paradigms not used in CI users before: 1) an MMN paradigm which presents four different deviants (pitch, timbre, intensity and rhythm) at four different levels but contains no standards (Fig 3), 2) a naturalistic paradigm which presents entire pieces of music. The latter approach is based on a new methodology introduced by Poikonen et al.[9] and is based on an extraction of musical features done in the MIR-toolbox[10]. Both with regard to the aspects of music listening and to methodology, the study has the potential to bring important new knowledge to the field[11].

Review paper on MMN and CIs. One side effect from MIB's engagement in Music and CI research is a new review paper on the global use of the Mismatch Negativity Response, recorded with EEG, in CI patients. The review[12] has been carried out in a new collaboration between MIB researchers Bjørn Petersen and Peter Vuust and Finnish researchers Professor Risto Näätänen and Lecturers Ritva Torppa and Eila Lonka.

Parental Singing. With a new original research proposal, MIB researcher Cecilie Møller has received 400,000 DKK to initiate the project Parental Singing. In brief, the project aims at teaching parents of children with CIs how to initiate and qualify musical interaction with their child, thus potentially stimulating the child's auditory and linguistic development. The programme is inspired by the Auditory Verbal Therapy method (AVT) applied by professional speech therapists worldwide.

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MIB AT THE DHL RELAY RACE

Photo: Hella Kastbjerg

In August 2016 MIB and CFIN participated with more than 30 runners and walkers at the annual DHL Relay Race.

The DHL Relay Race is the world's largest running event taking place in 5 Danish cities.

Participants can either participate in a 5 x 5 km relay race or a 5 km walk.

In Aarhus, 47,000 people participated over 3 days - 2,160 of those were from Aarhus University.

Photo: Niels Christian Hansen