# Music for Little Digital Ears - *music learning in preschool children with cochlear implants*

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***Background:*** Owing to neonatal hearing screening and early surgery, new generations of young children with cochlear implants (CI) are emerging. To unfold these infants' potential to develop spoken language and academic skills new methods in auditory-oral therapy must be developed. Music offers a learning environment, that may expand the auditory capabilities of these children and positively influence their quality of life – culturally, socially and linguistically.

***Participants:*** 21 preschool CI users (3-6 years) matched in two groups: **A)** Music group, who attended weekly musical training sessions for 3 months and **B)** Control group. A normal hearing (NH) group **C)** provided reference data for the musical tests. *(Table 1)*

| Group | Boys | Girls | Mean age at project start (months) | Mean age at implantation |
|---|---|---|---|---|
| Music grp. A | 3 (2) | 7 (2) | 61 (± 10.8) | 34.7 (± 17) |
| Control grp. B | 7 (4) | 4 (3) | 58 (± 13.4) | 23.3 (± 13.2) |
| NH grp. C | 3 | 7 | 63 (± 7.4) | - |

*Table1. Demographic data for the 3 groups. Numbers in brackets indicate number of children w. bilateral implants. The large variation in implantation age is due to the age difference and some cases of late-onset hearing loss.*

***Methods:*** We designed, prepared and realized an elementary group oriented music learning program based on imitation methods. To document music perception performance we created 3 tests:
1) Musical Instrument Identification (MII), 2) Pitch Change Detection (PCD) and 3) Familiar Melody Identification (FMI). Three existing linguistic tests were used for documentation of speech perception. The test data were collected and analyzed at the beginning and end of the 3 month intervention period.

***Results:*** Both groups improved their musical discrimination abilities. In the MII test the music group gained 54% (P = <0.001), while the control group gained 26% (P= 0.016) *(fig. 1)*. The difference shows a very strong trend (P = 0.097).

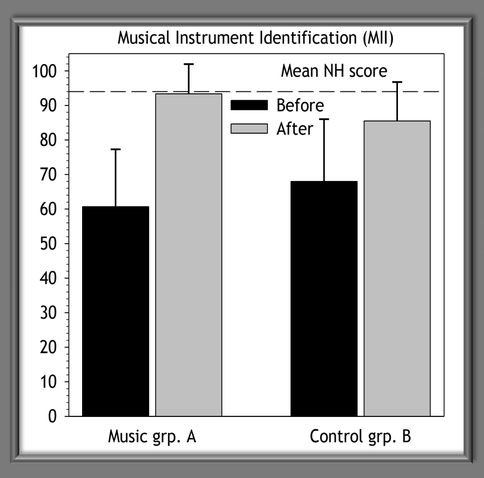


*Fig. 1. MII test: Mean scores before and after the 3 month intervention period. Error bars show SD. Dotted line is the NH mean score.*

In the PCD test the music group on average gained 26% (P = 0.008), while the control group gained 18% (P = 0.016). The difference in the increase of the two groups is not significant (P = 0.366)*(fig. 2)*.
In the FMI test the difference between the groups' mean scores was not significant (P=0.408). The children with CI's on average performed significantly worse than the NH group (P=0.001) *(fig. 3)*

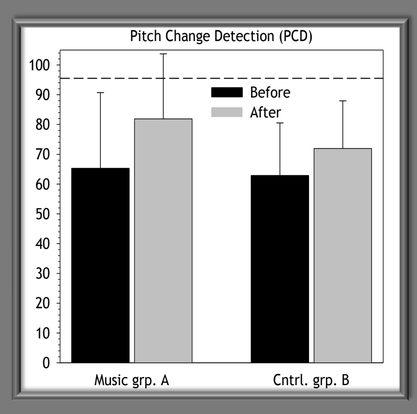


*Fig. 2, PCD test: Mean scores before and after the 3 month intervention period. Error bars show SD. Dotted line is NH mean score.*

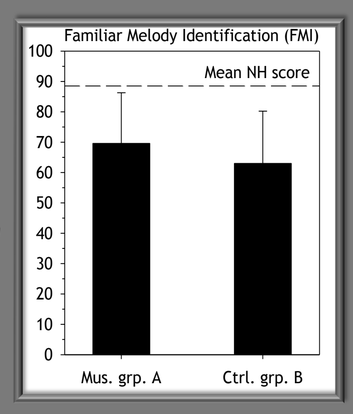


*Fig. 3, FMI test: Mean scores after the 3 month intervention period. Error bars show SD. Dotted line is NH mean score.*

In the three linguistic tests the music group showed an overall average increase ratio of 15% vs. 10 % in the control group. The difference in scores indicates a trend in favor of the experimental group but is not statistically significant (P=0.246)(fig. 4).
We observed a strong correlation between overall music performance and chronological age (Rsqr.=0.539; P=0.0002) but no significant effect of age at implantation (hearing age) (Rsqr.=0.00690; P=0.7203) (fig 5, 6).

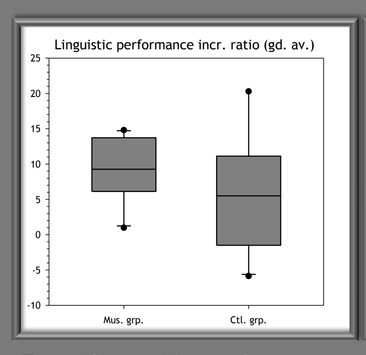


*Fig. 4 linguistic perf. increase*

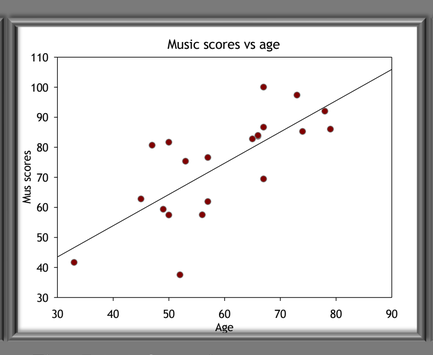


*Fig. 5 total music scores vs age*

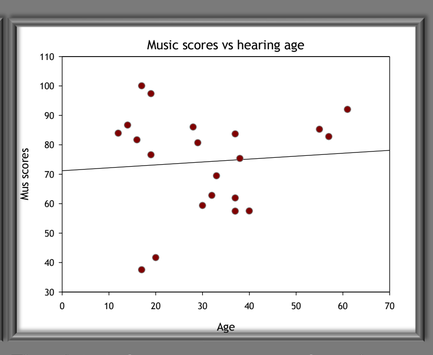


*Fig. 6 total mus. scores vs hearing age*

***Conclusion:*** Group oriented elementary music learning can be beneficial for the auditory development of cochlear implanted children. The obvious enjoyment of the participants, the positive parental feedback (data not presented) and the test results in combination indicate that music offers a valuable and enjoyable supplement to standard auditory-oral therapy.

# A *Reveille* for the Deaf Brain- *musical ear training with cochlear implantees*

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***Background:*** Cochlear implantation (CI) is a surgical treatment that helps deaf people to regain hearing abilities. Successful rehabilitation depends on the brain's ability to adjust to the CI stimulation and the postoperative efforts cf. above. Many CI users achieve good speech understanding but fail in perceiving music and speech prosody. No data, however, are at hand concerning the effects of one-to-one musical ear training with specific focus on musical features like rhythm, pitch, timbre, and music enjoyment, in CI users.

***Participants:*** 16 adult newly operated CI users (21-73 years) were matched in 2 groups: **A,** music group and **B,** control group. *(Table 1)*

| Group | Men | Women | Mean age at project start (years) | Postling. hearing loss | Preling. hearing loss |
|---|---|---|---|---|---|
| Music grp. A | 3 | 5 | 45 (± 16.72) | 4 | 4 |
| Control grp. B | 3 | 5 | 58 (± 8.41) | 6 | 2 |

*Table1. Demographic data for the 2 groups. All subjects were unilaterally implanted. The large difference in age mean is due to one single young subject in the music group.*

***Methods:*** Shortly after switch-on subjects in the music group began weekly one-to-one musical ear training lessons lasting 6 months. Sessions featured playing the keyboard, singing and drumming/tapping + listening exercises. In addition specially adapted audio-visual training material was provided for home practice.

To register the progress in musical discrimination skills, we created a battery that tested discrimination of pitch, rhythm, timbre and melodic contour. The progress in speech perception was tested with the Hagerman test and a specially adapted vocal emotion test. Stimuli were presented in random order in a computer environment.

We used Positron Emission Tomography (PET) to detect possible relative changes in regional cerebral blood flow in auditory brain areas. 4 water scans were run at each of the 3 sessions. As contrasting stimuli multi-talker babble (ICRA) or running speech (Dantale) was played back in random order (fig. 4).

***Results:*** Both groups improved their speech perception scores. During the 6 months period the music group gained 160% (P=0.002), while the control group gained 94% (P= 0.045). The difference in scores indicates a trend in favor of the music group but is not statistically significant (P= 0.387) (fig. 1).

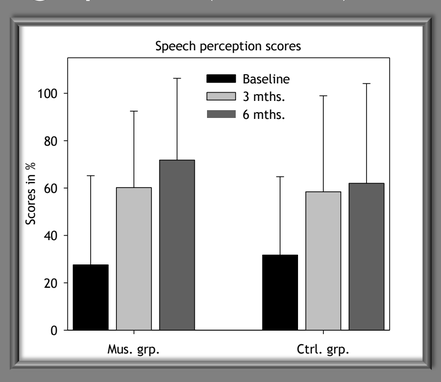



*Fig. 1. Mean speech perception scores*

Music tests: In musical instrument (timbre) discrimination the subjects in the music group on average increased their score by 32% (P=<0.001) vs. 5 % in the control group (P=0.289). The difference in mean increase is statistically significant (P=0.002) (Fig. 2).

The ability to identify a melodic contour improved in the music group with a mean of 46% vs. 13% in the control group. The difference is significant (Mann-Whitney P=<0.001) (Fig. 3).

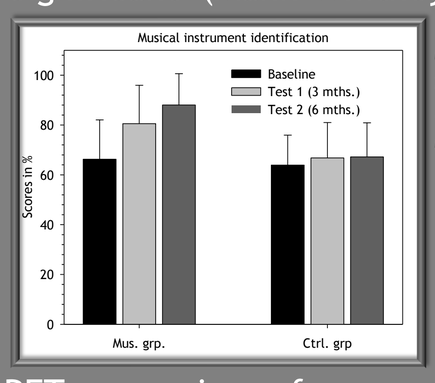



*Fig. 2 musical instrument test. Error bars show SD.*

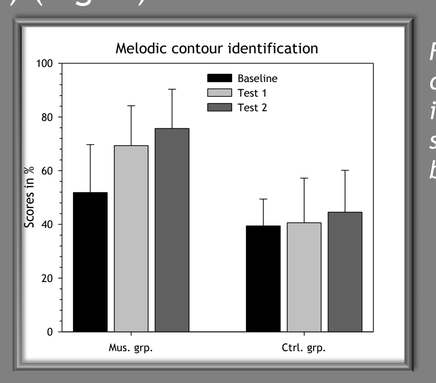
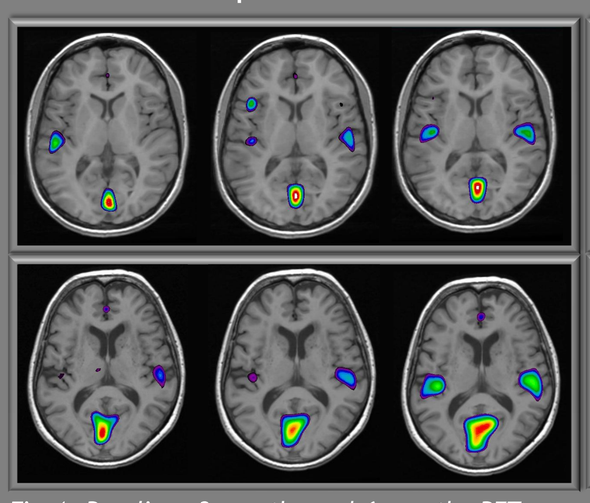
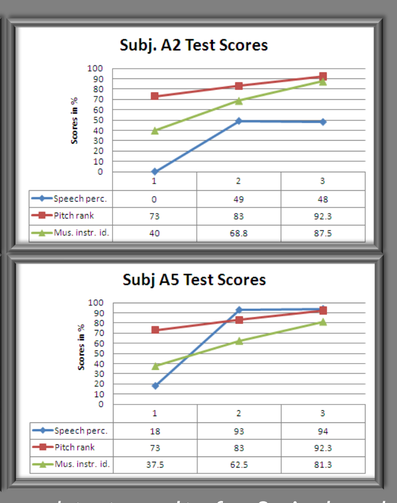



*Fig. 3 Melodic contour identification scores. Error bars show SD.*

PET vs. music performance






*Subject A2: 21 year old prelingually deaf woman.*




*Subject A5: 70 year old postlingually deaf woman; dur. of deafness: 15 y*

*Fig 4. Baseline, 3 months and 6 months PET scans and test results for 2 single subjects from the intervention group showing a synchronous increase in scores/intensity. The activation stimulus is running speech. Activations in the visual cortex (bottom center) show a constant intensity, while the activation in the auditory cortices expand from predominantly unilateral to equally bilateral.*

***Conclusion:*** Like little digital ears, big digital ears also possess the potential to make big changes at incredible speed. The observed progress in auditory capabilities correlated with the cortical changes in the brain, may represent a unique insight into neuroplasticity.

Our results indicate that one-to-one musical ear training has a great potential as a complementary method to improve fine grained auditory skills in CI users. However, to fully review the correlation between test data and PET images further analyses have to be done.

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