Music preference study with cochlear implant recipients using multi-track recordings

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Introduction

Cochlear implant (CI) recipients nowadays often reach near normal speech understanding in quiet environments. However, speech understanding in noisy environments is still rather poor, resulting in an important focus of cochlear implant research on signal processing for improving speech understanding in noise. Also perception of complex pitch has received significant attention in recent years, for improving speaker identification, for tonal language speech perception as well as for music perception. Results on improving complex pitch perception have nevertheless been disappointing so far. Studies on subjective music perception with cochlear implant recipients suggest a preference for simple monophonic melodies and rhythmic sounds, whereas more complex, polyphonic music, such as pop, rock or classical orchestral music is often perceived as unpleasant and noisy [Gfeller,2000&2003][Looi,2007]. The assumption that cochlear implant recipients prefer a more simple or monophonic representation over a polyphonic representation is investigated in this study using multi-track recordings.

Sound material

Multi-track recordings have been collected from well known as well as unknown pop and rock songs. Each recording includes a vocal track with the main melody. The background music may include piano, guitar, bass and drums as indicated in Table 1.

- Individual tracks are mixed down to MONO wave files (44.1 kHz)
- All tracks are normalized in loudness by using the loudness measurement from the ReplayGain specification [ReplayGain].
- Female singer: songs 1 & 3
- Male singer: songs 2, 4, 5 & 6

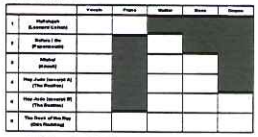

Table 1: Multi-track recordings

Methods

Postlingual CI test subjects



Experiment 1

TASK: The CI test subjects were given a mixing console and multi-track recordings with which they were asked to make an audio mix that sounded most enjoyable to them.

- The multi-track recordings of song 6 are provided in three configurations:
  - Two-channel configuration with vocals and background music
  - Three-channel configuration with vocals, piano/guitar and bass/drum
  - Five-channel configuration with vocals, piano, guitar, bass and drum



- Music is played at a maximum level of 65 dB(A) in free field in a sound treated room. The experiment is running on a laptop with multi-track editing software (Cubase Essential 5) which is connected to the mixing console (Behringer BCF2000).
- The song is presented ten times for every configuration
- Random volume off-set levels are applied to all individual tracks to prevent the subject from using visual cues on the mixing console (0, -2dB, -4dB, -6dB, -8dB).

Experiment 2

TASK: Preference rating experiment comparing audio mixes with predefined relative level settings for the different tracks (Figure 1).

- Experiment 2a: three conditions with different vocals-to-instrument ratio (A/B/C) defined for all songs containing three repeats per pair.
- Experiment 2b: two conditions with attenuated instruments and different bass/drum level (C/D) defined for all songs with drums containing nine repeats per pair.

Pair-wise comparison with preference rating score ranging from *Imperceptible* (0), *Slightly better* (1), *Better* (2), *Largely better* (3) to *Hugely better* (4).

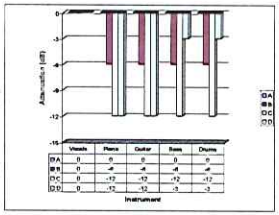

Figure 1: Predefined relative level settings in experiment 2

Results

Experiment 1

Figure 2 shows the results of the mixing console experiment with CI subjects S1-S4 for song 6. The three configurations are presented. The values on the Y-axis indicate the average level setting for each instrument relative to the vocal level.

- *Two-channel configuration*: the instruments are on average preferred at a level 8dB lower than the vocal level. (paired samples t-test: p<0,01)
- *Three-channel configuration*: also preference for attenuated instruments (p<0,01) and preference for bass/drum louder than piano/guitar (p<0,05)
- *Five-channel configuration*: piano, guitar and bass are preferred at a lower level than the vocals (p<0,01); the difference between drums and vocals is no longer significant.

The preferred attenuation of instruments relative to vocals becomes smaller with increasing degrees of freedom (= number of channels).

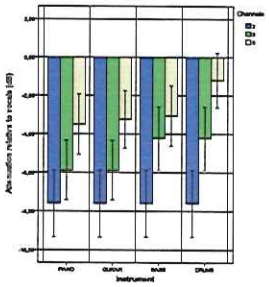

Figure 2: CI preferred audio mix for song 6

Experiment 2a

Pair-wise comparison results are presented in Figure 3 for both normal hearing (N=5) and CI subjects (S3-S7) for pairs A-B, A-C and B-C.

- NH: a clear preference is shown for the condition with equal loudness balance between vocals and instruments (condition A).
- CI: no strong preference for condition A in the average pair-wise comparison results for CI subjects. On the contrary, a trend towards a preference for attenuated instruments (condition B) can be observed.

The preference rating scores for the comparison between condition A and B for both NH and CI subjects are presented as a box plot in Figure 4. Positive scores represent a preference for condition A, whereas negative scores indicate a preference for condition B.

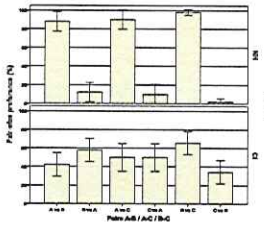

Figure 3: Preference rating for pairs A-B / A-C / B-C with NH and CI

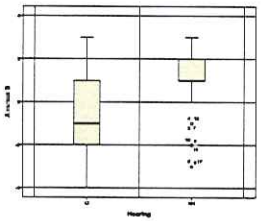

Figure 4: Preference rating scores for comparison A-B with CI and NH subjects

The effect of familiarity with the song and singer's gender is illustrated in Figure 5. For familiar songs and songs with a male singer a significant preference for condition B is observed.

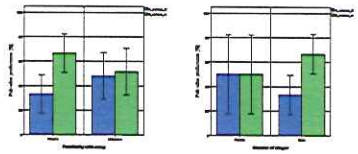

Figure 5: Effect of familiarity and singer's gender on comparison A-B

Results and discussion

Experiment 2b

An additional pair-wise comparison for CI subjects (S3-S7) is presented in Figure 6.

Two conditions with attenuated instruments and different bass/drum level are compared (C-D).

- The top graph shows a clear preference for the condition with boosted bass/drum track (condition D).
- The graph below illustrates with a box plot the preference rating scores for all CI subjects individually in the pair-wise comparison between condition A and C (blue) and between condition D and C (green). Even subjects S3 and S7, who clearly preferred condition C over condition A, prefer condition D over condition C, which means that also the CI subjects who clearly preferred an audio mix with attenuated instruments, prefer the condition with boosted bass/drum.

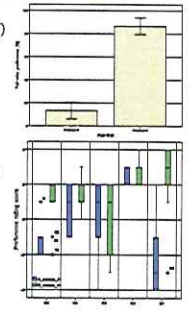

Figure 6: Pair-wise comparison C-D

Discussion

- The CI preference for a less complex audio mix with clear vocals and attenuated instruments is in agreement with the findings of [Gfeller, 2003], in which a negative correlation has been described between complexity and appraisal for CI subjects. For NH subjects this correlation is positive, which corresponds to a preference for more complex songs without attenuated instruments.
- The presence of clear rhythm and beat and the ability to follow the musical score or words are among the top factors to enhance musical enjoyment for CI subjects according to [Gfeller, 2000], which is confirmed in this study by the preference for an audio mix with boosted bass/drum track and clear vocals. An effect of singer's gender has been shown. In music with a female singer lyrics are in general easier to follow, whereas with a male singer CI subjects require or prefer attenuated instruments for this.
- Along with the enjoyment for rhythm and beat, the performance on rhythmic pattern perception tasks with CI subjects is comparable to normal hearing [McDermott, 2004] [Looi, 2008].

Conclusions

- A commercially available audio mix might not be the ideal audio mix for CI subjects
- NH subjects show a clear preference for an equal loudness balance between the vocal melody and the different instruments.
- The clear preference for equal loudness balance is not present in the results with CI subjects.
- For the songs provided in this study, CI subjects tend to prefer an audio mix with clear vocals and attenuated instruments, especially for known songs and songs with a male singer.
- Given an audio mix with attenuated instruments, all CI subjects prefer a boosted bass/drum track.

Acknowledgement

We would like to thank all CI and NH test subjects for participating in this music experiment. Also thanks to all people involved in collecting and recording the multi-track recordings (in alphabetic order): Anthony Claeys, Bart Delacourt, Bart Dirckx, Ellen Peeters, Gunter Peeters and Michel Verkempinck. This work was supported by a Baekeland PhD grant of the Institute for the Promotion of Innovation through Science and Technology in Flanders (IWT090274) and Cochlear Technology Centre Belgium.

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