Increasing Frequency Intervals Improves Melody Recognition in Cochlear Implant Users

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Key words

cochlear implant, music perception, melody recognition, frequency modulation

Introduction

It is well known that most of the cochlear implant (CI) users have difficulties in music perception (McDermott 2004). Generally, CI-users rate the quality of musical sounds as less pleasant than normal hearing (NH) listeners. Usually, CI-users score satisfactorily on rhythm identification tasks. However, pitch perception without additional temporal cues as well as perception of timbre (e.g. identification of musical instruments) are rather limited (Gfeller & Lansing, 1991). The recognition of melodies is poor even with sophisticated multi-channel speech processors (Gfeller et al., 2002; Kong et al., 2004). The aim of this study was to investigate melody recognition of well-known melodies, presented with increased distances between the notes. Another objective was to relate this performance to the results of a frequency discrimination task.

Methods

Participants: Ten cochlear implant subjects, five woman and five men, and five normal hearing volunteers were investigated.

Melodies: Each subject was asked to choose 10 out of 23 nursery songs well known to most German people. They all consisted of a maximum of six different tones. Melodies were presented as a sequence of sinus tones in four different conditions. Besides the original version, the songs were played in three different frequency spread (FS) conditions (figure 1): FS1: musical intervals were stretched by a factor of 4. A semi-tone step in a tune becomes a step of four semitones, a major third. FS2: An artificial octave was created within a pitch range from 130.8 Hz to 3500 Hz. FS3: each note of the song was played in a separate octave.

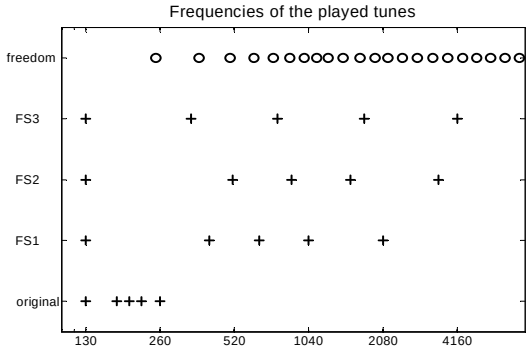

Figure 1: Allocation and manipulation of frequencies

Equipment and Procedure: Two sessions, one with and one without rhythm were performed. Melodies were presented to the subjects in an acoustically shielded room at a comfortable level selected for the individual between 65 and 75 dB SPL.

In each of the sessions, each melody was presented three times in each of the four frequency versions (i.e. original, FS1, FS2 and FS3) in random order. For the session with rhythmic melodies, an additional "rhythm only" version was also presented three times.

In a second experiment, frequency discrimination was determined using a 2AFC algorithm. Frequency steps were 1/4 tones in five frequency ranges (200 Hz, 500 Hz, 1 kHz, 2 kHz and 4 kHz) and the 1 up 2 down adaptive staircase rule was applied. Since this experiment is still in progress, results of this second experiment will be presented later on.

Results

Normal hearing subjects and cochlear implant patients exhibited large inter-individual differences. While some of the patients were able to identify songs in all conditions others only judged on the basis of rhythm.

As shown in figure 2, the NH subjects nearly identified 100 % of all nursery songs played with rhythm. The NH subjects had a lower performance in identifying the "rhythm only" version and scored only 70 % correct. This version was also the most difficult for the CI-user group. Adding pitch information increased the mean identification scores from about 43 % to in between 50 % and 63 %. However, this increase compared to the "rhythm only" version was only significant for the FS1 condition ($p=0.0254$).

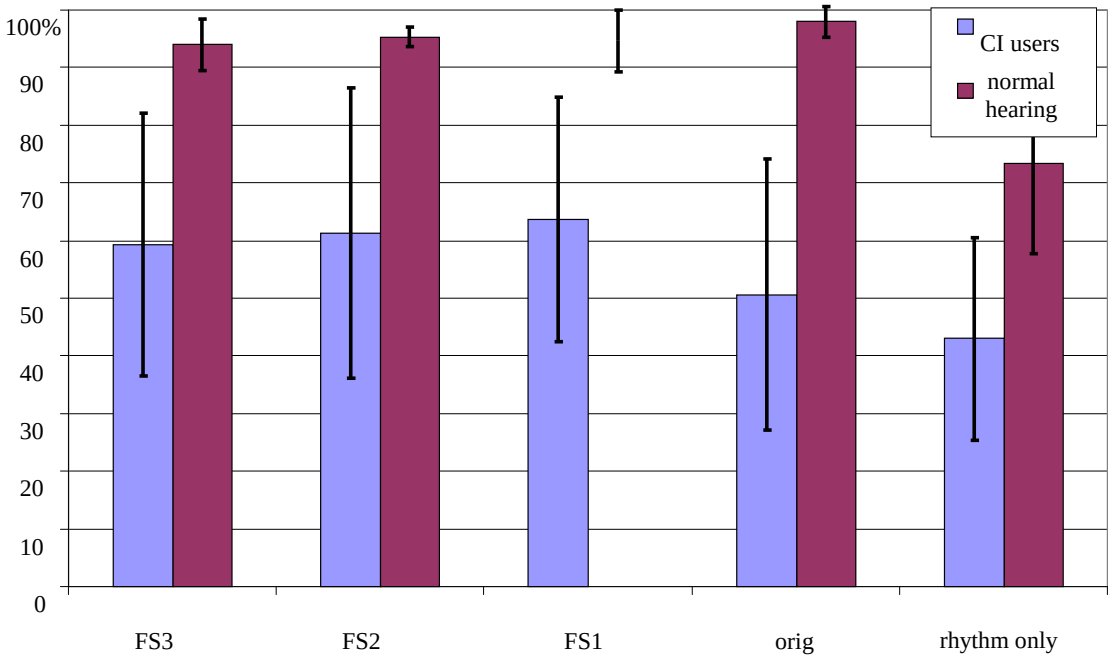

Figure 2: Melody recognition with rhythm

For melodies with excluded rhythmic information, both subject groups demonstrated poorer performance as shown in figure 3. For the NH subjects, the melodies presented with the FS2 and FS3 modifications were significantly less identified (p=0,0397 for both), whereas the CI-user group showed better results for all frequency manipulated versions compared to the original version ((p=0.0149 for FS3, p=0.0250 for FS2, p=0,0206 for FS1). There were no significant differences in between these three versions.

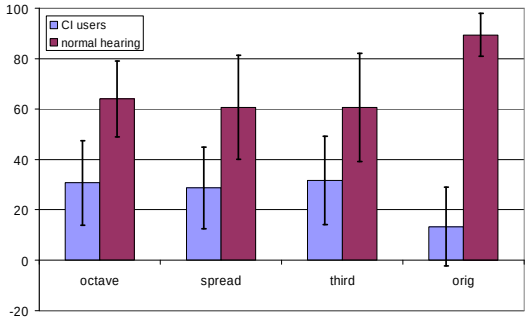

Figure 3: Melody recognition without rhythm

Discussion

In CI subjects, the recognition of melodies is rather limited. Inclusion of rhythm cues leads to a gain in recognition of about 30% for both groups, the CI-users and the NH subjects. Whereas NH subjects did not benefit from (any of) the new frequency conditions, CI subjects demonstrated an increase in recognition scores for melodies presented with an increased frequency range. This benefit was observed for both conditions, with rhythm and without rhythm. The different types of the frequency configurations did not result in significantly different melody recognition scores.

Conclusions

These results indicate that music perception might be increased on the basis of individually modified frequency allocations.

Literature

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