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Pitch discrimination for different musical instruments with cochlear implant simulations

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Aim: People with Cochlear Implants (CI) often report difficulties in listening to music. One reason is a limited perception of pitch and timbre. In this study the performance on discrimination of musical pitch with cochlear implants is investigated by simulations of CI.

Method: In a psychophysical experiment the difference limen for musical pitch discrimination were determined with stimuli processed by sine-excited vocoders which were presented to 20 normal hearing subjects. Unprocessed stimuli were presented to a normal hearing control group. Three notes were presented in a 3AFC-paradigm with one note higher than the other notes which should be identified by the subjects. To investigate the influence of the instrumental family pure tones and complex tones of seven instruments (clarinet, piano, trumpet, violin, celesta, harpsichord and guitar) in two octaves and additional pure tones were used. The acoustic stimuli were generated with a MIDI-synthesizer and presented in free field.

Results: Averaged over the octaves the mean of the determined difference limen was for pure tones (1.5 semitones) significant lower than for piano (2.9 semitones), guitar (2.5 semitones), harpsichord and trumpet (both 2.2 semitones). The limen of the other instruments were 1.9 semitones (violin) and 1.7 semitones (celesta and clarinet). The limen determined in the lower octave (2.4 semitones) were significant higher than the limen of the upper octave (1.7 semitones). The determined limen varied substantially between the subjects. The difference limen determined with unprocessed stimuli were mostly at the lower limit of the experiment at one semitone and therewith clearly lower than the limen determined with the processed stimuli.

Conclusion: The results show that the perception of musical pitch with processed stimuli is different for various instruments and altogether worse than with unprocessed stimuli. The time-frequency analysis of the acoustic and electric stimuli suggests that the number and the distribution of the harmonics and the attack of a tone influence the pitch perception.