MUSICAL TIMBRE PERCEPTION INVESTIGATED USING FORWARD-MASKING

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There is growing general interest in the perception of musical sounds by cochlear implantees. This study was aimed at the perception of one specific aspect of musical timbre, the shape of steady-state frequency spectra. The relationship of the physical and internal spectral shapes was investigated using a forward-masking technique. In addition, the ability of subjects to identify and discriminate selected musical sounds was tested in two related experiments.

Two different groups of subjects, all users of the Cochlear Ltd. CI22 device, participated in this study. The first (N=2) were presented with sounds from a MIDI sampler/synthesizer, connected to their regular Spectra-22/SPEAK processor. The second group (N=3) received stimulus patterns via a processor under the direct control of a PC. The stimulus patterns for the second group represented the sounds of the synthesizer/sampler, though in this configuration the exact electrode stimulus parameters could be specified. 10 musical sounds were used, 5 instruments: oboe, organ, cello, bell and synthesizer (sawtooth); and 5 sung vowels: /a/, /e/, /i/; /u/, /o/. Each sound had a fundamental frequency of 493.9 Hz, and a duration of 200 ms.

These 10 sounds were used as masking stimuli for the measurement of the internal spectra, using a forward-masking paradigm. Internal spectra were represented as sets of forward-masked thresholds for 20 ms probe tones, which were harmonic-frequency pure-tones for the Spectra-22 group, and single-electrode probe stimuli for the direct-stimulus group. Overall, the shapes of the physical and internal spectra were related in that the peaks and dips in each were located at similar frequencies for the Spectra-22 group, or similar electrode numbers for the direct-stimulus group. The direct-stimulus group showed a more precise relationship between the two types of spectral shapes. A clear yet smaller secondary peak was frequently observed in the internal spectra for electrodes at the basal end of subjects' arrays, possibly due to a spread of excitation from stimuli on the apical electrodes. Similar secondary peaks were not as clear for apical electrodes when stimuli were presented more basally.

For experiment 2, subjects discriminated the 10 musical sounds, presented in all possible pairs, using a 4IFC design. All instrumental sounds could be significantly discriminated, with average scores of 100% for the majority of pairs. Most vowel discrimination scores were lower, though still significant. Some subjects could not significantly discriminate the pairs /ɔ/+/u/, /ɔ/+/ʌ/, /ɔ/+/ɛ/, /a/+/u/, or /u/+/ɛ/.

For the third experiment, subjects identified the instrumental source sounds by their everyday names, using the closed set of instruments used, and without training. In most cases, identification scores were low, but still significant, from 30% to 40%. One subject scored 70%, and another could not significantly identify any sounds.

In conclusion, most sounds could be discriminated, though the difficulty in identifying them highlights the pertinence of temporal cues. The shapes of the internal spectra reflected those of the physical spectra, and for pairs where discrimination was difficult, the two internal spectra showed little difference. Thus, the detail in the internal spectra may reflect the information available for discrimination.
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