Sensitivity to temporal fine structure probed with pulse-spreading harmonic complexes

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Abstract

Temporal fine structure (TFS) is assumed to play an important role in both pitch and speech processing in normal hearing (NH) listeners. However, there is still some debate on how TFS is exactly coded in the auditory periphery. Moore and Sek (2009) provided evidence that NH subjects are sensitive to TFS at very high frequencies in stimulus conditions where spectral cues should not be present. This is important because it implies that neural phase locking may still provide useful information above 4000 Hz where it is commonly believed to be absent. Here, we examine sensitivity to TFS using different stimuli than the frequency-shifted complexes used previously.
Pulse-spreading harmonic complexes (PSHCs) are spectrally-dense complexes with a low f0 (here 2 Hz). The phase of the components is set so that the envelope rate can be manipulated independently from the f0. Here, we use a special case of PSHCs for which the TFS peaks are shifted from one envelope period to the next. For upward PSHCs (u-PSHC), the TFS peaks are progressively advanced, yielding a rising pitch percept across the stimulus while for downward PSHCs (d-PSHC), the peaks are progressively delayed, yielding a falling pitch percept. In Experiment 1, subjects heard u-PSHC, d-PSHC and regular (in)harmonic complexes bandpass-filtered between 2000 and 2540 Hz and were asked to identify whether the pitch was rising, falling or flat in a one interval, 3AFC task. The experiment was repeated at three envelope rates of 98, 200 and 450 pps. For the highest rate, subjects correctly identified the direction of the pitch change while for the lowest rate, the stimuli could not be discriminated. This shows that there is an envelope rate under which the auditory system is insensitive to changes in TFS.

This lower rate limit of TFS sensitivity was measured in Experiment 2 using an adaptive 3I2AFC odd-one-out task where subjects heard two d-PSHC and one u-PSHC which they had to pick. The stimuli were bandpass filtered in seven frequency regions with lower cutoff frequencies (Fc) varying from 250 Hz to 11200 Hz and were presented in a TEN background. The lower limit significantly increased from 42 pps to 710 pps with increases in Fc. The ratio between Fc and the envelope rate at threshold also increased from 6 to 18 when Fc increased from 250 to 2000 Hz, then remained flat for further increases in Fc and slightly decreased in the highest frequency region. For low frequency regions, this lower limit resembles the lower limit of melodic pitch measured by Pressnitzer et al. (2001). The results obtained in high frequency regions suggest that TFS may still convey pitch information at very high frequencies (10 000 Hz) when the rank of the lowest harmonic present in the pass-band is

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18, and all harmonics presumably unresolved, thereby corroborating the findings of Moore and Sek (2009). Additional experiments investigating how TFS information is coded are currently being performed.

References

Moore and Sek (2009) JASA 125:3186-3193
Pressnitzer et al. (2001) JASA 109:2074-2084