Masking patterns of stimuli exhibiting enhanced detection for spectrally notched precursors

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Introduction

A narrow-band signal is subjected to less masking from a simultaneous notched masker if it is preceded by a precursor that occupies the same spectral region as the masker (e.g., Viemeister, 1980; Carlyon, 1989; McFadden, 1989). This perceptual enhancement effect is not observed at the level of the auditory nerve (Palmer et al., 1995), but is evident in a population of neurons in the inferior colliculus (Nelson and Young, 2010). The current study psychophysically measures the internal representations of the signal and masker in enhancement experiments by obtaining temporal masking patterns, to provide further insight into the origin of the enhancement phenomenon.

General methods

Enhancement measurements:

•Signal: narrowband noises spectrally centered at f_c (randomly chosen from an octave range geometrically centered at 2 kHz for each trial).

•Masker and precursor: notched noises with lower bands between $1/2.4f_c$ and $1/1.2f_c$ and higher bands between $1.2f_c$ and $2.4f_c$.

•Signal detection threshold was estimated using 2-I, 2-AFC procedure with a 2-down, 1-up adaptive track.

Masking pattern measurements:

•Identical signal, masker, and precursor, as in the enhancement measurement.

•*Pure-tone probe:* a pure tone at f_c with a duration of 6 ms including 2-ms onset and offset ramps.

•In separate conditions, the probe was presented at delays of -50 to 200 ms relative to the signal/masker onset.

•Probe detection threshold was estimated using 2-I, 2-AFC procedure with a 2-down, 1-up adaptive track.

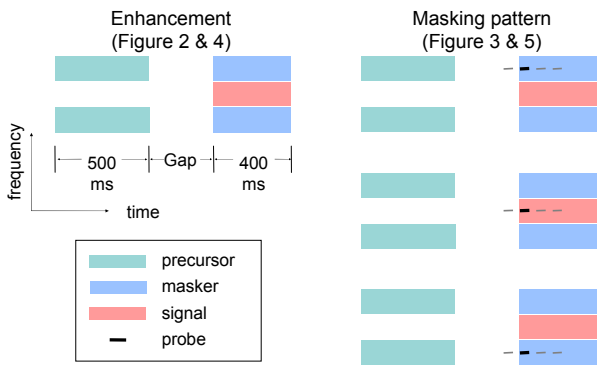

Figure 1: Schematics of stimulus spectrograms for the enhancement and masking pattern measurements in the current experiment. Potential probe placement in the masking pattern measurement is illustrated using black and grey lines.

Effect of masker-precursor gap

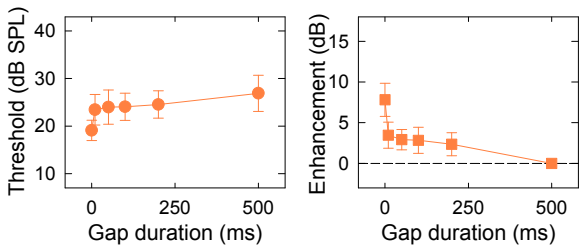

Figure 2: Left panel: the average detection threshold of the signal in the enhancement measurement across 4 young, normal-hearing listeners, plotted as a function of the temporal gap between the offset of the precursor and the onset of the masker. Right panel: the amount of enhancement, as the threshold increment from the 500-ms gap condition. Error bars indicate ± one standard error of the mean. The masker and precursor spectrum level was fixed at 30 dB SPL.

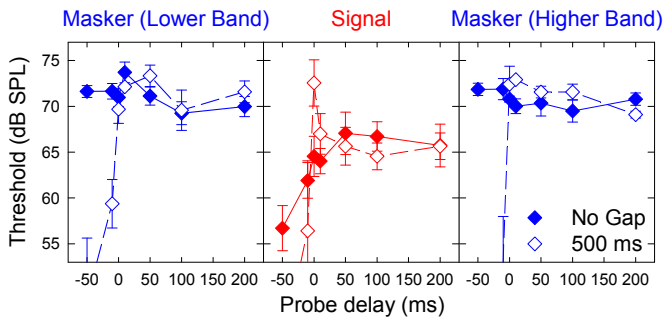

Figure 3: The average making patterns, functions relating probe thresholds to probe delay, for the signal (red) and the masker (blue). Filled and open symbols indicate the conditions where the precursor-masker gaps were 0 and 500 ms, respectively. Error bars indicate ± one standard error of the mean. The masker spectrum level was 30 dB SPL; the signal spectrum level was 25 dB SPL. Results shown are based on the same four listeners who participated in the corresponding enhancement measurements (Figure 2).

References

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Effect of precursor level

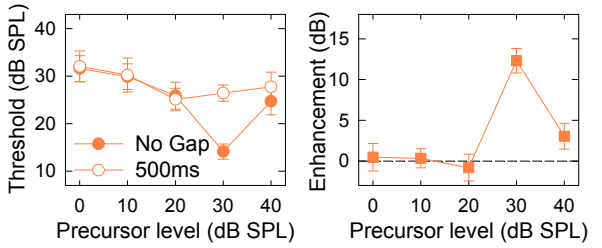

Figure 4: Left panel: the average detection threshold of the signal in the enhancement measurement across 4 young, normal-hearing listeners, plotted as a function of the precursor level. Right panel: the amount of enhancement, as the threshold increment from the 500-ms gap condition. Error bars in the figure indicate ± one standard errors of means. The masker spectrum level was fixed at 30 dB SPL.

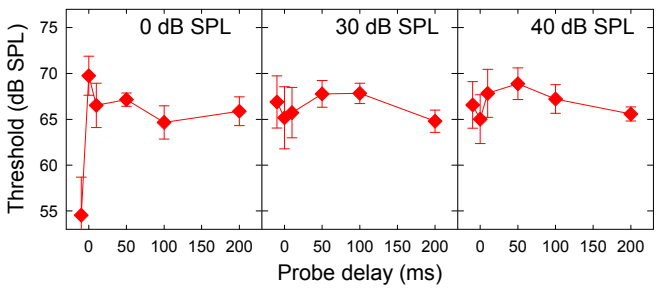

Figure 5: The average making patterns of the signal at three different precursor levels (in separate panels). The precursor-masker gap was 0 ms. Error bars indicate ± one standard error of the mean. The masker spectrum level was 30 dB SPL; the signal spectrum level was 25 dB SPL. Results shown are based on the same four listeners who participated in the corresponding enhancement measurements (Figure 4).

Conclusions

•The amount of enhancement decreases with increasing precursor-masker gaps (Figure 2).

•When no gap is present, the enhancement phenomenon seems to require equal precursor and masker levels (Figure 4). This finding does not support an "adaptation of suppression" hypothesis (Viemeister and Bacon, 1982), which would predict larger amount of enhancement at higher precursor levels.

•When the enhancement occurs, the internal representation of the masker is not strongly affected by the precursor (Figure 3, blue curves).

•On the other hand, the internal representation of the signal undergo a significant shape change: from a overshoot-like pattern to a gradual excitation build-up (Figure 3 and 5, red curves). On average, a broad peak is formed 50-100 ms after the masker/signal onset.