Forward masking of amplitude modulation detection includes a large perceptual effect

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**Background**

Forward masking of amplitude modulation (AM) detection is tuned: target sinusoidal AM (SAM) is masked more easily, for example, by masker SAM with a similar, rather than dissimilar, AM rate [Wojtczak and Viemeister, J. Acoust. Soc. Am. 118, 3188–3210 (2005)]. **Two hypotheses:** Two hypotheses have been offered to account for this finding: (1) it is a sensory effect related to interference between the target and masker within a modulation channel tuned to the target’s AM rate; (2) it is a perceptual effect related to the perceived similarity of the acoustically similar AM. The purpose of this study was to examine these two alternative possibilities.

**Approach**

We manipulated the perceived similarity of the target and masker modulators in a forward masking of AM detection paradigm. We reasoned that if the pattern of forward masking that was observed across maskers differed from what was expected based on within-AM-channel interference, it would indicate that the perceived similarity of the target and masker modulators was an important factor in producing masking. More specifically, we examined whether a square-wave masker modulator would produce as much masking of its third harmonic as a masker modulator comprising the third harmonic alone, the former being perceptually dissimilar from, and the latter being perceptually similar to, the third-harmonic target [cf. Nachmias et al., Vis. Res. 13, 1335-1342 (1973)]. **Predictions of the two hypotheses:** The within-AM-channel interference hypothesis (1) predicts that the square-wave masker should produce at least as much masking as the third-harmonic masker; the perceptual similarity hypothesis (2) predicts that the square-wave masker should produce less.

**Methods**

- **Task:** AM detection with and without a forward masker modulator
- **Observers:** Three (highly experienced in psychophysical tasks)
- **Carrier:** Broadband noise (650 ms total duration; 60-dB SPL overall level)
- **Target:** 96-Hz SAM starring 540 ms after carrier onset (6-cycles/62.5 ms total duration)
- **Maskers:** Applied to initial 500 ms of carrier (see Fig. 1 and 2 for details)
- **Procedure:** SI-SAF adaptive; three-down one-up stepping rule

**Conditions**

![Fig. 1](image1.png) Example envelopes for the different conditions. Each panel shows the envelope for a different condition with the condition names given by the inset text: N: No masker; f/3: 32 SAM with a modulation index (m) of 1. f/3-sq: 32-Hz square wave with a fundamental that had a modulation index of 1. Note that the square wave only included the first 99 odd harmonics of 32 Hz, hence the imperfect square shape. f: 96-Hz SAM with a modulation index of 0.33; i.e., the modulation index of the 96-Hz third harmonic of the 32-Hz square wave (cf. Fig. 2). The target (t) was 96-Hz SAM. In the experiment, the masker modulators had the modulation indices shown here; the modulation index of the target was the independent variable but in these examples is 0.5.

![Fig. 2](image2.png) Amplitude spectra of the masker envelopes, i.e., the first 500 ms of the envelopes shown in Fig. 1.

**Results**

![Fig. 3](image3.png) Target-modulation-detection thresholds for the three observers and the mean across observers (different panels, see inset text) for all conditions. Error bars in the individual observer plots give +/- 1 standard deviation across the four threshold replicates provided for each condition. Error bars in the group-mean plot give +/- 1 standard error of the mean.

**Discussion**

The square-wave masker (f/3-sq) did not produce as much masking of its third harmonic as the masker comprising the third harmonic alone (f). **Returning to the two hypotheses:** The results, therefore, were more consistent with the perceptual similarity hypothesis (2) than the within-AM-channel interference hypothesis (1). For example, one potential mechanism of interference is adaptation of a modulation channel tuned to the target’s AM rate [e.g., Malone et al., J. Neuro, 35, 5904-5916 (2013)]. If adaptation was the primary factor responsible for producing masking, masking should have increased with the power of the masker at the output of the target-AM channel. This is not what we found (Fig. 4).

**Conclusions**

The results suggested that forward masking of AM detection includes a large perceptual effect; masking did not conform to expectations based on within-AM-channel interference. Similar findings have been reported previously [Wojtczak and Viemeister (2005); Fullgrabe et al., Hear. Res. 405, 108244 (2021)]. An important new finding reported here, however, is that masking decreased with target-masker dissimilarity, despite an increase in masker envelope power. Dissimilarity may not have been the only factor driving this effect, however; across-AM-channel suppression, for example, could have played a role [cf. Shannon, J. Acoust. Soc. Am. 59, 1460-1470 (1976)].

**Acknowledgements**

This work was supported by NIH-NIDCD grants No. R01DC05454 and F31DC019819.