Comodulation masking release with tone pips added out of phase to the valleys of a sinusoidally amplitude modulated pure tone

Deborah A. Fantini, Roel Delahaye, and Ray Meddis

Department of Psychology, Essex University, Wivenhoe Park, Colchester CO4 3SQ ENGLAND

Abstract: The present work compares signal detection performance in several conditions related to comodulation masking release: with or without six flanking bands, which are either comodulated with the on-frequency band or not comodulated. Signals can result in an increase in level in the valley of a fully modulated OFB, or in a decrease in level in the valley of a 50% modulated OFB, when added in phase or out of phase to the carrier of the OFB, respectively. For both types of signal, the addition of correlated, fully modulated FBs had no effect on detection performance. And for both in-phase and antiphase signals, performance with correlated FBs was always better than with uncorrelated (CMR), and improvement increased with FB modulation depth.

INTRODUCTION AND METHOD

Typically in paradigms of comodulation masking release (CMR), a signal is added to a modulating masker which has the same frequency as that of the signal (the on-frequency band, OFB). The signal is usually of the same duration as the OFB, or has a duration which spans at least several cycles of modulation. This type of signal means that the addition of the signal to the OFB increases the amplitude of the OFB envelope, both in its valleys and its peaks. Moore Glasberg and Schooneveldt (1) addressed whether flanking bands (FBs) facilitate detection of signals which are present during part(s) of the OFB envelope, rather than during its entire duration.

Moore et al. (1) used signals added in phase to the valleys of a fully modulated masker, or signals added out of phase to the valleys of a 50% modulated OFB. With in-phase signals, threshold for detecting the signal was lowered when fully modulated comodulated FBs were added. However with antiphase signals, a strikingly different result occurred. Moore et al. set the signal level so that it completely cancelled the level of the OFB in the valleys. In this condition, subjects detected the signal nearly 100% of the time. However when 50% modulated correlated FBs were added, performance was reduced nearly to chance. This dramatic demonstration suggested that CMR occurs only when signals cause an increase in energy to the valleys of the OFB.

The present research intended to investigate the above result further. In essence, when the signal is added in phase to a fully modulated OFB, the subject is discriminating between a fully modulated OFB in the non-signal interval and a less than fully modulated OFB in the signal interval. When signals are added out of phase to the valleys of a 50% modulated OFB, the opposite is true. Thus it is not clear why the effect of correlated FBs should be different. One possibility is that the FBs had the same modulation depth as the OFB, which depended on whether the signal was in phase or out of phase. The difference in the depth of the FBs may have led to the different results. For this reason, the present research uses both 100% and 50% modulated FBs.

The OFB was a 700-Hz pure tone, at 50 dB SPL before modulation, with a total duration of 500 ms, and was modulated at a 10-Hz rate, yielding 5 complete modulation cycles. The signal consisted of three 700-Hz tone pips, each with a 50-ms total duration, including a 20-ms raised cosine rise and decay portion, with a 50-ms interval between pips. This signal was added either in phase or out of phase to the last three valleys of the OFB. Signal detection with only the OFB is the Reference condition. Four comparison conditions were also run. Six FBs were added at 300, 400, 500, 900, 1000, and 1100 Hz, which were either comodulated with the OFB (the Correlated condition) or which had modulation phases which varied in 90° intervals for each 100 Hz (the Quad condition), and which were either 50% or 100% modulated.

RESULTS AND DISCUSSION

First consider the data from the signals added in phase to fully modulated OFBs. The two subjects performed similarly, so the mean detection thresholds for 71% correct performance are presented in Table 1 below.
Table 1. Mean (and s.e.) detection threshold (dB) for signals added in phase to the OFB

<table>
<thead>
<tr>
<th>Reference</th>
<th>50% Corr FBs</th>
<th>100% Corr FBs</th>
<th>50% Quad FBs</th>
<th>100% Quad FBs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>27.99 (0.9)</td>
<td>27.04 (2.3)</td>
<td>26.38 (1.0)</td>
<td>40.19 (2.1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>42.84 (2.2)</td>
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The first thing to notice from Table 1 is the absence of a CMR relative to the Reference condition. On average, the addition of comodulated FBs did not affect detection of the signal. The addition of FBs in quad phase impaired performance on average. The elevation in threshold relative to the Reference threshold is about 12-15 dB, which is comparable to the elevation in threshold using quad phase FBs observed by Moore et al. (1).

Consider now the data obtained using antiphase signals, presented in Fig. 1 below.

Consider first performance with no FBs (open circles). Percent correct detections decline systematically with decreasing signal levels. Now compare performance using 50% modulated correlated FBs (open upward-pointing triangles). Moore et al.’s (1) subjects performed at chance in this condition. The present subjects performed much better than Moore et al.’s: percent correct drops only to 92% correct rather than to chance at the highest signal level, and does not approach chance until the signal level has decreased by 12 dB. Increasing the modulation depth of the FBs improves performance relative to 50% modulated FBs, but not quite to that achieved without FBs, a pattern similar to that observed using in-phase signals. The addition of FBs in quad phase (downward-pointing triangles) impairs performance relative to all other conditions, with the degree of impairment increasing as modulation depth increases (compare open and filled symbols). Again, this result is contrary to that observed by Moore et al. in that their subjects actually did better with quad phase FBs than with correlated FBs.

To summarize, subjects in the present experiment were able to detect changes in the valleys of the OFB envelope, whether those changes resulted in an increase of energy or a decrease in energy. While the addition of correlated FBs did not improve performance relative to no FBs using either in-phase or antiphase signals, it did not significantly impair performance either. Relative to quad phase FBs, performance with correlated FBs always improved performance; this improvement increased with increasing modulation depth of the FBs regardless of whether the signal was added in phase or out of phase to the OFB. Thus it appears that increases to OFB valleys is not the only type of envelope change which gives rise to good performance when comodulated FBs are present.

REFERENCES