

Title: Probing AM detection in noise with reverse correlation

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Abstract:

It is now acknowledged that part of the deleterious effect of a steady noise on the auditory perception of amplitude-modulation (AM) is due to the masking of useful modulations in the signal by the intrinsic random envelope fluctuations arising from the filtering of noise into cochlear critical bands (Dau et al., 1997, 1999). Reverse correlation techniques are particularly suitable for exploring the confounding effect of noise on perception (Murray, 2011), in particular for auditory perception (Varnet et al., 2013). However, the only attempt at applying this technique to an AM-detection-in-white-noise task yielded mixed results (Ardoint et al., 2007).

Here, we analyzed the effects of a white noise on AM perception, in order to unveil the subject's decision strategy in the task. More specifically, participants were required to detect the presence of a 4-Hz sinusoidal AM target applied to a 1-kHz tone carrier embedded into a white noise (yes/no task, 3.000 trials/participant). Then, using a reversed-correlation analysis on the collected data, we were able to reveal which aspects of the noise's temporal envelope influence the listener's responses. These results were compared with simulated data from two standard modulation-perception models: the Modulation Filterbank model (MFB; King et al., 2019; a simplified version of the Perception Model [PEMO] from Dau et al., 1997) and the Envelope Power-Spectrum Model (EPSM; Ewert and Dau, 2000).

The analysis revealed that human listeners are able to track the modulation peaks in the 4-Hz target, similar to the MFB model. However, they also show a marked temporal decay (giving more weights to the onset of the stimulus compared to the offset) and a consistent phase shift with the ideal template. Although none of the two models perfectly account for the experimental data, the comparison suggests that human listeners may in fact combine two different regimes (envelope-phase-sensitive and envelope-phase-insensitive) when performing AM detection tasks.

This study offers a direct illustration of the role of intrinsic modulations of noise maskers on auditory perception in noise: at a given signal-to-noise ratio, some noise samples have a greater influence than others depending on the exact temporal distribution of envelope energy. We also demonstrate that this effect of noise can be used to probe AM detection in noise in real and simulated listeners.