18 Forward Masking: Temporal Integration or Adaptation?

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1 Introduction

When a short signal tone is presented after a noise or tone masker, the threshold for detecting the signal is raised the smaller the gap duration between the masker and the signal is. This phenomenon is termed forward masking and refers to the fact that a masker affects the signal threshold when both are presented in a non-simultaneous, consecutive manner. With increasing temporal separation, signal threshold usually drops to performance in silence when the gap is in the region of hundreds of milliseconds. As a possible explanation for forward masking, mainly two different mechanisms have been discussed in the literature: (i) continuation or persistence of neural activity (e.g., Plomp 1964; Oxenham and Moore 1994), referring to temporal integration of neural activity at presumably higher stages than the auditory nerve; (ii) neural adaptation (e.g., Duifhuis 1973; Nelson and Swain 1996), assuming adaptation at various levels of the auditory pathway (including high levels). A third possible source for interaction of masker and signal is linked to the ringing of the auditory filters but is generally assumed to be negligible for signal frequencies of 1 kHz or higher (e.g., Vogten 1978). It is still unclear whether temporal integration or adaptation can better account for forward masking in various stimulus configurations (Oxenham 2001), nor have both mechanisms been compared directly in a common modeling framework to investigate their relation.

The current study compares two well established models of temporal processing in the auditory system using a unified modeling framework: (i) the temporal-window model (e.g., Oxenham and Moore 1994) representing a temporal-integration mechanism and (ii) the adaptation-loop model (e.g., Dau et al. 1996) as the representative for the adaptation mechanism. The unified modeling framework shares a compressive, non-linear auditory filter stage and a template-based (optimal detector) decision stage. The question is, whether the temporal-window model and the adaptation-loop model can be considered...
in a unified modeling framework while maintaining their predictive power. Specifically, it is investigated if the two models can help distinguishing between persistence and adaptation, the two hypothetical mechanisms underlying forward masking.

2 Methods

2.1 Procedure and Subjects

A three-interval, three-alternative forced-choice adaptive procedure (two-down, one-up rule) was used to determine detection thresholds in the simulations and experiments. The step size was 8 dB at the beginning and was halved after every two reversals, until it reached a minimum of 1 dB where eight reversals were obtained for threshold estimation. The starting level of the signal was 90 dB SPL. Two subjects participated as a control group. The stimuli were presented to one ear via headphones (AKG K-501) in a double-walled, sound-attenuating booth.

2.2 Stimuli

Two forward masking experiments with signal tones at 1 and 4 kHz were conducted to test the models. At 1 kHz, a 10-ms, Hanning-windowed signal was used. The masker was a 200-ms, 77-dB, 20- to 5000-Hz frozen noise, no ramps were applied. The experimental design was the same as in Dau et al. (1996). At 4 kHz, a 12-ms signal, including 2-ms, raised-cosine ramps, was added to a 200-ms, 78-dB, 0- to 7000-Hz, frozen-noise masker. The masker included 2-ms, raised-cosine ramps. The design was the same as in Oxenham (2001). The offset-offset time of the signal and the masker was varied in the range from −10 to 150 ms, thus including conditions of simultaneous as well as non-simultaneous masking.

3 Models and Predictions

The processing modules of the temporal-window (TW) model according to Oxenham (2001) were implemented. The TW model uses a linear, time-invariant integration after non-linear peripheral processing. The shape of the integration window relevant for forward masking results from two exponential functions with time constants of 4.6 ms and 16.6 ms, added with a weight of 0.17 for the longer time constant. In the nonlinear part, the model uses an instantaneous power-law compression with an exponent of 0.25 for