Effect of aspirin on the temporal effect in simultaneous masking with on- and off-frequency maskers

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Introduction

The threshold for a brief signal masked by a longer masker can be 10-20 dB higher when that signal is located at the onset of the masker than when it is located near the temporal center or end of the masker. This temporal effect has been observed with broadband noise and narrowband off-frequency maskers. A recent explanation for the temporal effect with broadband maskers incorporates the compressive input-output function of the basilar membrane [1]. This function is characterized as linear or nearly linear at low and high levels but compressive at levels between about 40-80 dB SPL [2]. Because the level of the brief signal is usually higher than the level of the noise masker in the auditory filter centered at the signal frequency, the signal and masker sometimes will be on different portions of the input-output function. The especially high thresholds near masker onset appear to occur when the masker is on the lower, linear portion of the function and the signal is on the middle, compressive portion [3]. The decrease in masking is thought to reflect a decrease in compression over time by means of an efferent feedback loop mediated via the influence of the medial olivocochlear bundle on the outer hair cells [4]. The compression explanation could account for several aspects of the temporal effect with broadband maskers. Both the amount of compression and the magnitude of the temporal effect are considerable at moderate levels but decrease at high levels [5]. Moreover, the temporal effect with broadband maskers is negligible for low frequencies but is considerable for high frequencies [6]. Consistently, physiological [7] and psychophysical [8] data indicate that the degree of compression may be reduced in the apical region of the cochlea. Finally, the temporal effect is reduced in subjects with permanent [9], [10] or temporary [11] cochlear hearing loss.

Although a temporal effect also exists with off-frequency maskers, the effects of masker level and signal frequency are quite different with these maskers than with broadband maskers, and thus the role of compression with off-frequency maskers is less clear. Nevertheless, we [12] have recently shown that the temporal effect with off-frequency maskers might be explained by cochlear compression.

The purpose of the present study was to examine the effects of aspirin on the temporal effect with both on- and off-frequency noise maskers in normal-hearing subjects, because aspirin temporarily alters the functioning of the outer hair cells [13] and hence temporarily reduces cochlear compression. The maskers were presented at both moderate and high levels, in order to determine whether aspirin reduces the temporal effect only at moderate levels, that is, only at levels that involve compression in the normal cochlea.

Methods

Subjects

Four individuals participated. They ranged in age from 21-29 years, and had thresholds of 15 dB HL or lower for octave frequencies from 0.25 to 8 kHz. All subjects except S4 had prior experience as a subject in similar experiments. They had 6 hours of practice (consisting of detecting a signal at masker onset for all masker levels and both masker types) prior to data collection. They completed medical screening to determine eligibility to participate, and blood samples were taken after the aspirin phase of the experiment to verify compliance.

Stimuli

The signal was a 1730-Hz (subjects S1-S2) or a 4000-Hz (subjects S3-S4) pure tone. For each signal frequency, two maskers were used. The on-frequency masker was arithmetically centered at the signal frequency with a width of 10 ERBs. The frequency ranges of the maskers for the two signal frequencies were 675-2785 Hz and 1720-6280 Hz, respectively. The off-frequency masker was 500-Hz wide and was positioned such that its lower frequency edge was 1.038 ERBs above the signal frequency. The frequency ranges of the maskers for the two signal frequencies were 1962-2462 Hz and 4500-5000 Hz, respectively. The 10-ms signal was presented either at the beginning (0-ms delay) or at the temporal center (195-ms delay) of the 400-ms masker.

For the on-frequency masker, two masker levels were used. The level referred to as "moderate" (spectrum level of 25 dB SPL for S1-S2, 15 dB for S3 and 5 dB for S4) produced a moderate signal level at threshold and a maximum temporal effect for the given subject. The level referred as "high" (spectrum level of 45 dB SPL for all four subjects) produced a high signal level at threshold and no temporal effect. For the off-frequency masker, the masker spectrum level ranged from 45 to 69 dB SPL for all four subjects.

Procedure

Thresholds were measured using an adaptive, two-interval, forced-choice procedure that estimates the 79.4% correct point on the psychometric function. The signal was presented in one of the two intervals, and the subject's task was to indicate the interval that contained the signal. A run started with the signal level 10-15 dB above the estimated threshold; the level was decreased following three correct responses and increased following one incorrect response. The step size was initially 5 dB, but was decreased to 2 dB following the second reversal. Each run consisted of 12 reversals; the threshold estimate for that run was the mean signal level at the last 10 reversals.

For the "normal" condition, each threshold reported is the mean of at least three runs obtained over three separate days prior to aspirin administration. For the "aspirin"

condition, subjects obtained the aspirin tablets from the university pharmacy and took three 325-mg tablets of aspirin four times a day (every six hours) for one and a half days (total daily dose of 3.9 grams). Each threshold reported in the "aspirin" condition is the mean of at least two runs obtained over a single day during aspirin administration.

Results and Discussion

Figures 1 and 2 show the individual masked thresholds as a function of masker level obtained with the on-frequency and off-frequency maskers, respectively. The signal was presented with a 0-ms delay (filled symbols) or a 195-ms delay (open symbols). Thresholds were measured prior to (circles) and during (squares) aspirin administration. The signal frequency was 1730 Hz (top row) or 4000 Hz (bottom row). The amount of aspirin-induced hearing loss (in dB SPL) for a 10-ms and a 200-ms signal, respectively, are indicated in the upper left corner of each panel.

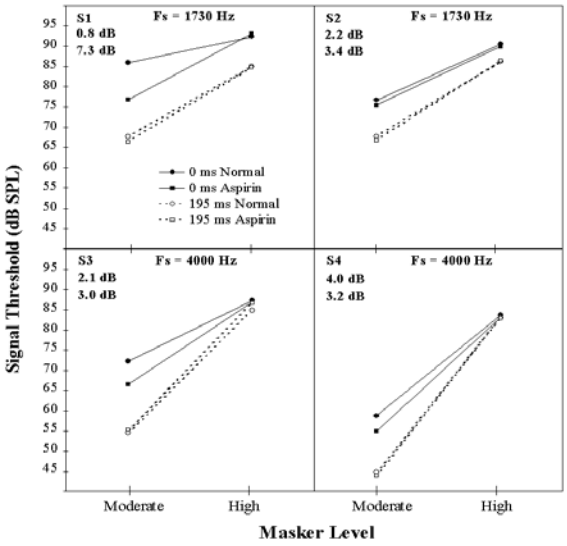

Figure 1: Individual masked thresholds as a function of masker level. The 10-ms signal frequency was 1730 Hz (top row) or 4000 Hz (bottom row). The 400-ms masker was a noise centered at the signal frequency with a width of 10 ERBs.

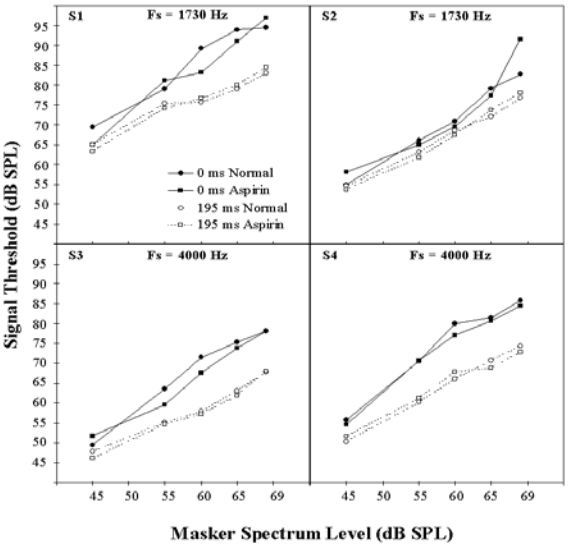

Figure 2: Same as Fig.1 except that the masker was a noise with a width of 500 Hz whose lower cutoff frequency was 1.038 ERBs higher in frequency than the signal.

Figure 1 shows that with on-frequency maskers, aspirin had no effect on the masked thresholds obtained with a 195-ms delay, independent of masker level. With a 0-ms delay, aspirin reduced thresholds by 4-9 dB (expect for S2) when the level of the masker and signal were moderate, consistent with results from previous studies [11]. Moreover, aspirin had no effect at high levels. Figure 2 shows that with off-frequency maskers, aspirin had no effect on thresholds with a 195-ms delay. With a 0-ms delay, aspirin tended to reduce thresholds by 3-6 dB (except for S2) at moderate levels, but had no effect at the highest levels tested.

In sum, for both on- and off-frequency maskers, aspirin (1) had no effect on thresholds when the signal was presented at the temporal center of the masker, (2) tended to reduce thresholds when the signal was presented at masker onset for moderate levels but not for high levels, and (3) therefore reduced the temporal effect at moderate levels. Despite some individual variability (S2 inexplicably showed little effect of aspirin), these results suggest that cochlear compression might be involved in the temporal effect in simultaneous masking observed with both on- and off-frequency maskers.

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