Masker laterality and cueing in forward-masked intensity discrimination[a)]

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(Received 17 March 1997; revised 2 November 1998; accepted 3 November 1998)

Forward-masked intensity discrimination was measured as a function of level in experiments designed to reveal insights into the mechanism(s) underlying the midlevel elevation of the Weber fraction. The standard and maskers were 1.0-kHz tones that were separated by 100 ms. Performance was measured for listeners with normal hearing using an adaptive procedure. In experiment 1, intensity discrimination was measured in the presence of an ipsilateral masker (80 dB SPL), a contralateral masker (93 dB SPL), and a binaural (dichotic) masker produced by combining the ipsilateral and contralateral maskers. Listeners perceived only the contralateral masker in the binaural-masker condition. The contralateral masker produced a small midlevel elevation of the Weber fraction. The ipsilateral masker and the binaural masker produced a large, midlevel elevation of the Weber fraction. Experiment 2 found that a two-tone masker resulted in a reduction (improvement) in the Weber fraction for some conditions, but the midlevel elevation remained for all subjects in this cue-tone condition. Experiment 3 demonstrated that cross talk could not account for all of the masking observed with contralateral maskers. Taken together, the results suggest that a single complex mechanism or multiple mechanisms may be responsible for the masking seen in these experiments. On the basis of the cueing results, it is concluded that a portion of the masking is due to cognitive factors; however, a sensory mechanism cannot be ruled out for the remaining portion, based on the results of these experiments. Finally, a small but significant amount of masking due to contralateral maskers places the mechanism for this outcome central to the cochlear nucleus. © *1999 Acoustical Society of America.* [S0001-4966(99)03402-5]

PACS numbers: 43.66.Ba, 43.66.Dc, 43.66.Fe [WJ]

INTRODUCTION

When pure-tone intensity discrimination is measured in the presence of a high-level forward masker that is turned off 100 ms prior to the onset of the standard, the Weber fraction is elevated relative to the Weber fraction measured in the absence of a masker. Surprisingly, the largest elevation of the Weber fraction is observed for midlevel standards (Zeng *et al.*, 1991). Several studies have attempted to identify the site of the mechanism or mechanisms causing this midlevel elevation of the Weber fraction.

Zeng and Shannon (1995) examined forward-masked intensity discrimination in several conditions in electrical and acoustical hearing. In electrical hearing, they observed elevated Weber fractions for midlevel standards in listeners with cochlear implants, but not in listeners with cochlear-nucleus implants. In acoustical hearing, a large elevation of the Weber fraction occurred for midlevel standards when the masker and standard were presented to the same ear; the masking effect was much smaller when the masker and standard were presented to different ears. The small amount of masking observed for contralateral maskers in acoustical hearing was argued to be consistent with cross hearing. In other words, the high-level masker (typically 90 dB SPL) in these conditions could have exceeded interaural attenuation by an amount sufficient to result in ipsilateral masking in the ear with the standard tone. Taken together, Zeng and Shannon's (1995) results suggest that the site of the mechanism responsible for the midlevel elevation of the Weber fraction in forward-masked intensity discrimination is either the auditory nerve or the cochlear nucleus.

Zeng *et al.* (1991) argue that a possible physiological correlate to the midlevel elevation of the Weber fraction may be the differential recovery from adaptation of auditory-nerve fibers. The spontaneous-firing rates of auditory-nerve fibers are bimodally distributed, as are fiber thresholds (Liberman, 1978). Fibers with low spontaneous rates (SR) tend to have, on average, higher thresholds for a criterion increase in rate than fibers with high SR (Liberman, 1978). Relkin and Doucet (1991) reported that low-SR fibers also have a slower recovery time from prior stimulation than do high-SR fibers. If intensity changes are coded by the firing rate of low-SR and high-SR auditory fibers, the midlevel elevation of the Weber fraction may be related to this slow recovery from prior stimulation of the low-SR fibers. For midlevel standards in the presence of a forward masker, high-SR fibers are saturated by the standard and presumably unable to code intensity changes, whereas low-SR fibers, whose rate-intensity functions normally code midlevel stimuli, would be adapted still by the masker. By contrast, low- and high-level standards would not show an elevation of the Weber fraction. For low-level standards, intensity changes would be coded by high-SR fibers with their rapid recovery from prior stimulation. At high levels, changes

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[a)] Portions of this paper were presented at the 129th meeting of the Acoustical Society of America in Washington, DC [Clement and Schlauch, J. Acoust. Soc. Am. **97**, 3276(A) (1995)].

[b)] Electronic mail: Schla001@maroon.tc.umn.edu would be coded by low-SR fibers because they would be operating in a more optimal region of their response curve.

The findings of Zeng and Shannon (1995) suggest a peripheral origin for the elevation of the Weber fraction seen for forward-masked intensity discrimination, but other studies imply a central influence on the midlevel elevation of the Weber fraction. For instance, the finding that backward-masked intensity discrimination produces a midlevel elevation of the Weber fraction (Plack and Viemeister, 1992) seems inconsistent with the idea that the mechanism responsible for the masking is related to the slow recovery from adaptation of low-SR fibers in the auditory nerve. Although separate mechanisms may cause the elevation observed in forward and backward masking, assuming dual mechanisms is not parsimonious, given the similarity of the data under both conditions. Further, a recent study by Schlauch *et al.* (1997) shows that the elevation of the Weber fraction is greatest when the masker and standard are perceptually similar. In their study, a short-duration masker resulted in more masking than a long-duration masker, a finding inconsistent with studies of adaptation of auditory-nerve fibers (Harris and Dallos, 1979) and a study of the effect of masker duration in forward-masked detection (Kidd and Feth, 1982). It should be noted that Harris and Dallos (1979), in their study of neural adaptation, did not use stimuli identical to those of Schlauch *et al.* (1997), but all of the neural studies of adaptation, to date, report an increase in the amount of adaptation as masker duration is increased (Young and Sachs, 1973; Smith, 1977; Harris and Dallos, 1979).

Given the conflicting hypotheses to account for the midlevel elevation of the Weber fraction (midlevel bump) in forward-masked intensity discrimination, a series of experiments was completed to examine possible mechanisms responsible for this phenomenon.

I. EXPERIMENT 1. DO SUBJECTS SHOW A MIDLEVEL BUMP IF THEY ARE UNAWARE THAT AN IPSILATERAL MASKER IS PRESENT?

As noted earlier, maskers and standards presented to the same ear result in a large elevation of midlevel Weber fractions for forward-masked intensity discrimination, whereas when the masker and standard are presented to different ears, the Weber fraction is elevated, but to a much smaller extent (Zeng and Shannon, 1995). If the amount of masking seen in forward-masked intensity discrimination requires conscious awareness and the listener were somehow made unaware that an ipsilateral masker was present, the midlevel elevation of the Weber fraction should be reduced or eliminated. On the other hand, if the masking effect remained large when the listener was unaware of the presence of the ipsilateral masker, the outcome would be consistent with a sensory or cognitive process that occurs without conscious awareness.

The ‘‘Stenger principle’’ provides a means for making a listener unaware that an ipsilateral masker is present. The Stenger principle states that when tones that are identical except for level are presented simultaneously to each ear of a person with normal hearing, the listener perceives the tone only in the ear with the greatest intensity (Martin, 1997). Stenger (1907) developed a test based on this idea to identify persons who are feigning a unilateral hearing loss (described in Rintelmann and Schwan, 1991). The original test was administered with matched tuning forks struck with different amounts of force, but the modern version of this test is administered typically by presenting one tone 10 dB below the person’s admitted threshold in the ear with the feigned loss, and the other tone 10 dB above threshold in their other (better) ear. No response is observed to this dichotic stimulus in most persons feigning a substantial unilateral loss, even though the 10-dB sensation-level (SL) tone in the better ear results in an unequivocal response every time it is presented monotically. The Stenger test is very effective (84%) at identifying persons feigning a unilateral loss when the presentation level to the poorer ear exceeds that of the better ear by more than 10 dB (Kinstler *et al.*, 1972). In other words, the more intense tone must be 11 dB or greater in level than the level of the less-intense tone to make the less-intense tone imperceptible.

Our experiment made use of the Stenger principle to render subjects unaware that a masker was present in the same ear as the standard tone in a forward-masked intensity discrimination experiment.

A. Method

Three listeners, aged 42, 24, and 30 years, served as subjects. All had hearing within normal limits (10 dB HL or better) for octave intervals between 0.25 and 8.0 kHz. Further, hearing thresholds were symmetrical, within 10 dB, between ears at each frequency that threshold was assessed. Two subjects (1 and 3) had considerable experience in psychoacoustic experiments. The other subject (2) had never participated in a psychoacoustic experiment previously. All listeners were given several hours of practice at the tasks in this study prior to data collection.

B. Stimuli

Maskers and standards were 1.0-kHz pure tones that were digitally generated at a sampling rate of 20.0 kHz by a custom-designed 16-bit digital-to-analog (D/A) converter. The output of the D/A converter was low-pass filtered with a cutoff frequency of 8.0 kHz. Three channels were employed. The standard and increment were generated using separate channels that were mixed before being presented to the headphones. The increment was added in phase with the standard. A third channel produced the masker tone. Maskers and standards were 100 ms. All stimuli had 5-ms cosine-squared onset and offset ramps.

Before data collection began, potential subjects were screened to determine if the Stenger principle held true for a 13-dB difference in level between ears.[1] Subjects were presented with a 50-trial block. Half of the trials contained a moderate-to-high level, 1.0-kHz tone for 300 ms. The remaining trials contained the same high-level, 300-ms tone, along with a tone that was 13 dB lower, presented simultaneously to the other ear. The level for the higher-level tone was randomly assigned a value for a given trial of between 50 and 90 dB SPL. The level was randomized to eliminate a potential loudness cue. Subjects were asked to judge for each trial whether the tone was presented to one ear or to both ears

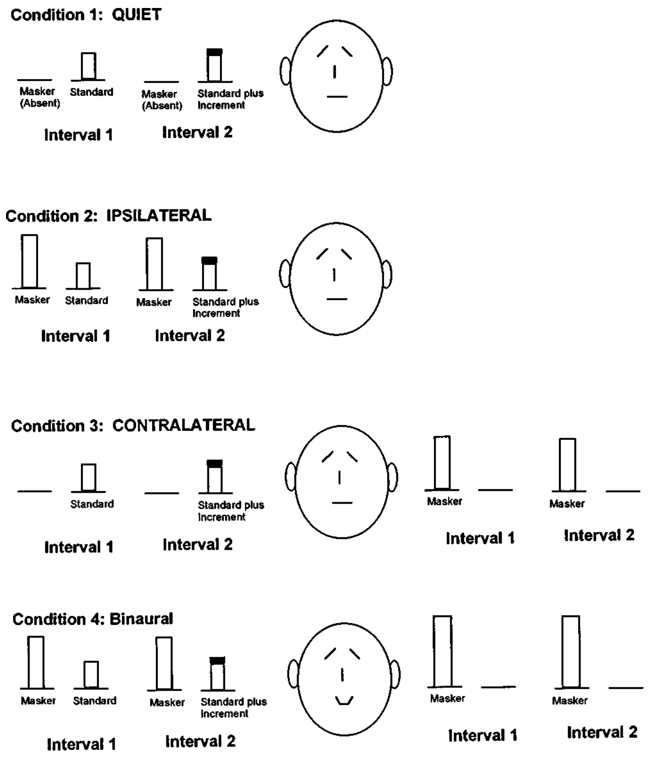

FIG. 1. A schematic drawing representing the four conditions of experiment 1. The increment appears in interval 2 for each of these examples, but it had an equal probability of occurring in either interval in the actual experiment.

simultaneously. No feedback was given regarding performance and trials were separated by 3 s. Lights marked the listening interval. Seven subjects had to be screened before three were found who performed at or near chance for this task (performance<0.6; chance=0.5). Binaural diplacusis may be responsible for four subjects being able to discriminate the binaural condition from the monaural (Newby, 1979). Burns (1982) reports pitch-intensity functions are significantly different in each ear of some, but not all, listeners. These differences in pitch across ears may have provided a cue to identify the presence of the dichotic stimulus in our four listeners who failed the screening by scoring significantly above chance.

C. Procedure

Intensity discrimination was measured as a function of level for the three subjects for whom the Stenger principle held. For each of four conditions, intensity discrimination was assessed for standard levels ranging from 20 to 80 dB in 10-dB steps. Performance was measured with a two-interval, forced-choice (2IFC) adaptive procedure using a decision rule that targeted 79.4%-correct performance (Levitt, 1971). For every incorrect response, the level of the tone added in phase with the standard was increased by 3 dB, whereas three consecutive correct responses resulted in a reduction in the level of the increment by the same amount. Subjects were given visual feedback regarding the accuracy of their responses following each trial. The Weber fraction for a single block was calculated based on the mean of reversals in stimulus-level direction within a given block. Weber fractions were based on a minimum of three 50-trial blocks that were collected during separate testing sessions (on three different days). If the standard deviation of those three blocks exceeded 3.5 dB, additional blocks, up to as many as eight, were completed. The order of conditions was selected randomly; once a condition was selected, one block for each of the seven standard levels was collected. The four conditions are described below and are also shown schematically in Fig. 1. Subjects listened to stimuli through headphones (Telephonics, TDH-39).

D. Conditions

Condition 1 (quiet): Intensity discrimination was measured in the absence of a masker. The standard was a 1.0-kHz tone. The inter-interval delay was 500 ms. This condition served as a baseline condition, so that the degree of masking in subsequent conditions could be quantified relative to intensity discrimination in the absence of a masker. The right ear was arbitrarily chosen for this condition for each of the subjects.

Condition 2 (ipsilateral masker): Intensity discrimination was measured in the presence of an ipsilateral forward masker that preceded each interval of the 2IFC task. The delay between the masker offset and the onset of the standard (zero voltage) was 100 ms. Both the masker and the standard were 1.0-kHz tones. The masker was fixed in level at 80 dB SPL.

Condition 3 (contralateral masker): In this condition, intensity discrimination was measured in the presence of a contralateral masker that was fixed in level at 93 dB SPL. The task, temporal sequence, and frequency of stimuli were all the same as those of condition 2.

Condition 4 (binaural masker): This condition was employed to induce the Stenger effect. The task, temporal sequence, and frequency of stimuli were the same as those of the previous conditions. Forward maskers were presented simultaneously to each ear of a listener. The masker level was fixed at 80 dB SPL in the ear ipsilateral to the standard tone, and 93 dB SPL in the ear contralateral to the standard tone.

E. Results

Figure 2 illustrates Weber fractions as a function of level for the four conditions in experiment 1. In quiet (condition 1), subjects 1 and 2 show a gradual reduction in the Weber fraction as level increases, a result known as the near miss to Weber's law (McGill and Goldberg, 1968). Subject 3 shows a midlevel elevation of the Weber fraction in quiet. Florentine *et al.* (1987) found individual differences of this sort for Weber fractions in quiet in their study of intensity discrimination.

An ipsilateral masker (condition 2) resulted in a large elevation of the Weber fraction for low and moderate levels of the standard; only a small elevation was found for the highest level of the standard (80 dB SPL). Prior published investigations of forward-masked intensity discrimination with a 100-ms delay between the masker and standard generally find the largest elevation for midlevel standards (Zeng and Turner, 1992). A reason for this difference may be that we used identical durations for the masker and standard (100

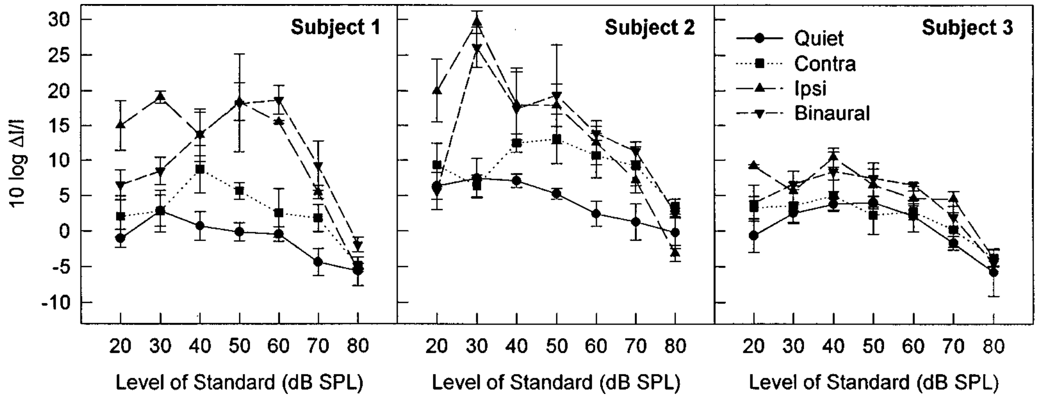

FIG. 2. The Weber fraction (dB) as a function of level for the four conditions of experiment 1 for each subject. Circles represent the quiet condition. Ipsilateral, contralateral, and binaural maskers are represented by triangles, squares, and triangles, respectively. Error bars represent plus- and minus-one standard deviation.

ms), whereas most prior studies employed a masker that was much longer in duration than the standard [e.g., 100 ms for the masker and 25 ms for the standard in Zeng and Turner (1992)]. Schlauch *et al.* (1997) argue that identical duration maskers and standards result in masking due to perceptual similarity, which has its greatest effects for low-level standards.

A contralateral masker (condition 3) resulted in a midlevel elevation of the Weber fraction for subjects 1 and 2. By contrast, subject 3 showed little or no masking for a contralateral masker. This small amount of masking observed for contralateral maskers is consistent with the results of earlier studies (Plack *et al.*, 1995; Zeng and Shannon, 1995).

The binaural masker (condition 4) elevated Weber fractions in a manner very similar to that for the ipsilateral masker, even though the subjects only perceived the higher-level contralateral masker. All of the subjects showed less masking for the binaural masker than for the ipsilateral masker for the lowest-standard levels (20 dB SPL for all subjects and 30 dB SPL for subjects 1 and 2). This improvement in performance seen when the second masker was added may be due to a lateralization cue. That is, in the binaural condition the masker was lateralized to the ear contralateral to the standard, which may have made it easier for the listener to dissociate the masker and standard than when they were both perceived to have originated in the same ear. In any event, a lateralization cue does not appear to be effective for reducing masking for the higher-level standards in this study. A similar outcome is seen in the data of Plack *et al.* (1995), who used equal-level binaural maskers in a forward-masked intensity discrimination experiment.

II. EXPERIMENT 2. DOES A TONAL CUE PRESENTED SIMULTANEOUSLY WITH THE MASKER REDUCE THE MASKING SEEN IN FORWARD-MASKED INTENSITY DISCRIMINATION?

It has been suggested that temporal uncertainty resulting from employing maskers and standards with similar frequencies and bandwidths increases the amount of forward masking in a detection task (Moore and Glasberg, 1982) and an intensity discrimination task (Schlauch *et al.*, 1997). That is, perceptually similar maskers and standards result, for some conditions, in more masking than ones that are perceptually dissimilar. In our experiment 1, where maskers and standards were employed that were identical in every respect except for level, some portion or all of the masking effect may have been due to the perceptual similarity of the masker and standard. In this second experiment, the masker was modified to help subjects distinguish the masker from the standard. To accomplish this, we used a two-tone complex for our masker and a single tone for the standard. The frequencies of the masker complex were 1.0 kHz and 4.133 kHz, whereas the standard frequency was 1.0 kHz. The 4.133-kHz tone is not harmonically related to the frequency of the standard and these two tones are separated sufficiently to avoid masking. Pilot data for subjects 1 and 2 (a few standard levels were sampled) confirmed that the 4.133-kHz tone alone resulted in no elevation of the Weber fraction.

A. Subjects

Subjects 1 and 2, who showed the greatest amount of masking in experiment 1, participated along with two additional subjects (subjects 3 and 4) who were recruited for this experiment. The two new recruits were young adults who met the same criteria for participation as noted in the methods for experiment 1. Subjects 3 and 4 were not administered the Stenger screening test.

B. Stimuli and procedure

Stimulus generation and procedure were identical to those of experiment 1. The only difference was that the masker was a two-tone complex comprised of 1.0-kHz and 4.133-kHz tones, rather than a single, 1.0-kHz tone. The level of each masker was 80 dB SPL.

Pilot data showed that subjects 3 and 4 produced only a small amount of masking with 100-ms maskers and standards. To increase the amount of masking, these subjects were run using 10-ms standards and maskers. Subjects 1 and 2 were run using 100-ms maskers and standards.

C. Results

Adding the remote-frequency cue to the ipsilateral condition resulted in reduced Weber fractions at several standard levels for three of the four subjects. Figure 3 summarizes the results. The greatest reduction occurred for the lowest-level standards for subject 2. Schlauch *et al.* (1997) reported a similar finding for one of their subjects in a condition that employed 10-ms maskers and 10-ms standards in a forward-masked intensity discrimination task. The increase in masking shown by subject 3 in the cue-tone condition is a result of masking by the 4.133-kHz tone. Masking data collected with the 4.133-kHz tone alone showed elevated jnd's even when the masker level was reduced to 60 dB SPL.

III. EXPERIMENT 3. CAN CROSS HEARING ACCOUNT FOR THE BUMP SEEN IN CONDITIONS WITH CONTRALATERAL MASKERS?

This experiment was designed to examine whether the elevation of the Weber fraction for midlevel standards in the contralateral-masker condition is due to the masker tone crossing over to the same ear as the standard tone. If the masker were crossing over to the ear with the standard tone, the skull would attenuate it. The amount of this attenuation, known as interaural attenuation, ranges from 40 to 75 dB for persons wearing TDH earphones mounted in supra-aural cushions (Snyder, 1973). The mean value of interaural attenuation at 1.0 kHz, measured in a group of 228 persons with complete unilateral hearing loss, is 60 dB (Snyder, 1973). Using 40 dB as the most conservative estimate of interaural attenuation, an ipsilateral forward-masking condition was set up in which we presented the maximum amount of ipsilateral masking that could have occurred during the contralateral condition. If contralateral masking is the result of the masker crossing over to the ear with the standard tone, the results for this low-level ipsilateral-masker condition should produce the same amount of masking that was seen with the high-level contralateral masker, or more.

A. Subjects, stimuli, and procedure

The subjects from experiment 2 participated in this experiment. The stimuli and procedures were identical to those of the ipsilateral-masker condition in experiment 2, with the exception that the masker level was set to 53 dB SPL and the masker was a single, 1000-Hz tone. This level represents the greatest amount of crossover that may have occurred in the contralateral condition employing the 93-dB SPL contralateral masker. For subjects 1 and 2, Weber fractions were measured only for the two midlevel standards that yielded the most masking (masked–quiet) in the presence of the contralateral masker (40 and 50 dB SPL for subject 1 and 50 and 60 dB SPL for subject 2). For subjects 3 and 4, Weber fractions were measured for standard levels of 40, 50, and 60 dB SPL.

B. Results

The results of these measurements are shown in Fig. 4. All of the measurements obtained with the 53-dB SPL masker yielded Weber fractions that are smaller than those obtained with the contralateral masker. Further, this low-level masker yielded Weber fractions that are only slightly elevated and nearly identical in size to those obtained in the quiet condition of experiment 1. Thus, cross hearing cannot account for the full effect of contralateral masking observed in experiment 1. The finding that a 53-dB SPL masker results in only a small increase in the Weber fraction is consistent with the results of Zeng and Turner (1992) and Plack *et al.* (1995).

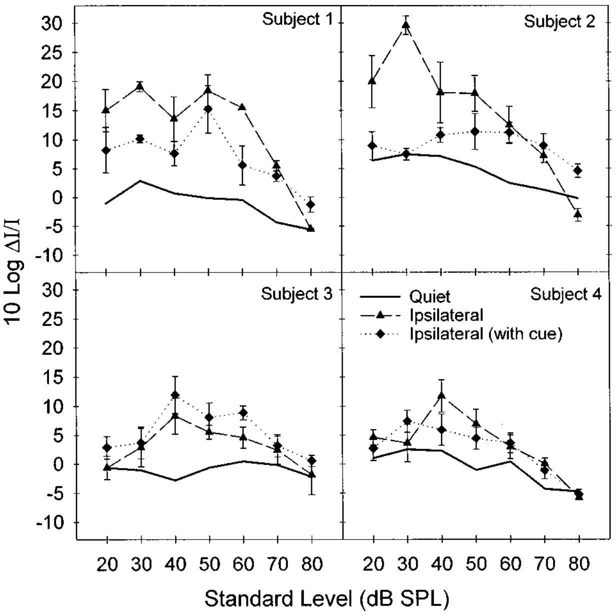

FIG. 3. The Weber fraction (dB) for the condition with an ipsilateral two-tone masker (triangles). For comparison, data are shown for a quiet condition and for an ipsilateral masker condition (data for Subjects 1 and 2 are from experiment 1). Quiet data are shown by a solid line, whereas data for the ipsilateral single-tone masker are shown as diamonds.

IV. GENERAL DISCUSSION

The finding that a contralateral masker produced substantially less masking than a binaural masker, even though the two masker conditions were indistinguishable, supports the idea that the midlevel elevation of jnd's in forward-masked intensity discrimination is the result of a mechanism that does not require conscious awareness. Contrary to early descriptions of this phenomenon where the putative mechanism was believed to be associated with adaptation in the auditory nerve (Zeng and Turner, 1992), the present results and those of some other recent studies suggest that it is at least partly due to more central mechanisms. For instance, the result in the current study that the midlevel elevation of jnd's seen with a contralateral masker cannot be accounted for by cross hearing suggests that the mechanism is located within the superior olive, the first station of binaural interaction, or even higher in the auditory system. Other evidence inconsistent with an explanation based on adaptation is the finding that the masker acts to increase rather than to decrease the subjective magnitude of the standard or standard plus signal (Carlyon and Bevridge, 1993; Zeng, 1994), and the finding that short-duration maskers can produce more masking than long-duration maskers (Schlauch *et al.*, 1997).

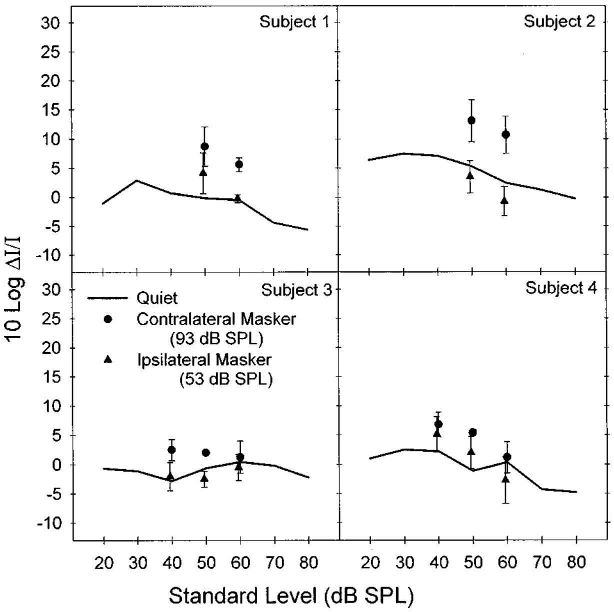

FIG. 4. The Weber fraction (dB) for a low-level masker (53 dB SPL) is shown as an upward-pointing arrow. For comparison, data for a quiet condition and for a contralateral masker are shown for the four participants in experiment 2 as solid lines and circles, respectively. Data for subjects 1 and 2 are from experiment 1. Note that the low-level masker produces less masking than the contralateral masker for all comparisons.

Our results suggest that a portion of the masking observed in our study could be accounted for by cognitive factors. When a two-tone complex was used to help listeners distinguish the masker from the standard, an improvement in performance was observed for some listeners, but the midlevel elevation of the Weber fraction remained. Plack and his colleagues (Plack *et al.*, 1995; Plack, 1996b) have suggested that the memory trace may be corrupted or that the variance of the memory trace may be increased by the presence of the masker in forward-masked intensity discrimination. There is evidence that a forward masker enhances the loudness of midlevel standards and introduces substantial variance in a listener's estimate of that loudness (Zeng, 1994). Plack and his colleagues demonstrated that a stimulus placed in close temporal proximity to the standard, either before or after the standard, results in an improvement in performance compared to a condition where the proximal stimulus was not present. These results demonstrate that listeners are able to make use of the proximal stimulus, but this outcome is not inconsistent with the idea that a sensory mechanism is responsible for the midlevel elevation of jnd's in forward-masked intensity discrimination. Plack (1996b) suggests that the role of the reference signal may be to modulate the sensory trace in a manner that provides the listener with a temporal profile. Changes in the temporal profile would enable listeners to identify the interval with the increment based on a within-interval comparison rather than a comparison of absolute levels across intervals. Plack (1996b) described a temporal model which predicted that the nature of a temporal cue would differ depending on whether the proximal stimulus was presented before or after the standard. Consistent with the model, two groups of subjects trained on tasks with different cues performed poorly when they switched tasks. Although this result is interesting, it does not address the mechanism underlying the midlevel elevation of jnd's.

The midlevel elevation of jnd's in backward masking is another result that is difficult to account for by a peripheral sensory mechanism (Plack and Viemeister, 1992). One possibility, which seems unlikely, is that different mechanisms are responsible for the elevation of jnd's in forward and backward masking; studies have shown that the effects of forward and backward masking on intensity discrimination and loudness are similar under a variety of conditions (Plack and Viemeister, 1992; Plack, 1996a). Another possibility is that masking in forward-masked intensity discrimination reflects a process of central origin known as an ''automatic process.''

An automatic process describes behavior in focused-attention tasks where subjects are unable to ignore an irrelevant stimulus (Schneider *et al.*, 1984). In one example, subjects asked to visually identify a letter in isolation take less time to respond than when they are asked to identify the same target letter in the context of a flanking letter. The longer response time is cited as evidence that subjects automatically processed the flanking letter along with the target letter, even though they knew in advance the location of the flanking letter and that it was irrelevant to the task. Schneider *et al.* (1984, p. 21) state that one defining feature of an automatic process is that it ''demands resources in response to an external stimulus, regardless of the subjects' attempts to ignore the distraction.'' They also state that a possible function of an automatic process is to bias or prime memory for subsequent inputs. In the case of forward- (or backward-) masked intensity discrimination, a high-level stimulus results in an assimilation of subjective magnitudes of moderate-level stimuli that are similar in frequency and presented in close temporal proximity to the high-level stimulus. Plack (1996a) argues that such a process may reflect long-term integration of intensity. Long-term integration of intensity of stimuli with similar spectra may promote perceptual streaming (attending to an auditory source over time). Plack (1996a) notes that such a process would not likely be deleterious to speech perception, given that fine spectral distinctions are not obscured by this type of masking and that intensity processing used for recognizing auditory objects is relative rather than absolute.

V. CONCLUSIONS

The midlevel elevation of the intensity jnd is determined almost entirely by the masker input to the ipsilateral ear rather than by the perceived location of the masker. However, a small elevation of the intensity jnd does occur with a contralateral masker, a finding that is not due to acoustic cross talk. Also, a cue tone reduces the amount of forward masking in some listeners. The reduction in the Weber fraction due to cueing and the finding that contralateral masking is not due to cross talk support the notion that a portion of the masking seen in these conditions is not the result of a peripheral sensory mechanism. On the other hand, conscious awareness of the ipsilateral masker is not necessary for masking to occur. This implies that the mechanism responsible for the midlevel elevation of the Weber fraction is the result of a cognitive process that occurs without conscious awareness, or that a portion of the masking is likely the result of a sensory mechanism.

ACKNOWLEDGMENTS

We are grateful to Dr. Chris Plack for his helpful comments during the review process. Discussions with Dr. Plack about the definitions of concepts such as ''cognitive'' and ''conscious awareness'' were particularly illuminating. This work was supported by NIH-NIDCD R29 DC01542.

[1] Hafter and Kimball (1980) have found that well-trained listeners given feedback are able to identify correctly ($d'=1$) the presence of a low-level tone that is as much as 45 to 50 dB below the level of a tone presented simultaneously to the other ear. The three listeners they tested differed considerably in their ability to do this task, even with training. Subtle differences in the perception of dichotically and monotically presented tones make identification of differences easier when the stimuli are presented in a same/different task such as in Hafter and Kimball's (1980) experiment, rather than our experiment, where short-term memory traces of both examples were not as readily accessible and feedback was not provided.

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