I. INTRODUCTION

It has recently been shown that the processing of ongoing interaural temporal disparities (ITDs) at high frequencies can be enhanced by using “transposed stimuli” similar to those first employed by van de Par and Kohlrausch (1997). The purpose of using transposed stimuli is to provide high-frequency auditory channels with envelope-based information that mimics waveform-based information normally available in only low-frequency channels. Specifically, the use of high-frequency transposed stimuli yielded both smaller threshold-ITDs (Bernstein and Trahiotis, 2002) and larger extents of laterality (Bernstein and Trahiotis, 2003) than did the use of “conventional” high-frequency stimuli such as narrow bands of Gaussian noise and sinusoidally amplitude-modulated (SAM) tones. Furthermore, with several of the high-frequency transposed stimuli, threshold-ITDs were as small, and extents of laterality were as large, as those measured with low-frequency pure tones and bands of noise having low center-frequencies.

Such findings may be interpreted to mean that the high-frequency channels of the auditory system are not, in and of themselves, less sensitive to ITDs than are the low-frequency channels. It occurred to us that transposed stimuli could be useful in evaluating current accounts and/or explanations of what has been termed “binaural interference.” In order to understand why this is so, it is necessary to consider what is generally known empirically about binaural interference and the nature of the theoretical explanations that have been offered to account for it.

Examples of binaural interference can be found in several experiments demonstrating that sensitivity to ITDs conveyed by a “target” presented within one spectral region can be degraded by the presence of a second, simultaneously gated stimulus, the “interferer.” An important characteristic of binaural interference is that the interferer occupies a spectral region remote from that of the target (e.g., McFadden and Pasanen, 1976; Davis, 1985; Zurek, 1985; Dye, 1990; Trahiotis and Bernstein, 1990; Bernstein, 1991; Buell and Hafter; 1991; Woods and Colburn, 1992; Buell and Trahiotis, 1993; Stellmack and Dye, 1993; Bernstein and Trahiotis, 1992a; 1995; Heller and Trahiotis, 1995). Another important characteristic of binaural interference is that it is asymmetric in that low-frequency stimulation adversely affects the processing of ITDs conveyed by high-frequency targets but high-frequency stimulation does not adversely affect the processing of ITDs conveyed by low-frequency targets.

The general theoretical framework used to account for binaural interference was first described by Buell and Hafter (1991) and incorporates a form of “non-optimal” processing wherein binaural interference arises from an obligatory combination of ITD-information conveyed by the target and the interferer, respectively. According to this model, the ITD-information conveyed within the target frequency channel and within the interferer frequency channel receive differential weights. The weights for the target and interferer, respectively, are inversely proportional to the magnitude of the threshold-ITD measured when each is presented in isolation. As a result, the stimulus having the lowest threshold-ITD, be it target or interferer, contributes most to the decision.

Recently, Heller and Trahiotis (1996) showed that predictions of binaural interference measured in an ITD-detection task could be markedly improved if the Buell and Hafter (1991) weights were augmented to include a factor representing the relative slopes of functions relating extent of...
laterality to ITD for targets and interferers presented in isolation. Based on Heller and Trahiotis’ model, one would predict that less binaural interference would be observed for high-frequency transposed targets than for conventional high-frequency stimuli. This is so because high-frequency transposed stimuli, unlike their conventional high-frequency counterparts, yield threshold-ITDs and extents of laterality that are similar to those obtained with low-frequency stimuli. Therefore, within the model, high-frequency transposed stimuli would receive greater weighting vis-a-vis the weighting applied to low-frequency interferers than would their conventional high-frequency counterparts. The Buell and Hafer (1991) model would also predict less interference for transposed targets but would do so based only on their relatively smaller threshold-ITDs.

In light of these issues, the purposes of this investigation were (1) to measure and to compare binaural interference effects obtained with either transposed or conventional high-frequency targets in an ITD-discrimination task and (2) to determine whether either of the quantitative models of binaural interference discussed above could account for the data. It will be seen that high-frequency transposed targets appear to be “immune” to binaural interference from low-frequency stimulation. In addition, it appears that neither of the models can account for the lack of interference obtained with transposed stimuli. The empirical and theoretical results, taken together, suggest that high-frequency transposed stimuli are, in some sense, “special” in that they appear to allow listeners effectively to disregard the presence of concurrent low-frequency stimulation and behave in a more “optimal” fashion.

II. EXPERIMENT 1

A. Stimuli

Five high-frequency stimuli served as targets: (1) a 4-kHz tone sinusoidally amplitude-modulated (SAM) at 128 Hz; (2) a 200-Hz-wide band of Gaussian noise centered at 4 kHz; (3) a 128-Hz tone transposed to 4 kHz; (4) a 50-Hz-wide band of Gaussian noise centered at 128 Hz that was transposed to 4 kHz; (5) a 100-Hz-wide band of Gaussian noise centered at 128 Hz that was transposed to 4 kHz. The transposed stimuli were generated in the manner described in detail by Bernstein and Trahiotis (2002; 2003). Briefly, the time-domain representation of a low-frequency tone or a narrow band of low-frequency Gaussian noise was (linearly) half-wave rectified by setting all negative values to zero. Rectified waveforms were then transformed to the frequency domain and the spectral components above 2 kHz were filtered out by setting their magnitudes to zero (see pp. 1027–1028 of Bernstein and Trahiotis, 2002 for a justification of the choice of this type of rectification and filtering). Rectified and filtered waveforms were then transformed back to the time domain and multiplied by a 4-kHz sinusoidal “carrier.” The product was a transposed stimulus having an envelope whose time signature mimicked that of the rectified and filtered low-frequency tone or low-frequency narrow band of noise.

Examples of each type of high-frequency target are depicted in Fig. 1. The left-hand panels show randomly chosen 50-ms epochs of each type of target; the right-hand panels show the (long-term) power spectrum of each target calculated over several tens of seconds. Beginning with the left-hand panels, note that there are six or seven envelope maxima for each type of target during the 50-ms epochs depicted. This reflects the fact that, by construction, the expected number of envelope maxima per second for each type of target is 128. For the SAM and transposed targets, this is more or less intuitively appreciated given that the basic waveforms that served as the “modulators” of the 4-kHz carriers were, as indicated in the figure, all centered on 128 Hz. For the 200-Hz-wide Gaussian noise target, some explanation seems in order. As shown by Rice (1954), the expected number of envelope maxima per second for a Gaussian noise is equal to 0.6411 times its bandwidth in Hz. Therefore, the bandwidth of the Gaussian noise target was chosen to be 200 Hz so that its rate of envelope fluctuation would be approximately 128 Hz, thereby matching the rate of envelope fluctuation of the other four types of targets.

There were three primary reasons for choosing a rate of envelope fluctuation of 128 Hz. First, transposed stimuli having a rate of envelope fluctuation of 128 Hz or so have been shown to produce the greatest enhancements of ITD-discrimination at high frequencies (e.g., van de Par and Kohlrausch, 1997; Bernstein and Trahiotis, 2002; 2003). Second, 128 Hz is well within the range of rates of envelope fluctuation that yield the smallest threshold-ITDs for conventional high-frequency stimuli such as SAM tones, two-tone complexes, and bands of Gaussian noise (see Henning, 1974; McFadden and Pasanen, 1976; Nuetzel and Hafter, 1981; Bernstein and Trahiotis, 1994). Third, the choice of this rate causes the vast majority of the energy to occur between 3750 Hz and 4250 Hz for all five types of targets (see right-hand panels of Fig. 1). This ensured that the energy within each type of target would fall almost entirely within the approximately 500-Hz-wide auditory filter centered at 4 kHz (see Moore, 1997). This was deemed necessary to help maximize the validity of comparisons of data obtained with the various targets and, perhaps, to simplify interpretations of the results. Also note that one of the two types of conventional targets (the SAM tone) was deterministic and had a discrete spectrum while the other one (the band of Gaussian noise) was stochastic and had a continuous spectrum. In somewhat parallel fashion, one of the transposed targets (the 128-Hz tone transposed to 4 kHz) was deterministic and had a discrete spectrum, while the other two transposed targets (the 50-Hz-wide and 100-Hz-wide bands of noise centered at 128 Hz which were each transposed to 4 kHz) were stochastic and had continuous spectra. These differences notwithstanding, the relative amounts of power within corresponding “sidebands” composing each of the three types of transposed stimuli was equal. For example, consider the sidebands centered on 3872 Hz. The level of that sideband within the spectrum of the target generated by transposing a 50-Hz-wide noise (fourth row) is 17 dB below the level of the corresponding sideband in the spectrum of the target generated by transposing a tone (third row). That difference results from the fact that the power of that sideband for the transposed
noise is spread across a 50-Hz-wide band of frequencies, rather than being concentrated at a single spectral frequency. Consistent with this, the level of the 3872-Hz sideband within the spectrum of the target generated by transposing a 100-Hz-wide noise (fifth row) is another 3 dB below the level of the corresponding sideband in the spectrum of the target generated by transposing a 50-Hz-wide band of noise. These comparisons ignore the negligible additional power contributed to the 3872-Hz sidebands that results from “overlap” with neighboring sidebands.

The stimulus that served as the interferer was a 400-Hz-wide band of Gaussian noise centered at 500 Hz. Such a

FIG. 1. Left-hand panels: Randomly chosen 50-ms epochs of the five types of targets employed in the main experiment. Right-hand panels: The long-term power spectra of each of the five types of targets.
stimulus was found by Bernstein and Trahiotis (1995) to produce substantial amounts of binaural interference for the resolution of ITDs conveyed by target bands of noise centered at 4 kHz. Thus, overall, the types of targets used in the experiment were chosen to optimize sensitivity to ITD in high-frequency channels while the interferer was chosen to maximize the possibility of observing binaural interference effects, should they occur.

All targets and interferers were generated digitally as 8192-point buffers using a sampling rate of 20 kHz (TDT AP2). Each stimulus used in the experiment was 300 ms long including 20-ms cos² rise-decay ramps and was extracted from the appropriate longer buffer. The stimuli were low-pass filtered at 8.5 kHz (TDT FLT2), and each was presented via Etymotic ER-2 insert earphones at a level matching 70 dB SPL as produced by TDH-39 earphones in a 6-cc coupler. Interfering stimuli were presented diotically and were gated on and off synchronously and identically with the target stimuli.

B. Procedures

Threshold-ITDs were determined using a four-interval, two-cue, two-alternative, temporal forced choice, adaptive task. Each trial consisted of a warning interval (500 ms) and four 300-ms observation intervals separated by 400 ms. Each interval was marked visually by a computer monitor. Feedback was provided for approximately 400 ms after the listener responded. The stimuli in the first and fourth intervals were diotic. The listener’s task was to detect the presence of an ITD (left-ear leading) that was presented with equal a priori probability in either the second or the third interval. The remaining interval, like the first and fourth intervals, contained diotic stimuli.

The starting phases of the components that composed each stimulus (prior to the imposition of an ITD) were chosen randomly for each observation interval within and across trials. All of the conventional waveforms required for a given trial were computed immediately prior to that trial. Because of the time required to generate the high-frequency transposed stimuli, it was necessary to calculate the transposed waveforms prior to each adaptive run. Twenty independently calculated tokens of the desired type of transposed stimulus were stored and one of them was chosen randomly (with replacement) for each of the four observation intervals defining a trial. Twenty tokens were employed so that the behavioral data were not dependent upon the occurrence of any particular stimulus. This set-size was considered to be sufficiently large based on Siegel and Colburn’s (1989) findings that only 10 independently generated tokens of noise yielded essentially equivalent performance to that measured with “running” noise in a binaural discrimination task.

Ongoing ITDs were imposed by applying linear phase-shifts to the representation of the signals in the frequency domain and then gating the signals destined for the left and right ears coincidentally, after transformation to the time domain. The ITD for a particular trial was determined adaptively in order to estimate 70.7% correct (Levitt, 1971). The initial step-size for the adaptive track corresponded to a factor of 1.584 (equivalent to a 2-dB change of ITD, assuming ITD to be a “10 log” quantity) and was reduced to a factor of 1.122 (equivalent to a 0.5-dB change of ITD, assuming ITD to be a “10 log” quantity) after two reversals. A run was terminated after 12 reversals and threshold was defined as the geometric mean of the ITD across the last 10 reversals.

Four normal-hearing adults served as listeners and three consecutive estimates of threshold-ITD were first obtained.
from each listener for each of the stimuli presented in isolation. Those stimuli were tested in random order. Then, three more estimates were obtained after revisiting the same stimulus conditions in reverse order. Estimates of threshold for targets presented in the presence of the interferer were obtained in the same manner after the estimates of threshold were obtained with targets presented in isolation. The same ordering of conditions was used for all listeners and all listeners received substantial practice before formal collection of data began. For each listener and stimulus condition, final estimates of thresholds were calculated by averaging the individual thresholds obtained from the six adaptive runs.

C. Results and discussion

Figure 2 contains the means of the threshold-ITDs (taken across the four listeners) obtained in each of the experimental conditions. The types of target stimuli are indicated along the abscissa. Unfilled bars indicate threshold-ITDs obtained without the interferer; filled bars indicate threshold-ITDs in the presence of the interferer. The cross-hatched bar at the far left of the figure indicates the mean threshold-ITD obtained when the 400-Hz-wide band of noise centered on 500 Hz that served as the interferer was presented in isolation. The error bars represent the standard errors of each mean threshold-ITD.

Visual comparisons among the data reveal two important trends. First, threshold-ITDs obtained with the high-frequency transposed targets are, on the average, smaller than those obtained with the conventional high-frequency targets. This general outcome replicates our earlier findings (Bernstein and Trahiotis, 2002). Second, sensitivity to ITD was degraded in the presence of the interferer for conventional targets, but not for transposed targets. That is, it appears that high-frequency transposed targets are effectively immune to binaural interference. This general outcome confirms the results of our preliminary or “pilot” studies (Bernstein and Trahiotis, 2001).

The data in Fig. 2 were subjected to a three-factor (conventional vs transposed targets) × [no interference vs interference] × [stochastic vs deterministic targets], within-subjects analysis of variance. In order to perform a “balanced” analysis of variance, the data obtained when the targets were either 50-Hz-wide or 100-Hz-wide bands of noise centered at 125 Hz and transposed to 4 kHz were averaged, respectively, within interference and no-interference conditions. The error terms for the main effects and for the interactions were the interaction of the particular main effect (or the particular interaction) with the subject “factor” (Keppe1, 1973). In addition to testing for significant effects, the proportions of variance accounted for (\(\omega^2\)) were determined for each significant main effect and interaction (Hays, 1973).

Consistent with visual inspection of the data, the main effect of conventional vs transposed targets was highly significant (assuming a criterion of \(\alpha<0.05\)) \(F(1,3) = 137.80, p = 0.001\) and accounted for 35% of the variability of the data. This reflects the fact that, on average, listeners were more sensitive to ITDs conveyed by transposed targets as compared to their conventional counterparts. The main effect of interference vs no interference was also significant \(F(1,3) = 57.17, p = 0.005\) and accounted for 6% of the variability in the data. This reflects the fact that, on average, threshold-ITDs were elevated in the presence of the interferer. More importantly, for our purposes, the interaction of [conventional vs transposed targets] × [interference vs no interference] conditions was also significant \(F(1,3) = 33.31, p = 0.01\) and accounted for 4% of the variability. This outcome reinforces the general conclusion stated above that only the conventional targets, and not the transposed targets, were subject to binaural interference.

The third main effect, deterministic vs stochastic targets, was also significant \(F(1,3) = 17.33, p = 0.025\) and accounted for 7% of the variability in the data. This reflects the fact that, on average, threshold-ITDs obtained with the deterministic targets were smaller than those obtained with the stochastic targets. It is also the case that the interaction of [conventional vs transposed targets] × [deterministic vs stochastic targets] was also significant \(F(1,3) = 65.72, p = 0.004\), accounting for 11% of the variability. This reflects the observation that threshold-ITDs for the transposed targets were essentially identical whether the stimuli were deterministic or stochastic while threshold-ITDs measured with the conventional SAM stimuli were smaller than those measured with the narrow-band Gaussian noise. The latter outcome replicates findings previously reported in an earlier, independent investigation that also included those two particular SAM and noise stimuli (Bernstein and Trahiotis, 1994).

Finally, neither the interaction of [interference vs no interference] × [deterministic vs stochastic targets], nor the triple interaction among all three factors reached statistical significance (for both types of interactions, \(p>0.25\)). This means that the double interactions found to be statistically significant do not have to be qualified by reference to levels of a third factor. In total, the within-subjects main effects and interactions accounted for 62% of the total variance in the data. Said differently, the properties of the stimuli accounted for the majority of the total variability in the data. Considering that only four listeners participated in the study, the large amount of variability accounted for attests to the robustness of the changes in threshold-ITD brought about by the specific properties of the stimuli.

III. TESTING THE HELLER/TRAHIOTIS QUANTITATIVE MODEL OF BINURAL INTERFERENCE

In 1996, Heller and Trahiotis described an extension of the Buell and Hafter (1991) “weighted combination” model that was successful in accounting for binaural interference in an experiment measuring threshold-ITDs. A fundamental underlying assumption of that model and of the Buell and Hafter model is that interference arises from an obligatory, across-frequency-channel, combination of binaural cues. That is, the processing of the targets and interferers is assumed to be “non-optimal” in that low-frequency diotic interferers, which convey no information useful for detecting ITDs within high-frequency targets, are not ignored. Said differently, the ITD value of zero conveyed by the low-frequency interferer is included in the decision variable and serves to “dilute” the value of the ITD conveyed by the high-frequency target. As a result, in the presence of the
low-frequency interferer, ITDs imposed on the high-frequency target must be increased in order to reach threshold.

The reader is referred to the appendix of Heller and Trahiotis (1996) for a detailed explication of their model and its relation to the model of Buell and Hafer (1991). In what follows, a brief summary of the material in that appendix is presented so that the manner in which the predictions for this study were derived can be understood.

In mathematical terms, the Heller and Trahiotis (1996) model can be represented by

\[ d_{t+i} = \frac{a \Delta x_i + b \Delta x_t}{\sqrt{a^2 \sigma_i^2 + b^2 \sigma_t^2}}, \]  

where \( d_{t+i} \) represents the listener’s sensitivity to changes in target-ITD in the presence of the interferer. The term \( \Delta x_t \) represents the change in lateral position resulting from the imposition of an ITD on the target when it is presented in isolation. In parallel fashion, \( \Delta x_i \) represents the change in lateral position resulting from the imposition of an ITD on the interferer, presented in isolation. Estimates of changes in lateral position (\( \Delta x_t \) and \( \Delta x_i \)), as a function of ITD, are obtained by using an acoustic pointing task to determine the slope, \( s \), of the linear portion (between values of ITD of 0 and 600 \( \mu s \)) relating the IID of the pointer to the ITD of the target or interferer when each is presented in isolation. Within this rubric,

\[ \Delta x_t = s_t \Delta ITD_t, \]  
\[ \Delta x_i = s_i \Delta ITD_i. \]

Note that the changes in lateral position, (\( \Delta x_t \) and \( \Delta x_i \)) are quantified by the IID of the pointer in dB.

Returning to Eq. (1), the terms \( \sigma_t \) and \( \sigma_i \) represent the square-roots of the variances associated with the auditory processing that results in changes in lateral position of the target and interferer, respectively. The values \( \sigma_t \) and \( \sigma_i \) are in units of dB. They are estimated by equating \( \Delta ITD_i \) and \( \Delta ITD_t \) in Eqs. (2) and (3), respectively, with the (threshold) values of ITD required to yield \( d' = 1 \). When that is done

\[ d_t' = s_t \text{threshITD}_t / \sigma_t = 1, \]
\[ d_i' = s_i \text{threshITD}_i / \sigma_i = 1. \]

It follows that

\[ \sigma_t = s_t \text{threshITD}_t, \]
\[ \sigma_i = s_i \text{threshITD}_i. \]

Within Eq. (1), the weights \( a \) and \( b \), applied to the target and interferer “channels,” respectively, are taken to be inversely proportional to \( \sigma_t^2 \) and \( \sigma_i^2 \), respectively.

When the interferer is diotic and, therefore, \( \Delta ITD_i = 0 \), making appropriate substitutions and rearrangements among the relations given above (see Heller and Trahiotis, 1996, p. 3637) yields an equation that can be used to make predictions of target-threshold-ITDs in the presence of an interferer:

\[ \text{threshITD}_{t+i} = \text{threshITD}_t \sqrt{1 + \frac{s_t \text{threshITD}_t}{s_i \text{threshITD}_i}}. \]

Note that, as emphasized by Heller and Trahiotis (1996), the predicted threshold-ITDs under conditions of interference are determined completely by quantities (i.e., threshold-ITDs and slopes of lateralization) obtained when targets and interferers are each presented in isolation. It is also the case that setting the slopes, \( s_t \) and \( s_i \), to 1 in Eq. (8), yields the formulation used by Buell and Hafer (1991) to predict interference effects. The fundamental difference between the two models is that the Heller and Trahiotis model derives predictions directly in terms of changes in lateralization while the Buell and Hafer model derives predictions directly in terms of changes in stimulus-ITD.

In order to derive predictions of threshold-ITDs for targets presented simultaneously with the interferer in the current experiment, an acoustic pointing task was used to determine the slope of the linear function relating the IID of the pointer to values of ITD from 0 to 600 \( \mu s \) for each of the five types of target and for the interferer utilized in the main experiment. The acoustic pointing task was the one employed successfully in several previous investigations. Briefly, the listener was required to adjust the interaural intensive disparity (IID) of a 200-Hz-wide noise centered at 500 Hz until its intracranial position matched that of the stimulus that conveyed the ITD (see, Bernstein and Trahiotis, 1985, 2003; Heller and Trahiotis, 1996).

Three of the four listeners who participated in the main experiment were available to participate in the acoustic pointing task. For each listener and type of stimulus (target or interferer), the slope relating the IID of the pointer to ITD was computed via linear regression. Because those slopes were highly similar across listeners, we computed the average slope, taken across the three listeners, separately for each of the six stimuli (five types of target and the interferer). Those mean slopes and the mean threshold-ITDs obtained in the main experiment were entered into Eq. (8) to derive predictions of ITD-thresholds for each type of target in the presence of the interferer. For archival purposes, those slopes and threshold-ITDs are provided in Table I.

Figure 3 contains the data obtained in the main experiment replotted from Fig. 2 along with the predictions of threshold-ITD in the presence of the interferer. The crosses represent predictions obtained with the Buell and Hafer (1991) model; the asterisks represent predictions obtained with the Heller and Trahiotis (1996) model. Beginning with the conventional targets, note that the predictions derived with the Heller and Trahiotis model are very accurate, being well within the standard error of the measurement of the data themselves (see Fig. 2). The Buell and Hafer model, however, overestimates the effects of interference. These two general outcomes replicate the findings of Heller and Trahiotis.

In contrast, and of great import for the purposes of this study, note that both models, which assume an obligatory, non-optimal combination of information in the low- and high-frequency channels, fail to predict the absence of interference effects that was found with the transposed stimuli. Given the success of the Heller and Trahiotis (1996) model in accounting for interference effects with conventional high-frequency targets, its inability to account for data obtained
with transposed stimuli does not appear to be attributable to some kind of “experimental error” or shortcoming in the experiment, per se. The model’s failure is consistent with the notion that listeners were somehow able to “ignore” the non-information-bearing diotic low-frequency interferer and base their decisions solely on changes in ITDs conveyed by the high-frequency transposed targets. At this time, it is unclear to us what factor(s) render the transposed stimuli employed in this experiment effectively immune to binaural interference. Perhaps future experiments using a wide variety of transposed and conventional targets and interferers will provide information concerning which stimulus conditions are necessary for binaural interference effects to occur and help clarify why binaural interference effects appear to be asymmetric with respect to frequency. At this time it is not clear whether such asymmetric binaural interference effects stem from properties of the binaural system per se, or instead reflect “floor effects” resulting from the overall greater sensitivity to ITDs conveyed by low-frequency conventional stimuli, as compared to their conventional high-frequency counterparts.

IV. SUMMARY AND CONCLUSIONS

Threshold-ITDs were measured with a variety of conventional and transposed “targets” centered at 4 kHz. The targets were presented either in the presence or absence of a simultaneously gated diotic noise centered at 500 Hz, the interferer. As expected, the presence of the low-frequency interferer resulted in substantially elevated threshold-ITDs.
for the conventional high-frequency stimuli. In contrast, these interference effects were either greatly attenuated or absent for ITDs conveyed by the high-frequency transposed targets. The binaural interference effects observed with the conventional high-frequency stimuli were well accounted for, quantitatively, by the model described by Heller and Trahiotis (1996). The lack of binaural interference effects observed with the high-frequency transposed stimuli was not predicted by that model. It is suggested that transposed stimuli may be one of a class of stimuli that do not foster an obligatory combination of binaural information between low- and high-frequency regions. If this were the case, then one could still consider models of binaural interference, such as the one described in Heller and Trahiotis to be valid descriptors of binaural processing under those conditions that do foster such an obligatory combination.

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1Stimulus levels produced according to the calibration supplied with the Etymotic ER-2 earphones sounded less loud than stimuli presented at nominally the same level via TDH-39 earphones, according to their calibration. Dr. Mead Killion, of Etymotic Research, validated our listening experience across those two targets neither distorted nor compromised the meaning and meaningfulness of the statistical analysis.

2This was determined to be justified on two separate grounds. First, as the data in Fig. 2 show, threshold-ITDs obtained with those two targets were virtually identical within interference and no-interference conditions. Second, two additional, separate, analyses of variance were performed while including only the data obtained with the 50-Hz-wide noise or only the 100-Hz-wide noise (rather than their mean). All three sets of analyses of variance resulted in the same factors and interactions either reaching or failing to reach statistical significance. Therefore, our averaging of the data across those two targets neither distorted nor compromised the meaning (and meaningfulness) of the statistical analysis.


