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This supplemental grant supported a graduate student, Ward Drennan. During the grant period, Mr Drennan collaborated on two major research projects. The first project involved frequency discrimination of a single central tone in a sequential sequence of 9 tones under minimal uncertainty conditions. The second project involved intensity discrimination of a single central tone in a complex of 11 tones presented simultaneously or "profile analysis". The primary results of the first project were presented at the 125th meeting of the Acoustical Society of America (ASA) (Watson, et al. 1993a, 1993b). The results of the second project were presented at the 129th, 131st and 132nd meetings of ASA (Watson and Drennan, 1995; Drennan and Watson, 1996a, 1996b).

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Final Report for AFOSR F49620-93-1-0335
"A Systematic method of uncertainty reduction for complex sound perception."

This supplemental grant supported a graduate student, Ward Drennan. During the grant period, Mr. Drennan collaborated on two major research projects. The first project involved frequency discrimination of a single central tone in a sequential sequence of 9 tones under minimal uncertainty conditions. The second project involved intensity discrimination of a single central tone in a complex of 11 tones presented *simultaneously* or "profile analysis". The primary results of the first project were presented at the 125th meeting of the Acoustical Society of America (ASA) (Watson, et al. 1993a, 1993b). The results of the second project were presented at the 129th, 131st and 132nd meetings of ASA (Watson and Drennan, 1995; Drennan and Watson, 1996a, 1996b).

Project 1

A method of adjustment was used to establish the importance of each of several structural properties of the context tones, in nine-tone sequences, in determining the perceptual isolability of target components. A difficulty in tonal-pattern research is that several thousand trials are typically required to approach asymptotic discrimination performance under minimal-uncertainty testing conditions. One solution to this problem has been to use the method of adjustment to determine thresholds, rather than a forced-choice psychophysical method. In this study, the extremely brief times that were required for a listener to achieve perceptual isolation for single component of multi-component patterns using the method of adjustment instead of a forced-choice method (minutes as opposed to hours) were again demonstrated. A quantitative criterion for "perceptual isolation" reached when a frequency match was made that was as close to the standard as can be achieved when the standard and variable tones were both presented in isolation, rather than in a pattern context. Listeners who were "perceptually isolating" could hear a frequency difference of less than 1-2% for the 50-ms tones in these sequences. Not all adjustments were this accurate, however. A useful distinction between difficult and easy adjustments was shown to be the percent of the adjustments, for a given combination of target and context tones, that met this perceptual-isolation criterion.

The context property that was found to primarily affect the frequency matches was the separation, in Hz between the target tone and both the local and (to a lesser degree) the remote context tones. Other than its bandwidth, the *form of the local pitch contour* (the target tone plus the single tones immediately before and after it) had no clear effect on the ability to "hear out" the target tone, i.e., whether the local context was ascending, descending, concave up or concave down. The contours of the remote context tones (first and last three in the patterns) likewise had no effect on performance. Performance ranged from 25% target tones "perceptually isolated" for the most difficult conditions to 90% for the easiest.

Project 2

"Profile" stimuli consisting of multiple simultaneous fixed-frequency sinusoidal components are more representative of naturally occurring sounds than the spectrally simpler waveforms more often used in psychoacoustic experiments. However, most naturally occurring sounds are characterized by dynamic rather than static spectra, and by harmonically-spaced rather than logarithmically-spaced components. Discriminations were based on the detection of an intensity increment added to the mid-frequency component of 11-component, 400 ms profiles. Each profile had a starting frequency range of 200 to 2200 Hz. Dynamic profiles increased in frequency continuously over their 400-ms durations. Each listener was run under four stimulus conditions (static-log, static-harmonic, dynamic-log, dynamic-harmonic) generally for a minimum of 2000 trials per condition., in an adaptive tracking procedure. Mean differences between asymptotic thresholds for the stimulus conditions were small compared to differences among the listeners. These individual differences were sufficiently large to constitute a study of individual differences in profile analysis.

An experiment was conducted to estimate the distribution of profile discrimination abilities for normal-hearing listeners. Forty-six listeners were screened using static-log profiles. The distribution of thresholds was roughly normal with a range of -2 to -26 dB (signal level relative to component level) and an s.d. of 4.8 dB. *No dichotomy in profile discrimination ability was found.*

Listeners from each tail of the distribution were selected and tested using the static-log, static-harmonic, dynamic-log, and dynamic-harmonic profiles. Seven "good" and four "poor" listeners were selected. Each listener was tested again on the static-log profile at the end of the experiment. All the listeners improved from the beginning to the end of the experiment. Two of the four "poor" listeners improved to the levels of the "good" listeners after listening to 2,000 trials of each profile.

Two further issues arose as a result of this study. First, in comparing performance on different profiles, the testing order affected the results. Listeners preformed better on the profiles they heard first. Thus, it was necessary to present the different types of profiles in a random order. Secondly, no roving level was employed in these studies, so it remained unclear whether or not listeners were basing their decision on simultaneous comparison of level across the frequency spectrum or a successive comparison of overall level. Thus, it was also necessary to test several listeners on the four profiles with and without a within-trial roving level.

A final study was conducted with a select group of excellent profile listeners. The four different profiles were presented in a random order with and without a 20-dB within trial rove in the overall level. Seven listeners heard all four profiles in a random order without a rove. Three of those were also tested with the roving levels. Thresholds for the static-log profiles were, on average, about 7.4 dB lower than those for static-harmonic. The standard deviation of the difference was 5.3 dB. Four out of seven listeners showed an interaction between spacing and temporal contour. For these listeners, the dynamic changes hindered performance when the spacing was logarithmic and enhanced performance when spacing is harmonic. The detrimental effect of roving level was less for dynamic profiles than for static profiles. The mean difference was 8.6 dB for static profiles and 1.4 dB for dynamic profiles. Even when listeners were screened for ability to discriminate profiles, individual differences were substantial. Data from dynamic profile analysis experiments should be considered on a listener by listener basis. Interleaving two or more track histories was recommended to obtain a measure of within-listener variance.

Manuscripts describing both of these projects are being prepared for publication.

References

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