Age related changes in glide discrimination and its relation to the ERB

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1. INTRODUCTION

Various psychophysical phenomenon concerning the detection of changes in signal features can be understood in the general framework of an excitation-pattern (EP) model (Moore & Sek, 1994). The EP of a tone is its representation in a bank of tonotopically organized auditory filters and is a reflection of the activity in several overlapping filters (Demany & Clement, 1997). Moore and Sek (1994) have advanced the argument that if discrimination is below the phase locking capabilities of auditory fibers, then thresholds should be based on 'place' cues and be a constant proportion of the ERB. If it is assumed that in the process of glide discrimination, a listener compares signals by comparing the differences between their start and endpoints, the accuracy with which this change can be measured would be determined by the resolution of the location of these points along the basilar membrane. This in turn would be a function of the slope of the excitation pattern, which in turn is determined by the bandwidth of the auditory filters centered at and just below the test frequency (Moore & Sek, 1998). The purpose of the present research was to investigate whether frequency glide discrimination could be explained in terms of an EP model.

2. METHOD

2.1 Participants

143 persons ranging in age from 20-75 years of age were selected for participation. The final group of listeners represented five decades as follows: 20-34 years, n = 30; 35-44 years, n = 30; 45-54 years, n = 28; 55-64 years, n = 25; and 65-75 years, n = 30. The two youngest age groups were recruited from the University of Calgary and the outside community. Other age groups were volunteers from the outside community. Each participant had pure tone thresholds no greater than 20 dB HL for the frequencies of .5kkHz to 8kHz and normal middle ear status.

2.2 signals

Glide signals were created at 2 different frequency regions: one centered slightly above 1kHz (low frequency region) with a center frequency (CF) of the maximal total glide excursion of 1030 Hz; the second series was slightly above 2500 Hz (high frequency region) with a CF of the maximal glide excursion of 2685 Hz. Two different patterns of glide trajectory: upward or downward, and end frequency conditions: diverging or converging, were constructed. Background noise was presented for only the converging upward and diverging downward series of signals at each frequency region for a total of twelve discrimination conditions. The following abbreviations will be used to describe the signals: DU (diverging up); DD (diverging down); DD-N (diverging down in background noise); CD (converging down); CU (converging up); and, CU-N (converging up in background noise. For all series the slowest changing signal in the series was designated as the 'standard' and was used as the comparison stimulus in all pairings.

For each frequency continuum, a series of 17 gliding signals were created. At the low frequency region, signals spanned a maximal excursion of 900 Hz to 1110 Hz. At the higher frequency region the maximal glide excursion was 2685 Hz. Signals were constructed such that the CF of each glide was roved over a range of frequencies. At the low frequency region, Λ CF spanned a range of 80 Hz from 1005 Hz to 1085 Hz. At the high frequency region, Λ CF spanned a range of 240 Hz. Discrimination thresholds were determined under two listening conditions: quiet and in the presence of speech spectrum noise. The noise was low pass filtered at 1kHz and had a 10dB per octave roll off to simulate the long term spectral characteristics of speech and was presented ipsilaterally at a spectrum level of 35 dB. Stimuli were delivered monaurally to the right ear through Kros Pro/4x headphones at a presentation level of 60 dB SPL. The noise was played continuously during the background noise condition.

2.3 Procedure

A two-alternative forced-choice (2AFC) paradigm was used to determine the smallest discriminable differences that individuals could determine. Each trial consisted of two stimuli with an inter-stimulus interval (ISI) of 500 ms and listeners responded 'same' or 'different' via pushing one of two buttons on a board. Each continuum of signals at both frequency regions was presented in blocks of 370 trials. Each trial consisted of the standard stimulus and one of the other 16 signals in the series with the standard being either the first or the second member of the pair an equal number of times. Each series of signals were tested within one block though the order of experimental trials within each block was randomized for each participant.

3. RESULTS

Percentage correct data were then transformed into probit scores. Thresholds were measured from the 70% correct position on the psychometric function. The width of the ERB for the center frequencies of both frequency region were computed based upon Moore and Glasberg's (1990) equation: ERB = 24.7(4.37F +1). The ERB for the CF at the low frequency region is 133 Hz, and the ERB for the high frequency region is 314.5 Hz. Threshold values were expressed in Hz/ ERB for each signal condition at each frequency region. As the extent of the signal was variable within each signal condition (to keep duration and either the endpoint or the starting frequency constant), signals are not a constant proportion of the ERB. However, the standard signals in the low frequency region spanned .38 ERB, and the standard in the high frequency region spanned .48 ERB. Table 1 shows the threshold values expressed on a scale of auditory filters (ERBs).

Table 1. ΔF values expressed on a scale of auditory filters (ERBs) for each age group (top row).

	20-34		35-44		45-54		55-64		65-75	
	L	H	L	H	L	H	L	H	L	H
du	.26	.37	.27	.38	.32	.42	.33	.37	.38	.54
cu	.30	.36	.32	.37	.32	.48	.35	.53	.42	.82
cun	.33	.42	.41	.43	.43	.52	.42	.62	.47	.81
dd	.25	.32	.25	.32	.35	.38	.37	.34	.34	.47
ddn	.28	.35	.32	.37	.31	.29	.38	.38	.37	.50
cd	.44	.51	.45	.50	.47	.54	.49	.54	.43	.69

4. DISCUSSION

When thresholds were expressed as Hz/ERB the proportions ranged from fairly constant at .3 for the 20-44 year olds across conditions and frequency regions. However, values for the 45-74 year olds ranged from .3 to .5 within each signal type for each group. These values are higher than the values of Moore and Sek (1998) and Madden and Fire (1997) for their 50 ms signals with a transition span of .5 ERBs at 2 kHz for the youngest groups of listeners. The proportions are considerably higher for the eldest group of listeners. The increase in the proportions in this study could be a reflection of experience. In the studies by Moore and Sek (1998) and Madden and Fire (1997) listeners were practiced for 10-15 hours before data collection. Therefore, their values probably represent asymptotic performance of discrimination.

In summary, these data do not support models of glide discrimination which predict an enhancement for an upward sweep, nor do they support models of cochlear dispersion cues based on an increment in frequency targets. The most parsimonious explanation is that listeners in this study were relying on terminal frequency pitch cues for discrimination. However, the ΔF/F values are quite large. Weber fraction equivalents of the values in Table 1 range from .3 to .6 which are considerably larger than ΔF/F values for equivalent pure tones (Wier, Jesteadt, and Green,1977) or for glide detection (Dooley & Moore, 1988).

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