FREQUENCY DISCRIMINATION AND CRITICAL BANDS FOLLOWING THE SELECTIVE DESTRUCTION OF COCHLEAR INNER AND OUTER HAIR CELLS

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The role of the inner and outer hair cells of the cochlea in frequency discrimination and critical band measurements is not clearly understood. There is, however, evidence for an interaction between the hair cells in threshold determinations (1) and frequency selectivity (2). Furthermore, although there is increasing evidence that a place theory is more important than a periodicity theory in frequency coding the situation is still not clear, and the role of the inner and outer hair cells in frequency discrimination and critical band measurements should provide additional evidence to help clarify the situation.

The present behavioural studies were carried out on seven monauralized cats which were trained to respond to the conditioned suppression technique (3). Behavioural auditory thresholds were determined by plotting suppression ratios for frequencies of 1 kHz, 4 kHz, 8 kHz, 10 kHz, 12 kHz and 16 kHz. This was carried out in a specially-designed conditioning box (4) in which the acoustic field was measured. Frequency discrimination was determined in three cats by plotting suppression ratios for various changes in frequency (ΔF/F) at 1 kHz, 4 kHz, 8 kHz, 10 kHz, 12 kHz and 16 kHz, at an intensity of 60 dB with intensity randomized over a 10 dB range to prevent maxima and minima in the auditory field being used as false clues. Critical bands were measured in the remaining four cats at the same frequencies by recording the pure tone thresholds in the presence of a masking noise with six different bandwidths, a constant total power and geometrically centred on the test tone (5). The cats were then given a series of intramuscular injections of kanamycin (200 mg kg⁻¹) for 10 days to selectively destroy the outer hair cells, and behavioural thresholds determined shortly afterwards. Frequency discrimination at 60 dB and critical bands were again measured at all the previous frequencies except 16 kHz, where the auditory behavioural threshold was too high. At the completion of the experiments behavioural thresholds were re-determined, the animals were anaesthetized with pentobarbital sodium (40 mg/kg, i.p.) and auditory nerve action potentials recorded. The animals were perfused, the cochleas perfused for surface preparation (4) in which the acoustic field was measured. Frequency discrimination was determined in three cats by plotting suppression ratios for various changes in frequency (ΔF/F) at 1 kHz, 4 kHz, 8 kHz, 10 kHz, 12 kHz and 16 kHz, at an intensity of 60 dB with intensity randomized over a 10 dB range to prevent maxima and minima in the auditory field being used as false clues. Critical bands were measured in the remaining four cats at the same frequencies by recording the pure tone thresholds in the presence of a masking noise with six different bandwidths, a constant total power and geometrically centred on the test tone (5). The cats were then given a series of intramuscular injections of kanamycin (200 mg kg⁻¹) for 10 days to selectively destroy the outer hair cells, and behavioural thresholds determined shortly afterwards. Frequency discrimination at 60 dB and critical bands were again measured at all the previous frequencies except 16 kHz, where the auditory behavioural threshold was too high. At the completion of the experiments behavioural thresholds were re-determined, the animals were anaesthetized with pentobarbital sodium (40 mg/kg, i.p.) and auditory nerve action potentials recorded. The animals were perfused, the cochleas perfused for surface preparation histology, and the inner and outer hair cells counted along the length of the cochleas so that the cochleograms could be constructed on the basis of studies correlating the site of lesion with functional deficit.

The results of the frequency discrimination study are summarized in the table. Changes in frequency discrimination were evaluated statistically with a two-way analysis of variance, and the interaction of the ΔF/F effect and the pre- and post- drug effect was considered appropriate for assessing changes in frequency discrimination. The most important finding was that a significant difference in frequency discrimination only occurred with the loss of inner hair cells in excess of 50%, at a frequency of 12 kHz. The significant result for cat 6 at 1 kHz was due to an improvement in frequency discrimination and was considered a practice effect. The results of the critical band study showed no difference between the pre- and post-drug conditions for frequencies of 1 kHz, 4 kHz, 8 kHz and 10 kHz. The only difference occurred at 12 kHz where the post-drug critical band was too broad to be determined, and this was associated with a greater than 50% loss of inner hair cells for all four cats.

Conclusions: These studies show that the inner hair cells are important in frequency discrimination and critical band measurements.

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