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Sound localization in chinchillas III: Effect of pinna removal

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Abstract

The ability of chinchillas to make left/right, front/back, and vertical locus discriminations was determined before and after surgical removal of the pinnae. The animals were tested behaviorally using a conditioned avoidance procedure. In the left/right localization tests,

chillas, a species with relatively large and mobile pinnae and whose high-frequency hearing limit is approximately 1 octave higher than that of humans (Heffner and Heffner, 1991).

This report is the third in a series exploring the ability of chinchillas to localize sound (Heffner et al., 1994, 1995). It examines the role of the pinnae in sound localiza-

2.3. Acoustic apparatus and stimuli

The acoustic apparatus and sound-measuring equipment were identical to those used for similar tests with normal chinchillas (Heffner et al., 1995). The signal consisted of broadband noise which was equalized (Sentek EQ3) to achieve a relatively flat spectral acoustic signal containing

culty; that is, the angle chosen was the smallest which resulted in an average performance of 80% for animals localizing a broadband signal and for which performance rarely fell below 70% (note that this sustained performance usually averaged slightly lower than asymptotic performance on which thresholds were based). By using such a moderately difficult stimulus angle, any reduction in the effectiveness of the signal would be likely to result in a

rion were: 30° (±15°) around the median sagittal plane for left/right tests, 90° (±45°) around the interaural line for front/back tests, and 45° for vertical localization. However, chinchillas without pinnae were unable to localize the 45° vertical separation; hence the effect of low-pass filtering was assessed using a 75° vertical separation and compared to normal performance at that angle.

The electrical signal was generated by a noise generator

2.4.1. Calculation of performance scores

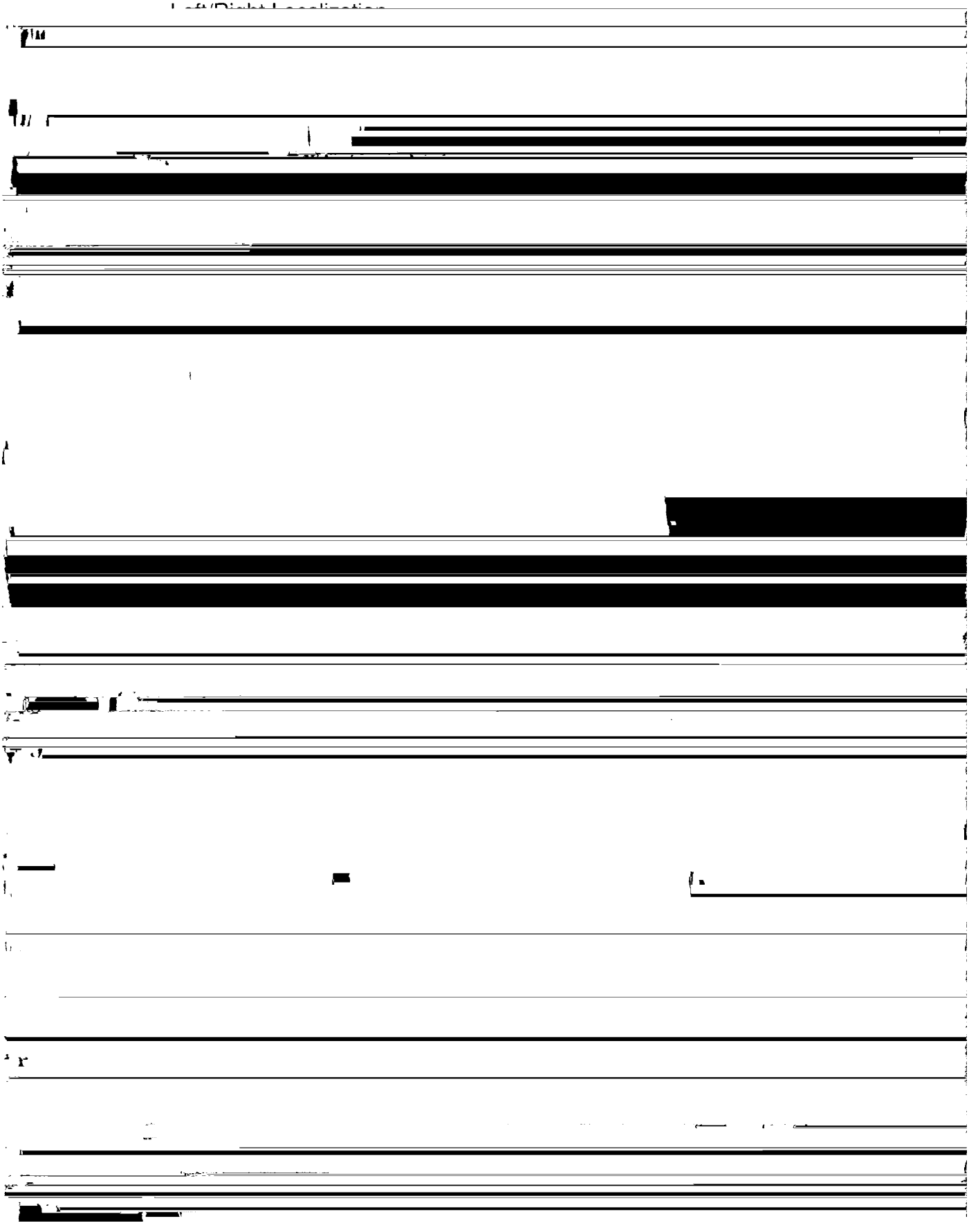
Behavioral performance was determined in the following way. Breaking contact with the spout for at least half of the final 150 ms of a warning trial served to indicate that the animal had detected the shift in locus and was considered a 'hit'; similarly breaking contact during the final 150 ms of a safe trial was considered a 'false alarm'. Performance scores for each stimulus condition were cal-

age performance score was then determined for each stimulus by correcting the observed hit rate for the proportion of false alarms observed under each stimulus condition using the formula:

$$\text{CorrectedDetection} = \text{HitRate} - (\text{FalseAlarmRate} \times \text{HitRate})$$

Performance (i.e., corrected detection) could thus range

Acepromazine followed by 40 mg/kg Ketamine. The fur [redacted] in the removed areas of the left and right pinnae in the [redacted] animals tested after unilateral pinna amputation ($P > 0.05$).



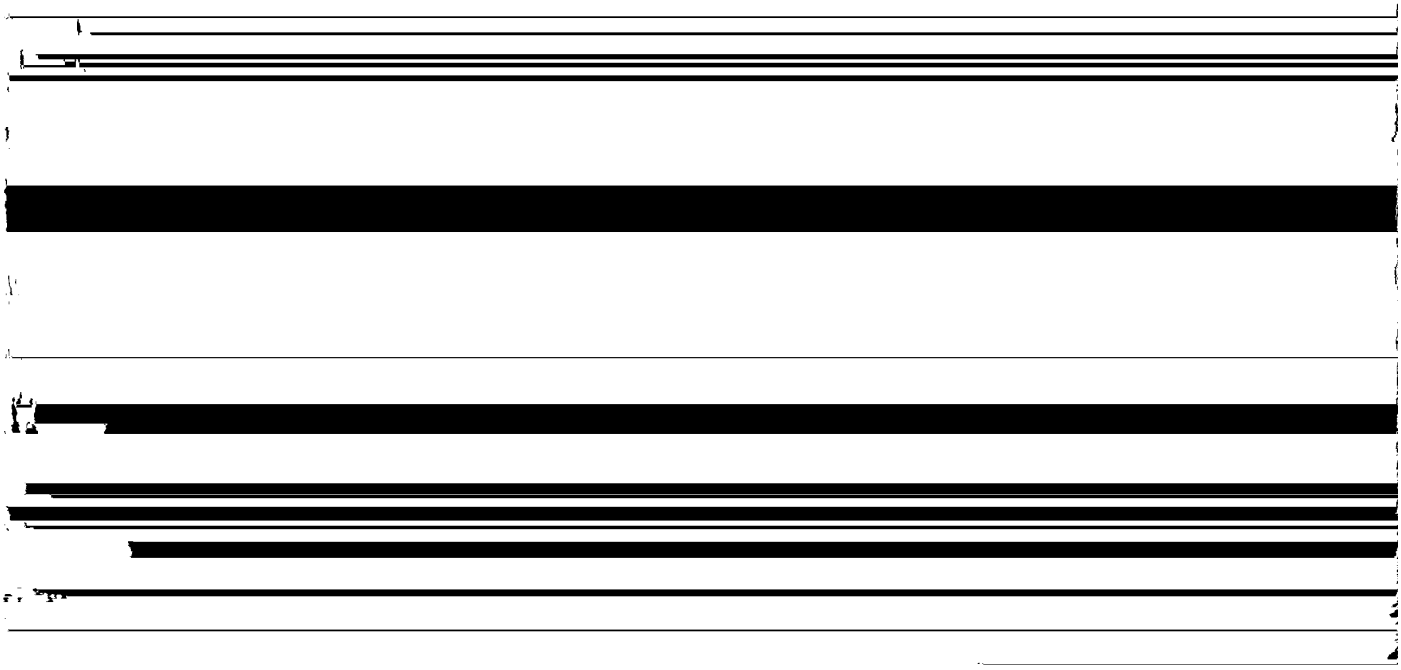
grossest discriminations of vertical locus in chinchillas.

results demonstrate the importance of the pinnae for vertical sound localization.

4. Discussion

The purpose of these experiments was to examine the effect of removing the pinnae on sound localization involving left/right, front/back, and vertical discriminations.

The following discussion describes the role of the pinnae in situations in which binaural cues are the primary cues (left/right discriminations) as well as in situations in



which pinna cues are the primary cues (front/back and

Although it is possible that the decrease in performance in the low-pass noise test resulted from the loss of pinna cues that normally supplement binaural cues, it is conceivable that pinnae removal may have affected the animals' ability to use the binaural locus cues themselves — that is, the difference in the time of arrival of a sound at the two ears and the difference in the frequency-intensity spectrum reaching the two ears. First, pinna removal affects the frequency-intensity spectrum reaching the ear

because the pinnae are major contributors to the change in the spectrum of a sound that occurs as its location changes relative to an animal's head (e.g. Phillips et al., 1982; Jen

and Sun, 1984; Carlile and Pettigrew, 1987; Musicant et

auditory canals and the small remaining stumps of the pinnae.

4.2.1. Variability of performance using pinna cues

Individuals differ substantially in their ability to localize using pinna cues. Among both normal and operated animals there was more variability between animals in the

chillas seems to contribute more to localization than the far pinna of humans.

The observation that, in chinchillas, the far pinna approaches the effectiveness of the near pinna when high frequencies are present may be due to the extension of the pinnae of chinchillas above the head well into the direct path of the sound. In contrast, the pinnae of humans lie

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