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HEARING IN A CHIMPANZEES

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Introduction

Although language has been regarded as a special ability with which only human beings are endowed, recent research on the vocal communication of monkeys in the field(1) and the learning of 'language' by chimpanzees in the laboratory(2),(3),(4) suggests that human language is a result of mutations and natural selection. We assume that the voco-auditory communication systems of early hominids were not so different from those of living apes. To study differences in audition, speech perception and phonation between chimpanzees and humans may help us to understand the course of the evolution of human speech. However, there are few reports of experiments on the voco-auditory functions of chimpanzees. In the present study, the auditory sensitivity of a chimpanzee was investigated. Although humans show the highest sensitivity to 1-4 kHz tones, Old- and New-world monkeys have a loss in sensitivity to 2-4 kHz tones(5),(6). It is of interest to ascertain whether chimpanzees have a human-type or monkey-type auditory function.

Method

The subject was a 7-year-old female chimpanzee. The subject sat in a chair and wore earphones (TDH-39 with MX-41/AR ear cushions). She faced a panel which contained a lamp and a telegraph key in a double-walled, sound attenuating room. A reaction time task was employed. A trial was started by illumination of the lamp. The subject was required to hold the key down until a pure tone was presented. The time between the key press and the onset of the tone (foreperiod) varied between 2-6 sec. The subject was extensively trained to release the key as quickly as possible when she detected the tone. Key release during the 1-sec tone produced a reward (a piece of fruits), turned off the light and terminated the trial. The latency of the key release (reaction time) after the onset of the tone was measured. In general, reaction time became shorter as the intensity of the tone was increased. A curvilinear regression line was fitted to the intensity-latenc functions. If the subject did not release the key within one second after the onset of the tone, or if she released the key during the foreperiod, the stimulus was turned off and the trial was terminated. The frequencies used were from 62.5 Hz to 32 kHz in 1-octave intervals and 24 kHz. The rise and fall times of each tone were 15 msec. Intensities were selected in 10-dB steps from -10 dB to 90 dB SPL (dB re 20 Pa, SPL: sound pressure level) and changed randomly every eight trials, except

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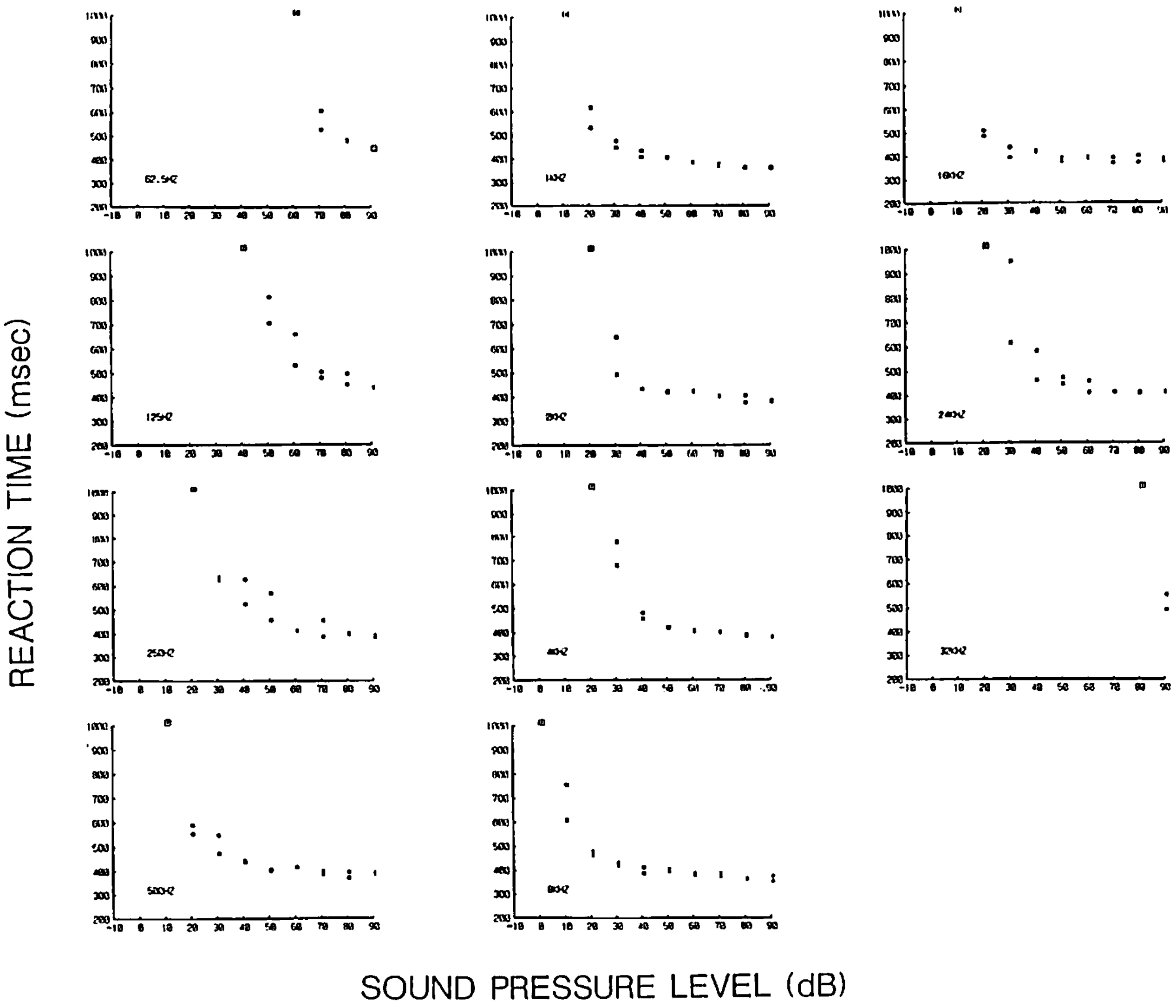

Fig. 1. Intensity-latency functions at each frequency.

for the first eight trials, in which a 90-dB tone was always presented. Tone signals were presented to the subject's right ear through one of the earphones. Because it was difficult to calibrate the earphone when it was attached to the ear, the earphone was calibrated using a 6-cc coupler with a 450-g weight. A single frequency was used in daily sessions of 96 trials, and each frequency was tested twice.

Results

Fig. 1 shows the intensity-latency functions for each frequency. Each black square indicates a mean reaction time for 8 trials. White squares with a dot indicate that the mean reaction time was the same for two sessions. It is clear that the reaction times became shorter as the sound pressure level of the tone increased. A curvilinear regression line was fitted to the intensity-latency functions and equal latency contours were obtained (see Fig. 2). The absolute threshold at each frequency was defined as the intensity with a 800-msec mean reaction time. The chimpanzee was sensitive to 0.5-1 kHz and 8 kHz tones. The best frequency was 8 kHz. She could detect 32-kHz tones when their intensity was 90 dB. Interestingly, the subject showed a 10-20 dB loss in auditory sensitivity to 2-4 kHz tones. Thus, the chimpanzee showed a W-shaped auditory sensitivity function.

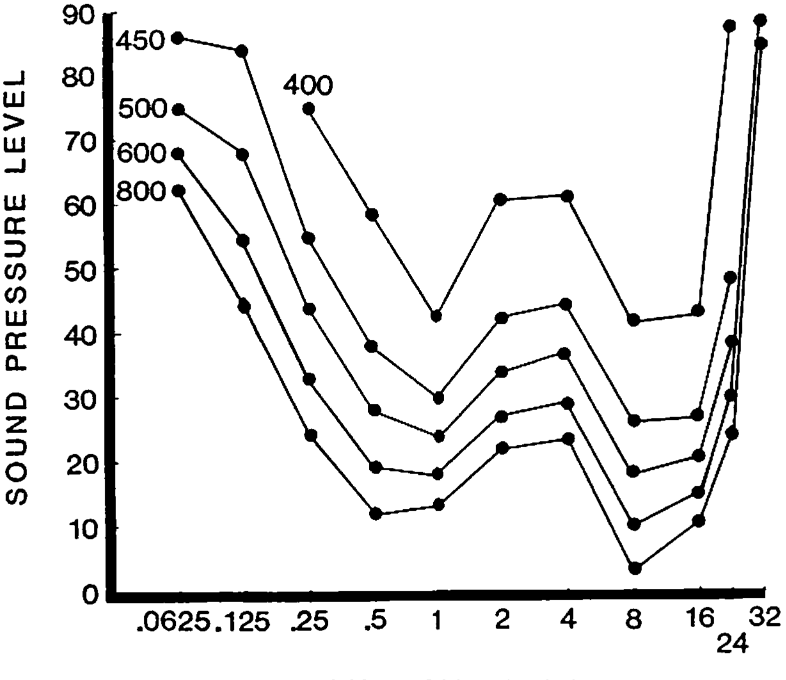

Fig. 2. Equal latency contours. Each number in the figure indicates latency (reaction time).

Reaction time to auditory stimuli has been suggested as a measure of loudness in nonverbal animals⁷⁾. As shown in Fig. 3, equal loudness contours were derived from the intensity-latency functions. A similar W-shaped auditory function was obtained.

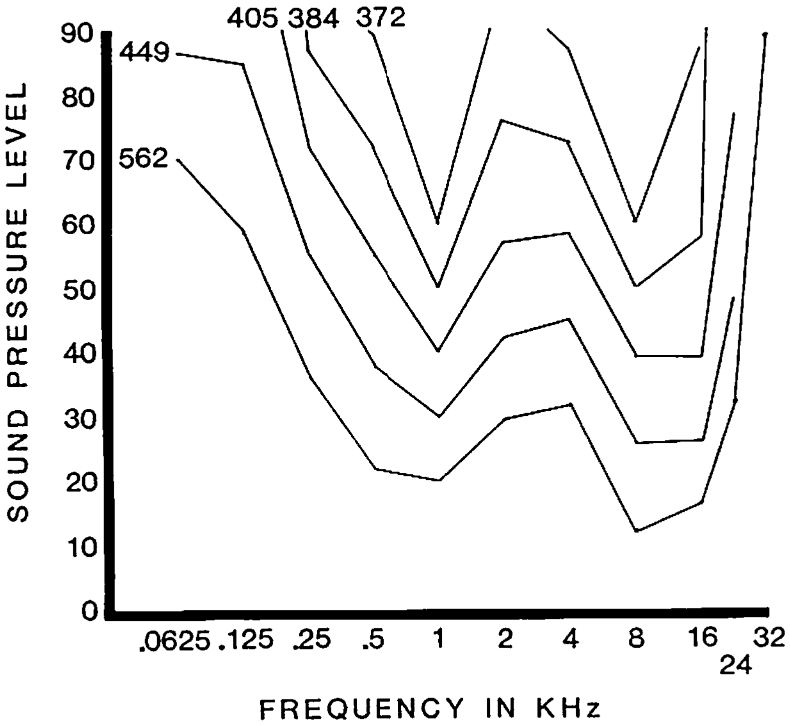

Fig. 3. Equal loudness contours. Numbers are latencies.

Discussion

The chimpanzee showed a loss in auditory sensitivity to 2-4 kHz tones and showed a W-shaped auditory function, which is similar to that of Old- and New-world monkeys and different from that of humans. The chimpanzee was more sensitive than humans, but less sensitive than other monkeys, to higher frequencies. Recently, the author⁸⁾ studied the auditory sensitivity of a human using the same apparatus and the same procedures. A comparison of the human and chimpanzee data revealed that the chimpanzee was less sensitive to lower frequencies (below 250 Hz) than the human. Thus, humans may have a unique auditory function.

High sensitivity to higher frequencies in monkeys and apes is correlated with the distance between the left and the right ears and has been suggested to be related to the auditory localization function$^{9)}$. Sounds with frequencies of less than 4 kHz are frequently used in human speech, and only human beings have spoken language. Therefore, higher sensitivity to 2-4 kHz tones and to lower frequencies in humans may be related to an adaptation to the perception of the human voice. The next step in my experiments will be to examine the differences in human speech perception between chimpanzees and humans.

References

1) Snowdon, C.T., C.H. Brown and M.R. Petersen: Primate communication. Cambridge Univ. Press, Cambridge, 1982.
2) Gardner, R.A. and B.T. Gardner: Teaching sign language to a chimpnzee. Science, 165, 664-672, 1969.
3) Premack, D.: Intelligence in ape and man. Lawrence Erlbaum Associates, Hillsdale, 1976.
4) Rumbaugh, D.: Language learning by a chimpanzee. Academic Press, New York, 1977.
5) Stebbins, W.C.: Hearing of Old world monkeys (Cercopithecinae). Amer. J. Phys. Anthrop., 38, 357-364, 1973.
6) Beecher, M.D.: Hearing in the owl monkey (Aotus trivirgatus): I. auditory sensitivity. J. Comp. Physiol. Psychol., 86, 898-901, 1974.
7) Pfinst, B.E., R. Hienz, J. Kimm and J. Miller: Reaction time procedure for measurement of hearing: I. suprathreshold function. J. Acoust. Soc. Amer., 57, 421-430.
8) Kojima, S.: Studies on the origin of human speech. Paper presented at the 3rd annual meeting of the Japan Primatological Society, Oosaka, June 1987.
9) Masterton, B., H. Heffner and R. Ravizza: The evolution of human hearing. J. Acoust. Soc. Amer., 45, 966-985, 1969.