INVESTIGATION OF OCTAVE SIMILARITY IN PITCH PERCEPTION IN RATS : IN SEARCH OF COMMON AUDITORY PROPERTIES BETWEEN HUMANS AND ANIMALS

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Pitch is the psychological representation of tone height. Pitch is a very important sound attribute that conveys information in speech, music, and animal vocalizations (Doupe & Kuhl,1999; Rothenberg et al., 2014). Various models have been proposed for how we perceive pitch, but they have yet to be fully demonstrated.

It has been found that mental representations of pitch are more likely to explain various phenomena if they are multidimensional. The spiral structure model (Shepard, 1964) is based on the theory that there are two aspects of pitch perception: pitch height, which has a linear relationship with fundamental frequency, and pitch chroma, which is a repeated sequence of notes. These aspects are illustrated in the model of a sound spiraling up the outside of a cylinder. In this model, one revolution of the pitch chroma represents an octave.

When two sounds have a frequency ratio of 1:2, i.e., are in octaves, the perceptual impression of the two sounds is similar. This phenomenon called octave similarity. Octave similarity forms the basis of the pitch chroma concept and can be said to be the foundation for examining pitch perception models. Octave similarity is known to be a general characteristic that is not limited to musical experience and has been observed in infants and in rhesus monkeys (Demany & Armand, 1984; Wright et al., 2000). This suggests that octave similarity is common in a wide range of animal species, not only humans, and that it may have a biological origin. However, the mechanism and evolutionary function of octave similarity are still unclear.

In this study, we used the rat (*Rattus norvegicus*), which is frequently used as a model animal for speech communication, to aim to investigate the mechanism and biological origin of octave similarity in more detail. Although the detection of octave similarity has been explored in other species other than primates, it has not yet been fully demonstrated (Deutsch, 1943; Burns, 1999; Cynx,1993). We conducted behavioral experiments using operant conditioning to elucidate whether octave similarity can be detected in the auditory system of rats.

The experiment was conducted in an operant apparatus. Five rats were first rewarded with a sucrose solution to form left and right lever-pressing behavior. Two groups of octave-related sound stimuli (A: 1250 Hz, 2500 Hz, 5000 Hz; B: 1000 Hz, 2000 Hz, 4000 Hz) were set up, and the rats were trained to discriminate between left and right lever presses according to the pitch of these sound stimuli. Finally, the rats were probed with a sound 1-2 octaves away from the sound presented in the training.

As a result of the discrimination training, all rats achieved the training criterion and were able to perform the probe test twice. As a result of probe tests, all rats perceived the probe sounds and showed left or right lever-pressing responses. However, the results did not show octave similarity, i.e., similarity of perception of the probe sound to that of the training sound, and the rats showed different responses depending on the individual and the probe sounds. The analysis of response latency suggested that compared to the sound stimuli presented in the training trials, probe sounds were perceived as different, and this tendency was particularly pronounced for probe sounds that were two octaves apart.

When we examined the difference in response shown by rats, it was suggested that comparing the relative pitch of the presented sound stimuli may have caused a deflection of the left/right response. Furthermore, it was considered that some rats responded not only to the presented sound stimuli but also to left/right preference and past response content in lever pressing during the session as a cue during the probe test. From now on, we will adjust the experimental method to eliminate response cues other than the presented sounds. In addition, we plan to conduct a test in which rats are trained to discriminate a part of the probe sounds and then presented with another new probe sounds, in order to further verify the phenomenon of pitch perception.

The progress of this study will allow us to examine the possibility that octave similarity is a common mechanism in many animal species, and will provide new insights into auditory research. Furthermore, the possibility that octave equivalence is related to the specificity of human speech signals can be examined.

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