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Central Neuronal Plasticity in Tinnitus: Functional Assessments in the Inferior Colliculus and the Hippocampus

We earlier reported that loud sound exposure can cause changes in the inferior colliculus, which is located in the midbrain. The results obtained in the present study demonstrate another aspect of the brain's plasticity (the ability to adapt to change in demands and recover after injuries) in the limbic system or "the emotional brain." The limbic system is involved in some forms of severe tinnitus.

We studied a part of that system — the *hippocampus* — and found that brief exposure to loud sounds could change the function of neurons in the hippocampus. The hippocampus is involved in cognitive functions including memory, which explains some of the symptoms that many people with severe tinnitus experience. To the best of our knowledge, no study has been published that shows involvement of the hippocampus in connection with tinnitus or over-exposure to sound.

In the present study, we recorded electrical activity in the hippocampus of rats using permanently implanted microelectrodes. We specifically studied their neural activity as they explored a maze for a reward. After baseline recordings were made, the rats were exposed to high-intensity noise. When the recordings were repeated after the noise exposure, we saw large changes in the recorded activity, which lasted for many hours.

Before noise exposure, the average firing rate of cells in the hippocampus was approximately 1 Hz; after noise exposure, it increased to more than 50 Hz and that persisted for at least 70 minutes. Other neurons essentially "shut down" after the initial noise-induced burst of activity and fired rarely during maze exploration sessions. Other neurons showed altered characteristics after noise exposure.

We conclude that the noise exposure opened new sensory pathways and seriously altered and/or disrupted the activity of nerve cells in the hippocampus. This means that brief noise exposure could have significant long-term effects on cognitive systems that rely upon the stability of the hippocampus. Degradation of neural activity in the hippocampus is often viewed as being responsible for difficulties in learning and forming new memories, while facilitation of this activity is associated with improved memory. The novel findings of the present study suggest that some forms of tinnitus may be associated with changes in the function of the hippocampus.

It might be possible to reverse or prevent the expression of neural plasticity in the hippocampus. These studies, therefore, open new possibilities for curing or preventing tinnitus. We are continuing the research on the involvement of the hippocampus in tinnitus.