

APRIL 18, 2003

## White Noise Delays Auditory Organization in the Brain

Exposure to continuous white noise sabotages the development of the auditory region of the brain, which may ultimately impair hearing and language acquisition, according to researchers from the University of California, San Francisco.

According to the scientists, the young rats used in their study were exposed to constant white noise that is relevant to the increasing, random noise encountered by humans in today's environment. They theorize that their findings could aid in explaining the increase in language-impairment developmental disorders over the last few decades.

The researchers, which included Howard Hughes Medical Institute medical student fellow Edward Chang and otolaryngology professor Michael Merzenich at the University of California at San Francisco, published their findings in the April 18, 2003, issue of the journal *Science*.

---

"If we knew that a child had a susceptibility to noise, we could intervene to enrich the child's acoustic experience to foster more normal auditory and language development."

- Edward Chang

---

"While the rat is not a perfect model of human auditory development, it does allow us to investigate the fundamental role of early sensory experience in mammalian auditory development," said Chang. "For example, we do know that exposing infant rats to specific sound stimuli can induce long-standing representational changes in the brain. Other researchers have shown that there are striking parallels in humans and other animals."

Although past experiments have demonstrated the important effects that visual experience can have on brain development in animals and humans, Chang said very few comparable experiments have been reported that explore

the effects of patterned early auditory experience on cortical development.

“Auditory experience is clearly an important factor in humans for learning language,” he said. “We learn to speak and read through our sensitivities to speech sounds that are heard during early life.”

Thus, Chang and Merzenich designed experiments in which they reared rat pups in an environment of moderate continuous background noise, which, while not injurious to their peripheral hearing, was loud enough to mask normal environmental sounds. They then used electrophysiological methods to gauge the organization of the auditory cortex in those animals, as well as in control animals raised in a normal auditory environment.

The mapping technique consisted of recording the responses of auditory cortex neurons to a variety of sounds presented to anesthetized animals.

“We knew from previous work that the rat auditory cortex normally undergoes a very dramatic, specific, and progressive development,” said Chang. “During the first month of life, it becomes much more specific and well tuned to different frequencies and temporal patterns of sound. The brains of animals reared in noise, however, did not achieve the basic benchmarks of auditory development until they were three or four times older than normal animals,” he said.

Additional tests on the maturing noise-reared rats showed that their auditory regions continued to be plastic—they continued to reorganize their neural circuitry in response to exposure to sound stimuli alone, long after the brains of normal rats had ceased rewiring. This suggested that a “critical period” for exposure-based plasticity in the brain had been extended.

They performed supplementary long-term experiments that showed that although auditory development was delayed in the noise-exposed rats, it did mature to normal adult levels once the animals were removed from the noisy environment. And furthermore, they observed those plasticity effects consolidated during the extended critical period persisted into the future, suggesting that this exposure were indeed “critical.” Chang summarized, “it’s like the brain is waiting for some clearly patterned sounds in order to continue its development. And when it finally gets them, it is heavily influenced them, even when the animal is physically older.”

Chang said that the findings “suggest that there are two sides to the coin. “On the negative side, these findings suggest that noise can have devastating effects on the rate of development of the brain. They emphasize the importance that children, especially those at risk, be exposed to salient features in speech sounds in order for their auditory development to be normal. On the positive side, our findings may mean that the time frame may be longer in which treatment of such children will allow them to catch up.” According to Chang, the need for exposure to structured sounds underscores

the importance of special therapy for children with disorders that might affect auditory processing.

“There are many linkages between neurons in the auditory system from the cochlea to the cortex where information has to be passed along,” he said. “And in addition to environmental noise, a number of acquired or inherited disorders could potentially degrade the signal at any of these points, masking the sensory input. From these findings, we theorize that disorders, for example, such as focal epilepsies or defects in myelination, might affect the fidelity of this signal, disrupting normal development of the auditory cortex. A combination of external and internal elements would be highly detrimental.”

Chang's future studies will address whether humans with developmental disorders have higher levels of noise in their auditory systems. Such studies, he said, could lead to diagnostic and predictive tests.

“If we knew that a child had a susceptibility to noise, we could intervene to enrich the child's acoustic experience to foster more normal auditory and language development,” said Chang.