Multisensory Integration of Natural Odors and Sounds in the Auditory Cortex

A new study reveals a connection between odor and auditory sensory information in mothers.

Instinctive mothering behavior towards care of newborns has long been recognized as a phenomenon in humans and animals, but now research at the Hebrew University has shown that motherhood is associated with the acquisition of a host of new behaviors that are driven, at least in part, by alterations in brain function.

The research, by Prof. Adi Mizrahi of the Edmond and Lily Safra Center for Brain Sciences (ELSC) and the Silberman Institute of Life Sciences at the Hebrew University, has just been published in the journal Neuron.

It provides insight into how neural changes integrating odors and sounds lie behind a mouse mother’s ability to recognize and respond to distress calls from her pups.

“We know that distinct brain changes are linked with motherhood, but the impact of these changes on sensory processing and the emergence of maternal behaviors are largely unknown,” explains Mizrahi. “In mice, olfactory and auditory cues play a major role in the communication between a mother and her pups. Therefore, we hypothesized that there may be some interaction between olfactory and auditory processing so that pup odors might modulate the way pup calls are processed in the mother’s brain.”

Prof. Mizrahi and his postdoctoral colleague Dr. Lior Cohen examined whether the primary auditory cortex, a brain region that is involved in
the recognition of sounds, might serve as an early processing region for integration of pup odors and pup calls. The primary auditory cortex is known as a site that undergoes functional changes in response to sensory input from the environment.

In their study, the researchers exposed regular mice, mice that had experienced interaction with their pups, and lactating mother mice to pup odors, and then monitored both spontaneous and sound-evoked activity of neurons in the auditory cortex. The odors triggered dramatic changes in auditory processing only in the females that had interacted with pups, while the lactating mothers were the most sensitive to pup sounds. The olfactory-auditory integration appeared in lactating mothers shortly after they had given birth and had a particularly strong effect on the detection of pup distress calls.

Taken together, the findings suggest that motherhood is associated with a previously un-described form of multisensory processing in the auditory cortex.

“We have shown that motherhood is associated with a rapid and robust appearance of olfactory-auditory integration in the primary auditory cortex occurring along with stimulus-specific adaptation to pup distress calls,” says Prof. Mizrahi. “These processes help to explain how changes in neocortical networks facilitate efficient detection of pups by their caring mothers.”

Source: [Dept. Media Relations, Hebrew University](https://www.university.humansciences.huji.ac.il/)

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**Summary**

Motherhood is associated with different forms of physiological alterations including transient hormonal changes and brain plasticity. The underlying impact of these changes on the emergence of maternal behaviors and sensory processing within the mother’s brain are largely unknown. By using in vivo cell-attached recordings in the primary auditory cortex of female mice, we discovered that exposure to pups’ body odor reshapes neuronal responses to pure tones and natural auditory stimuli. This olfactory-auditory interaction appeared naturally in lactating mothers shortly after parturition and was long lasting. Naive virgins that had experience with the pups also showed an appearance of olfactory-auditory integration in A1, suggesting that multisensory integration may be experience dependent. Neurons from lactating mothers were more sensitive to sounds as compared to those from experienced mice, independent of the odor effects. These uni- and multisensory cortical changes may facilitate the detection and discrimination of pup distress calls and strengthen the bond between mothers and their neonates.

**Video Abstract:**

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