

Face-specific brain area responds to faces even in people born blind

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MIT researchers have found that the fusiform face area, which is specialized to recognize faces, lights up in people who have been blind since birth when they touch a three-dimensional model of a face with their hands. The finding suggests that this area does not require visual experience to develop a preference for faces. Credit: Massachusetts Institute of Technology

More than 20 years ago, neuroscientist Nancy Kanwisher and others discovered that a small section of the brain located near the base of the skull responds much more strongly to faces than to other objects we see. This area, known as the fusiform face area, is believed to be specialized for identifying faces.

Now, in a surprising new finding, Kanwisher and her colleagues have shown that this same region also becomes active in people who have been blind since birth, when they touch a three-dimensional model of a face with their hands. The finding suggests that this area does not require visual experience to develop a preference for faces.

"That doesn't mean that visual input doesn't play a role in sighted subjects—it probably does," she says. "What we showed here is that visual input is not necessary to develop this particular patch, in the same location, with the same selectivity for faces. That was pretty astonishing."

Kanwisher, the Walter A. Rosenblith Professor of Cognitive Neuroscience and a member of MIT's McGovern Institute for Brain Research, is the senior author of the study. N. Apurva Ratan Murty, an MIT postdoc, is the lead author of the study, which appears this week in the *Proceedings of the National Academy of Sciences*. Other authors of the paper include Santani Teng, a former MIT postdoc; Aude Oliva, a senior research scientist, co-director of the MIT Quest for Intelligence, and MIT director of the MIT-IBM Watson AI Lab; and David Beeler and Anna Mynick, both former lab technicians.

Selective for faces

Studying people who were born blind allowed the researchers to tackle longstanding questions regarding how specialization arises in the brain. In this case, they were specifically investigating face perception, but the

same unanswered questions apply to many other aspects of human cognition, Kanwisher says.

"This is part of a broader question that scientists and philosophers have been asking themselves for hundreds of years, about where the structure of the mind and brain comes from," she says. "To what extent are we products of experience, and to what extent do we have built-in structure? This is a version of that question asking about the particular role of [visual experience](#) in constructing the face area."

The new work builds on a 2017 study from researchers in Belgium. In that study, congenitally blind subjects were scanned with functional magnetic resonance imaging (fMRI) as they listened to a variety of sounds, some related to faces (such as laughing or chewing), and others not. That study found higher responses in the vicinity of the FFA to face-related sounds than to sounds such as a ball bouncing or hands clapping.

In the new study, the MIT team wanted to use tactile experience to measure more directly how the brains of blind people respond to faces. They created a ring of 3-D-printed objects that included faces, hands, chairs, and mazes, and rotated them so that the subject could handle each one while in the fMRI scanner.

They began with normally sighted subjects and found that when they handled the 3-D objects, a small area that corresponded to the location of the FFA was preferentially active when the subjects touched the faces, compared to when they touched other objects. This activity, which was weaker than the signal produced when sighted subjects looked at faces, was not surprising to see, Kanwisher says.

"We know that people engage in visual imagery, and we know from prior studies that visual imagery can activate the FFA. So the fact that you see the response with touch in a sighted person is not shocking

because they're visually imagining what they're feeling," she says.

The researchers then performed the same experiments, using tactile input only, with 15 subjects who reported being blind since birth. To their surprise, they found that the brain showed face-specific activity in the same area as the sighted subjects, at levels similar to when sighted people handled the 3-D-printed faces.

"When we saw it in the first few subjects, it was really shocking, because no one had seen individual face-specific activations in the fusiform gyrus in blind subjects previously," Murty says.

Patterns of connection

The researchers also explored several hypotheses that have been put forward to explain why face-selectivity always seems to develop in the same region of the brain. One prominent hypothesis suggests that the FFA develops face-selectivity because it receives [visual input](#) from the fovea (the center of the retina), and we tend to focus on faces at the center of our visual field. However, since this region developed in blind people with no foveal input, the new findings do not support this idea.

Another hypothesis is that the FFA has a natural preference for curved shapes. To test that idea, the researchers performed another set of experiments in which they asked the blind subjects to handle a variety of 3-D-printed shapes, including cubes, spheres, and eggs. They found that the FFA did not show any preference for the curved objects over the cube-shaped objects.

The researchers did find evidence for a third hypothesis, which is that face selectivity arises in the FFA because of its connections to other parts of the brain. They were able to measure the FFA's "connectivity fingerprint"—a measure of the correlation between activity in the FFA

and activity in other parts of the brain—in both blind and sighted subjects.

They then used the data from each group to train a computer model to predict the exact location of the brain's selective response to faces based on the FFA connectivity fingerprint. They found that when the model was trained on data from sighted patients, it could accurately predict the results in blind subjects, and vice versa. They also found evidence that connections to the frontal and parietal lobes of the brain, which are involved in high-level processing of sensory information, may be the most important in determining the role of the FFA.

"It's suggestive of this very interesting story that the brain wires itself up in development not just by taking perceptual information and doing statistics on the input and allocating patches of brain, according to some kind of broadly agnostic statistical procedure," Kanwisher says. "Rather, there are endogenous constraints in the brain present at birth, in this case, in the form of connections to higher-level [brain](#) regions, and these connections are perhaps playing a causal role in its development."

More information: N. Apurva Ratan Murty et al. Visual experience is not necessary for the development of face-selectivity in the lateral fusiform gyrus, *Proceedings of the National Academy of Sciences* (2020). [DOI: 10.1073/pnas.2004607117](https://doi.org/10.1073/pnas.2004607117)

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