

Fingerprints filter the vibrations fingers feel

Ridges may help make touch sensation efficient

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FEELING FINGERTIPS By designing artificial fingertips (top right), researchers found that real human fingerprints (left and bottom right) may help the finger sense fine-scale textures efficiently. Images courtesy of Science/AAAS

The intricate patterns of swirls on human fingers may do more than help cops nab crooks. A study online January 29 in *Science* helps crack the case of fingerprints' real job: Epidermal ridges, fingerprints' professional name, likely serve as filters to help in the efficient detection of fine textures.

"The functional role of fingerprints has remained something of a mystery," says Sliman Bensmaia, a neuroscientist at Johns Hopkins University in Baltimore who studies touch sensations. But the new results show that "fingerprints enhance our ability to perceive surface texture."

When a finger sweeps over a finely textured surface, such as a cotton sleeve or a wooden coffee table, the interaction sends a large range of vibrations into the skin. Specialized sensors called Pacinian fibers, the tips of nerve fibers, detect only a select few of the vibrations — those right around 250 hertz — before sending the signal to the brain, where the touch sensation is processed. Other receptors in the finger detect different frequencies.

To study the details of touch, a group of physicists led by Georges Debrégeas at the CNRS École Normale Supérieure research center in Paris took a robotics approach. The researchers developed biomimetic sensors to detect vibrations similar to those created when fingers move over a fine texture. Elastic caps that mimicked human fingertip skin covered the sensors. One fake fingertip had ridges similar in size and distribution to human fingerprints, and another was left smooth.

The vibrations detected by the two sensors, one smooth and one covered in fingerprints, showed very different properties. The sensor covered in fingerprints registered much less variation in vibrations, while the smooth sensor picked up a much larger range of signals.

Like sunglasses that filter out UV light and let the useful visible light through, the artificial fingerprints filtered out vibrations above and below 250 hertz, leaving only the vibrations that could be detected by Pacinian fibers. Fingerprints, the researchers propose, make the touch-sensing system more efficient by sculpting the input to activate only the receptor meant to sense it..

"If you take white noise, like a completely random texture, and scan across it, the low and high vibrations get dampened," explains Ellen Lumpkin, a neuroscientist at Baylor College of Medicine in Houston, who was not involved in the study.

The researchers also found that fingerprints only do their vibration-filtering job when the finger motion is perpendicular to the fingerprint ridges. But not to worry: Human fingerprints are patterned in swirls — every direction of swiping will activate some filtering properties.

"The nice thing is that pattern doesn't matter," Debrégeas says. The distinctiveness of fingerprint patterns from one person to the next doesn't seem to have an effect on filtering capabilities.

The new work points to an interesting parallel between fingertips and another sensory organ — the cochlea in the ear. The cochlea works by breaking down a complex sound into its components, acting, as Lumpkin calls it, as a frequency analyzer. "Like the cochlea is a frequency analyzer for sounds, the fingertips are frequency analyzers for fingers," says Lumpkin. Humans' ability to see color also depends on frequency selection. Specific proteins respond selectively to the light waves of different colors, allowing humans to see colors efficiently.

Figuring out the complicated system of touch sensation is important work, Bensmaïa says. A prosthetic hand with fingerprints could "greatly enhance amputees' ability to perceive texture," he says.

Lumpkin points out that the study was conducted on artificial tissue, not the real thing, which will be far more difficult. "What we have is a plausible model," Lumpkin says. "This could be the way it works in biology. Now, biologists need to verify that."