Wearable device that vibrates fingertip could improve one's sense of touch

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Georgia Tech applied physiology associate professor Minoru Shinohara conducts a single-point touch test on mechanical engineering assistant professor Jun Ueda, who is wearing a glove with a vibrating fingertip designed to improve his sense of touch. Credit: Georgia Tech/Gary Meek

A little vibration can be a good thing for people who need a sensitive touch.

Researchers at the Georgia Institute of Technology have developed a glove with a special fingertip designed to improve the wearer's sense of touch. Applying a small vibration to the side of the fingertip improves tactile sensitivity and motor performance, according to their research results.

Previous research has shown that adding an appropriate amount of white noise -- a concept called stochastic resonance -- can improve sight, hearing, balance control and touch, but the white noise had not been incorporated into a wearable device. The Georgia Tech prototype is believed to be the first wearable stochastic resonance device, attaching to the fingertip to improve the sense of touch.

Georgia Tech researchers have developed a glove with a vibrating fingertip that improves tactile sensitivity and motor performance. The device uses an actuator made of a stack of lead zirconate titanate layers to generate high-frequency vibration to the side of the fingertip. Credit: Georgia Tech/Gary Meek

"This device may one day be used to assist individuals whose jobs require high-precision manual dexterity or those with medical conditions that reduce their sense of touch," said Jun Ueda, an assistant professor in the George W. Woodruff School of Mechanical Engineering at Georgia Tech.

Ueda worked with Minoru Shinohara, an associate professor in the School of Applied Physiology at Georgia Tech, and visiting scholar Yuichi Kurita, to design the device and test its capabilities on a small group of healthy individuals.

Details of the device and preliminary test results were presented in May at the 2011 IEEE International Conference on Robotics and Automation in Shanghai.

The device uses an actuator made of a stack of lead zirconate titanate layers to generate high-frequency vibration. The ceramic layers are piezoelectric, which means they generate an electrical charge when a mechanical force is applied to them. The actuator is attached to the side of the fingertip so that the palm-side of the finger remains free and the individual wearing the glove can continue to manipulate objects.

For this study, the researchers attached the device to 10 healthy adult volunteers who performed common sensory and motor skill tasks, including texture discrimination, two-point discrimination, single-point touch and grasp tests. The experimental results showed that the volunteers performed statistically better on all of the tasks when mechanical vibration was applied.

"All of the experimental results showed that some mechanical vibration was better than none at all, but the level of vibration that statistically improved sensorimotor functions varied by test," noted Ueda.

For each test, researchers attached the device to a volunteer's non-dominant index finger and subjected the finger to six randomized vibrations that ranged from 0-150 percent of that person's vibration amplitude threshold, a value that was determined by earlier testing. The threshold value was the magnitude of vibration required for a subject to feel that the device was vibrating.

In the two-point discrimination test, two sharp points were pressed against the fingertip and volunteers reported whether they could reliably distinguish two points touching their finger versus just one. The results showed that when individuals were subjected to vibrations equal to 75 and 100 percent of their thresholds, they could sense two points that were closer together.

The single-point touch experiment involved pressing a fiber strand against each individual's finger. Subjects were asked to report if they could feel filaments of different weights touching their fingers. The volunteers could feel lighter weight filaments when exposed to vibrations up to their vibration amplitude threshold.

In the third experiment, pieces of sandpaper with different grits were glued on one side of a plastic board. Researchers then randomly selected a test piece of sandpaper and attached it to the other side of the board -- which the subjects could not see. Subjects touched the single piece of sandpaper and tried to select the matching piece from the nine samples on the other side of the board. At vibration levels of 50 and 100 percent of their thresholds, the subjects selected the correct piece of sandpaper 15 percent more often than when they were not exposed to any vibration.

For the grasping test, each subject pinched and held an object for three seconds with as small a force as possible without letting it slip. Statistically significant improvements in grasping were observed for cases of 50, 100 and 125 percent of threshold vibration.

All four sensing ability tests confirmed that the application of certain levels of mechanical vibration enhanced the tactile sensitivity of the fingertip. However, because the levels of vibration that created statistically significant results varied, the researchers are currently conducting experiments to determine the optimal amplitude and frequency characteristics of vibration and the influence of long-term exposure to vibrations. The researchers are also working on optimizing the design of the glove and testing the effect of attaching actuators to both sides of the fingertip or the fingernail.

"The future of this research may lead to the development of a novel orthopedic device that can help people with peripheral nerve damage resume their daily activities or improve the abilities of individuals with jobs that require skills in manipulation or texture discrimination," said Ueda.

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