Beauty and the brain: Electrical stimulation of the brain makes you perceive faces as more attractive

June 12 2013, by Marcus Woo

(Medical Xpress)—Beauty is in the eye of the beholder, and—as researchers have now shown—in the brain as well.

The researchers, led by scientists at the California Institute of Technology (Caltech), have used a well-known, noninvasive technique to electrically stimulate a specific region deep inside the brain previously thought to be inaccessible. The stimulation, the scientists say, caused volunteers to judge faces as more attractive than before their brains were stimulated.

Being able to effect such behavioral changes means that this electrical stimulation tool could be used to noninvasively manipulate deep regions of the brain—and, therefore, that it could serve as a new approach to study and treat a variety of deep-brain neuropsychiatric disorders, such as Parkinson's disease and schizophrenia, the researchers say.

"This is very exciting because the primary means of inducing these kinds of deep-brain changes to date has been by administering drug treatments," says Vikram Chib, a postdoctoral scholar who led the study, which is being published in the June 11 issue of the journal *Translational Psychiatry*. "But the problem with drugs is that they're not location-specific—they act on the entire brain." Thus, drugs may carry unwanted side effects or, occasionally, won't work for certain patients—who then may need invasive treatments involving the implantation of electrodes into the brain.

So Chib and his colleagues turned to a technique called transcranial direct-current stimulation (tDCS), which, Chib notes, is cheap, simple, and safe. In this method, an anode and a cathode are placed at two different locations on the scalp. A weak electrical current—which can be powered by a nine-volt battery—runs from the cathode, through the brain, and to the anode. The electrical current is a mere 2 milliamps—10,000 times less than the 20 amps typically available from

wall sockets. "All you feel is a little bit of tingling, and some people don't even feel that," he says.

"There have been many studies employing tDCS to affect behavior or change local neural activity," says Shinsuke Shimojo, the Gertrude Baltimore Professor of Experimental Psychology and a coauthor of the paper. For example, the technique has been used to treat depression and to help stroke patients rehabilitate their motor skills. "However, to our knowledge, virtually none of the previous studies actually examined and correlated both behavior and neural activity," he says. These studies also targeted the surface areas of the brain—not much more than a centimeter deep—which were thought to be the physical limit of how far tDCS could reach, Chib adds.

The researchers hypothesized that they could exploit known neural connections and use tDCS to stimulate deeper regions of the brain. In particular, they wanted to access the ventral midbrain—the center of the brain's reward-processing network, and about as deep as you can go. It is thought to be the source of dopamine, a chemical whose deficiency has been linked to many neuropsychiatric disorders.

The ventral midbrain is part of a neural circuit that includes the dorsolateral prefrontal cortex (DLPFC), which is located just above the temples, and the ventromedial prefrontal cortex (VMPFC), which is behind the forehead. Decreasing activity in the DLPFC boosts activity in the VMPFC, which in turn bumps up activity in the ventral midbrain. To manipulate the ventral midbrain, therefore, the researchers decided to try using tDCS to deactivate the DLPFC and activate the VMPFC.

To test their hypothesis, the researchers asked volunteers to judge the attractiveness of groups of faces both before and after the volunteers' brains had been stimulated with tDCS. Judging facial attractiveness is one of the simplest, most primal tasks that can activate the brain's

reward network, and difficulty in evaluating faces and recognizing facial emotions is a common symptom of neuropsychiatric disorders. The study participants rated the faces while inside a functional magnetic resonance imaging (fMRI) scanner, which allowed the researchers to evaluate any changes in brain activity caused by the stimulation.

A total of 99 volunteers participated in the tDCS experiment and were divided into six stimulation groups. In the main stimulation group, composed of 19 subjects, the DLPFC was deactivated and the VMPFC activated with a stimulation configuration that the researchers theorized would ultimately activate the ventral midbrain. The other groups were used to test different stimulation configurations. For example, in one group, the placement of the cathode and anode were switched so that the DLPFC was activated and the VMPFC was deactivated—the opposite of the main group. Another was a "sham" group, in which the electrodes were placed on volunteers' heads, but no current was run.

Those in the main group rated the faces presented after stimulation as more attractive than those they saw before stimulation. There were no differences in the ratings from the control groups. This change in ratings in the main group suggests that tDCS is indeed able to activate the ventral midbrain, and that the resulting changes in brain activity in this deep-brain region are associated with changes in the evaluation of attractiveness.

In addition, the fMRI scans revealed that tDCS strengthened the correlation between VMPFC activity and ventral midbrain activity. In other words, stimulation appeared to enhance the neural connectivity between the two brain areas. And for those who showed the strongest connectivity, tDCS led to the biggest change in attractiveness ratings. Taken together, the researchers say these results show that tDCS is causing those shifts in perception by manipulating the ventral midbrain via the DLPFC and VMPFC.

"The fact that we haven't had a way to noninvasively manipulate a functional circuit in the brain has been a fundamental bottleneck in human behavioral neuroscience," Shimojo says. This new work, he adds, represents a big first step in removing that bottleneck.

Using tDCS to study and treat neuropsychiatric disorders hinges on the assumption that the technique directly influences dopamine production in the ventral midbrain, Chib explains. But because fMRI can't directly measure dopamine, this study was unable to make that determination. The next step, then, is to use methods that can—such as positron emission tomography (PET) scans.

More work also needs to be done to see how tDCS may be used for treating disorders and to precisely determine the duration of the stimulation effects—as a rule of thumb, the influence of tDCS lasts for twice the exposure time, Chib says. Future studies will also be needed to see what other behaviors this tDCS method can influence. Ultimately, clinical tests will be needed for medical applications.

The title of the *Translational Psychiatry* paper is "Noninvasive remote activation of the ventral midbrain by transcranial direct current stimulation of prefrontal cortex."

Provided by California Institute of Technology