Ethical Issues in Neuromodulation

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Journal of Mood Disorders 2015;5(4):189-90

Dear Editor,

In recent years, neuromodulatory techniques have gained increasing attention in the treatment of mood disorders. Brain stimulation involves either the direct application of electrical current to the nervous system or the indirect application of current using electromagnetic induction.

In 2008, the US Food and Drug Administration approved the use of repetitive transcranial magnetic stimulation (rTMS) for treatment-resistant cases of depression. Evidence suggests that rTMS delivered at a low frequency (1 Hz and lower) tends to decrease cortical excitability, whereas higher frequencies (faster than 5 Hz) tend to increase excitability (1). The rationale for high-frequency stimulation to the left dorsolateral prefrontal cortex (DLPFC) arose from the observation that patients with major depressive disorder (MDD) exhibit a reduction in resting activity in the left DLPFC on positron emission tomography (PET) imaging (2). In the treatment of major depressive disorder, clinical response to rTMS is found to be related to local changes in cortical activity but also to an alteration of connections between prefrontal and subcortical brain regions relevant to depression. Evidence also suggests that rTMS may modulate plasticity in the cortex. Finally, both BDNF and dopaminergic increases have been reported, both of which have been related to the therapeutic mechanisms of rTMS (3).

Transcranial direct current stimulation (tDCS) is another noninvasive brain stimulation technique, involving the application of small electrical currents to the scalp through 2 surface electrodes. Despite its benign side-effect profile, tDCS has not yet received approval from the FDA for any clinical indication. Nevertheless, encouraging data indicate that TDCS may be effective in treating major depressive disorder (4).

Although brain stimulation techniques offer remarkable benefits in psychiatry, ethics of neuromodulation using noninvasive brain stimulation is a dispute. rTMS and tDCS were shown to induce transient improvement in learning and memory in healthy subjects. TDCS was shown to improve the working memory performance and performance on various complex motor learning tasks (5) and visuospatial processing (6). TMS and tDCS of language-related regions of the left hemisphere have been shown to influence object naming and anodal tDCS administered to the left prefrontal cortex has been proved to enhance verbal fluency (7).

The use of TMS and tDCS for cognitive enhancement leads to some potentially problematic ethical issues. The risks associated with rTMS and TDCS are notably low; however, there is not much evidence for the long-term effects. One possible risk that may be associated with brain stimulation is that focal brain stimulation enhancing some brain functions may be detrimental to others (8). TMS theoretically have the potential to produce unintentional deleterious effects on neurologic function, since some studies in neuroscience use TMS to suppress the activity of a local area. All the known enhancing impacts of TDCS and rTMS on brain functions are transient, but it is possible that prolonged stimulation could increase the period of outcomes, consequently provoking maladaptive changes (9). If the stimulated brain area is a part of a complicated network, the stimulation might have unexpected effects on distinct functions.

Direct manipulation of the brain may lead to changes in character. Character and personhood relate to our thoughts, perceptions, and motivations. Recent research suggests that TMS and tDCS can transiently alter an individual’s social cognition, moral judgment, and behavior (10). Knoch et al. reported that after inhibitory noninvasive brain stimulation of the right dorsolateral prefrontal cortex, subjects were more likely to accept low offers, even though they noticed them as being unfair (11). TMS and tDCS of the dorsolateral prefrontal cortex have also been shown to manipulate behavior in a variety of reward seeking tasks (8). Studies regarding tDCS ethics...
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reveal its ability to induce changes in decision-making (3). Findings of Mameli et al. show that manipulating DLPFC function with tDCS modulates lying for general information but leaving those on personal information unchanged (12). In a study, it was shown that the polarity of TDCS might result in either selfish or selfless behavior (13). Although the effects were short-lasting, repetitive stimulation may lead to long-lasting changes, which may disrupt character and psychosocial development.

CONCLUSION

Although, brain stimulation offers unique benefits as a treatment option for mood disorders and a variety of debilitating neurologic and psychiatric conditions, they also raise some ethical concerns. The ethical issues related to character traits and personhood are likely to arise if the use of noninvasive brain stimulation becomes more popular. The ability to change the mental and mood states may impact social relationships. The clinicians and investigators applying brain stimulation need to be informed about the ethical concerns associated with these technologies.

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This letter was accepted for publication in August 24, 2015.

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