

Brain Stimulation as a Potential Treatment for Addiction

In addiction research, the majority of studies have used a “figure 8 coil” to stimulate the dorsolateral prefrontal cortex, (DLPFC) whereas few studies have used an “H coil”, which can reach deeper parts of the brain. Nicotine dependence is the most studied substance use disorder, and a number of studies have indicated that stimulating the DLPFC reduces craving for cigarettes. However, fewer studies have investigated smoking cessation itself.

Amiaz et al performed a randomized study of high frequency rTMS to the DLPFC, which used a sham control (where subjects think rTMS is being delivered through a coil, but no actual stimulus is delivered). The results showed that cigarette smoking, measured by self-report and urine cotinine (a metabolite of nicotine), was reduced in the active rTMS group compared to sham. However, the effect tended to dissipate once the rTMS sessions ended, suggesting that maintained stimulation may be needed.

Only one study has been published using the H coil, which stimulates broader parts of the frontal cortex (the insula, ventrolateral prefrontal cortex and the DLPFC). This study was a large randomized trial (n=115) that compared high and low frequency rTMS for 10 days, with a maintenance phase, and showed that high frequency rTMS reduced cigarette smoking. In alcohol use disorders, the majority of rTMS studies have investigated craving only, with no randomized controlled trials investigating alcohol drinking. As with the studies of nicotine dependence, most of these have used high frequency rTMS to target the DLPFC. However, the effect of rTMS on craving for alcohol is mixed, with some studies showing an effect while others do not.

More promising results have been reported with the H coil, but these are preliminary open trials. One small study of subjects with comorbid dysthymic disorder/alcohol use disorder used bilateral H coil stimulation of the prefrontal cortex and showed improvement in depressive symptoms and a reduction in craving for alcohol. Similar results were reported in a pilot study using the H coil directed at the medial prefrontal cortex vs sham which showed that high frequency rTMS decreased subjects report of their alcohol intake (mean number of drinks per day and drinks on days of maximum alcohol intake).

Only a few studies have been performed investigating the effect rTMS in stimulant abuse (cocaine and methamphetamine), and these have only focused on targeting the DLPFC and its effects on craving. While these show some promise, there is a need to perform clinical trials that investigate actual drug taking.

Transcranial direct current stimulation (tDCS)

Transcranial direct current stimulation (tDCS) delivers a low voltage, weak current across an anode and cathode, usually delivered with a 9 volt battery. The electrical current penetrates the skull to a degree, though this current is much too low to change the firing rate of neurons. These devices can be purchased online, and there are numerous reports of TDCS improving a wide range of neurological and psychiatric disorders, but there is no clear consensus on its usefulness or even how effective such a low current could be.

The studies in addiction using TDCS have generally used only a few sessions (consisting of wearing the device for about 20 minutes) and subjects are asked to rate changes in craving. Overall, the results are very mixed, with some studies showing beneficial effects while others do not (see Addiction and Jansen et al.).

The only studies using TDCS and investigating an effect on drug intake have looked at smoking. These studies show that TDCS reduces smoking when subjects are asked to report on their cigarette intake, but not when breath carbon dioxide levels are measured, which questions efficacy of TDCS.

Studies have been performed in cocaine, alcohol and cannabis abuse, but while these studies report results such as decreased craving, improved cognition, or improved mood, they have not looked at drug consumption itself (see Addiction and Jansen et al.).

Deep brain stimulation (DBS)

Deep brain stimulation (DBS) uses electrodes that are placed in a specific brain region by a neurosurgeon. DBS is FDA-approved to treat movement disorders and obsessive compulsive disorder, but DBS is not approved for addiction. Small number of preliminary research studies are being performed and studies in rodents have shown that brain stimulation of the nucleus accumbens reduces alcohol and cocaine consumption.

In humans, there have been case reports of DBS having a beneficial effect on reducing the consumption of substances of abuse, such as alcohol, nicotine, and heroin, although these have been cases where patients received DBS for disorders other than addiction (such as depression). A few small studies using DBS have been performed specifically in addicted individuals with addiction. A case series of 5 severely alcohol dependent patients was performed at the University of Lübeck, Germany, where bilateral electrodes were implanted in the nucleus accumbens. The results showed that all of the patients experienced a reduction in craving and two achieved complete abstinence from alcohol.

Small studies have been conducted specifically using DBS to treat refractory alcohol dependence. Five severe alcohol dependent patients were treated at the University of Lübeck, Germany, where bilateral electrodes were implanted in the nucleus accumbens. These studies showed that the subjects experienced a reduction in craving and two achieved complete abstinence from alcohol. In heroin dependence, a case report of two subjects who received bilateral DBS to the nucleus accumbens reported an improvement in depressive symptoms and anxiety in these patients, and a reduction, though not cessation, in their drug use.