Treatments for ADHD: Can neurotherapies help treat children and adults?

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Professor Katya Rubia from the Institute of Psychiatry, Psychology, and Neurosciences at King's College London discusses the potential of non-invasive brain therapies, including neurofeedback, as treatments for ADHD

Attention Deficit/Hyperactiivity Disorder (ADHD) is defined as age-inappropriate problems with inattention and/or hyperactivity/impulsiveness and has a high prevalence of about 5-7% in children and 2% in adults. Neuroimaging studies have shown associations with abnormal structure and function in several regions and networks, particularly those involving the dorsal and inferior frontal cortex, parietal regions, basal ganglia and cerebellum. Stimulant medication is the most effective treatment for ADHD but is not working for about 30% of patients, has side effects, adherence is poor in adolescence, and longer-term effects have not been demonstrated. Alternative treatments with better side effect profiles and longer-lasting effects would be desirable.

Can neurotherapies help treat ADHD?

Non-invasive brain therapies, like neurofeedback or non-invasive brain stimulation, have potential as treatments for ADHD as they can target the key brain abnormalities that have been found to be associated with the disorder. Furthermore, they have a good side effect profile, and there is evidence for longer-term effects, possibly via brain plasticity. Last but not least, parents and patients prefer non-drug treatments.

In neurofeedback (NF), the child is taught to self-regulate certain brain regions by giving feedback about the activity of these regions via a visual display or a video game connected to the brain activity in real-time. Brain stimulation is more passive and consists of a small electrical stimulation, typically 1mA in children or 2mA in adults, over frontal or parietal regions, which can be combined with cognitive training. The most common brain stimulation techniques are transcranial magnetic stimulation (TMS) or transcranial direct current stimulation (tDCS). Another form of indirectly stimulating brain regions is trigeminal nerve stimulation (TNS), which stimulates the arousal system in the brainstem, which then, in a bottom- up way, can increase activity in the frontal and other regions.

Treatments for ADHD: Does neurofeedback work?

There are almost 50 years of research on neurofeedback using electroencephalography (EEG). The latest meta-analyses of EEG-NF show relatively small effects of improving ADHD symptoms relative to non-active control conditions, which are inferior to medication effects. However, it may be beneficial for some patients.[1]

We conducted two pioneering studies testing neurofeedback of the right inferior frontal cortex using functional magnetic resonance imaging (fMRI) in ADHD. We found no improvements in clinical symptoms or cognitive functions when compared to neurofeedback of another region or placebo. [1,2]

Can non-invasive brain stimulation help people with ADHD?

Over the past decades, several studies have tested whether brain stimulation techniques such as transcranial magnetic stimulation (TMS), transcranial direct current (tDCS) or random noise stimulation (tRNS) can improve clinical symptoms or cognitive functions in ADHD. The majority of TMS studies tested adults with ADHD and stimulated the dorsolateral or inferior frontal cortex in a few sessions in small samples. Most studies found no convincing improvements in clinical symptoms or cognition except one study that stimulated both regions and combined it with cognitive training over 15 sessions in 43 adults with ADHD.[1]

tDCS is more child-friendly as it is hardly noticeable as opposed to TMS, which is slightly painful. Studies using tDCS over the dorsolateral or inferior prefrontal cortex have also mostly tested relatively few sessions in small samples. Our meta-analysis of tDCS studies and our largest study of 15 sessions of tDCS in pediatric ADHD found no significant improvements in ADHD symptoms or cognitive functions. [3,4] However, our study in 64 adults with ADHD that tested home-applied tDCS over the right dorsolateral prefrontal cortex in 28 daily sessions over four weeks found significant improvements in inattention symptoms with a large effect size. [5] More studies are needed to test the efficacy of tDCS in large samples of patients over longer time periods.

Is trigeminal nerve stimulation a novel and safe treatment for people with ADHD?

TNS has only recently been applied to neurology and psychiatry. Apart from indirectly activating frontal and other brain regions via brainstem stimulation, TNS is also thought to increase noradrenaline and potentially other brain chemicals that are implicated in ADHD and which are increased with stimulant and non-stimulant medications. Our meta-analysis showed that TNS has an excellent safety profile with minimal and transient side effects. [6]

A proof-of-concept study in the USA showed relatively good effects of improving ADHD symptoms in 62 children with ADHD, which was associated with activation of right frontal regions. We are currently conducting a large multi-center randomised trial of real versus

sham TNS in 150 children with ADHD to test whether we can replicate the efficacy of TNS on clinical symptoms. We will also test for effects on cognitive functions and the underlying mechanisms of action on brain function using magnetic resonance imaging.

Treatments for ADHD: Conclusions

Research on brain therapies for ADHD is still in its infancy. Brain stimulation seems more promising than neurofeedback. However, far more research is needed to understand the optimal protocols, such as the best brain region(s) or brain networks to stimulate (given that ADHD is characterised by complex network abnormalities), the optimal number of sessions or amplitude of stimulation, or whether combining it with cognitive training is adding benefits.

Potential effects on non-stimulated regions also need to be better understood. It is likely that different patients with ADHD benefit from different protocols or different brain therapies depending on their individual underlying brain abnormality patterns, their age or their different clinical manifestations. Finding out which patients respond to which treatment will be crucial to improve the lives of people with ADHD.

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