Is deep brain stimulation a prospective “cure” for addiction?

Wayne Hall^{1,2*} and Adrian Carter^{1,3}

Addresses: ¹UQ Centre for Clinical Research, The University of Queensland, Herston, QLD 4029, Australia; ²Queensland Brain Institute, The University of Queensland, St Lucia, QLD 4072, Australia; ³School of Psychological Sciences, The University of Melbourne, Carlton, VIC 3010, Australia

* Corresponding author: Wayne Hall (w.hall@uq.edu.au)

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Abstract

Deep brain stimulation has been put forward as a potential “cure” for intractable drug addiction. This is largely based on preclinical studies in animal models of addiction and small case series of positive, but short-term, effects on addictive behaviour in highly selected individuals. The history of neurosurgical treatment for psychiatric disorders suggests that we should be cautious in prematurely advocating invasive neurosurgical procedures on the basis of such limited evidence. Further research is required in animal models of addiction and in people treated for other neurological or psychiatric disorders before trials in addicted populations can be justified.

Addictive disorders are among the most common mental disorders in many developed countries. Although many of these disorders remit without treatment in young adulthood, under the influence of increased responsibilities of marriage, mortgages, and children, addiction can become chronic and relapsing. People with more severe forms of addiction often seek help from specialist addiction and mental health services when they are in their early 30s. Psychosocial and pharmacological treatments can reduce the severity of problems in many cases but enduring abstinence can be difficult to sustain. Unresolved addiction lies at the heart of many social ills, sometimes driving people into crime or prostitution in order to support their habit, or onto the streets when they fall prey to it.

Advocates of trials of deep brain stimulation in addiction argue that it is a potentially useful treatment for cases that fail to respond to existing treatments, citing evidence from preclinical and clinical studies. Deep brain stimulation is a neurosurgical intervention that has been used to treat intractable movement disorders in patients with Parkinson’s disease. The technique uses a surgically implanted, battery-operated neurostimulator—a bit like a pacemaker—to deliver electrical stimulation that

modulates electrical signals in targeted areas of the brain. The neurostimulator is normally implanted under the skin near the collarbone and connected to electrodes extending through a small hole in the skull to the desired brain area. The device can be removed at a later date.

Deep brain stimulation is currently being trialled in the treatment of intractable psychiatric disorders such as Tourette’s syndrome, obsessive compulsive disorder (OCD), and depression [1]. In this article, we review the evidence used to advocate the use of deep brain stimulation in the treatment of intractable addiction [2].

The case for trialling deep brain stimulation

First, neuroscience research on animals and human neuroimaging studies have identified the brain reward circuits involved in drug effects and addiction. What’s more, researchers have been able to reduce self-administration of addictive drugs in animals by stimulating or ablating these regions in the dopaminergic reward pathway (see [3]).

Second, there are case studies in which deep brain stimulation has reduced addictive behaviour in patients treated for Parkinson’s disease. Two patients with

Parkinson's disease treated with deep brain stimulation were able to overcome the compulsive use of their dopamine replacement therapy [4]. Similarly, Parkinson's disease patients who developed gambling problems or hypersexuality while taking dopamine replacement therapy have reported that these disorders disappear following deep brain stimulation treatment [5]. These observations are supported by small case series in which deep brain stimulation has reportedly reduced addiction to nicotine, alcohol, and heroin in patients treated for other disorders [6-8]. For example, a woman whose agoraphobia was unsuccessfully treated by bilateral deep brain stimulation of the nucleus accumbens reported improvements in her alcohol dependence [8]. The same group conducted a retrospective study of ten smokers who underwent deep brain stimulation of the nucleus accumbens for Tourette's syndrome, OCD, or anxiety and found that three had stopped smoking [7]. The variability of this sample and their intention to quit makes interpreting this study difficult.

This evidence is supported by the apparently successful neurosurgical ablation of the nucleus accumbens for heroin addiction by Chinese neurosurgeons [9]. There is also one report in which deep brain stimulation of the nucleus accumbens greatly reduced alcohol craving and consumption in three long-term, treatment-refractory, alcohol-dependent individuals; two were abstinent after one year and a third had markedly reduced their drinking [10,11].

The case for caution

First, there are important differences between the case for deep brain stimulation in Parkinson's disease and that for addiction. Patients with Parkinson's disease who no longer respond to dopamine replacement treatment face a course of irreversible deterioration in motor function and increasing disability. In contrast, addiction does not usually follow an inexorable path to severe disability and death; it is generally more amenable to pharmacological and psychotherapeutic treatment, so drastic remedies are less justifiable. In fact, many of the failures of addiction treatment are due to inadequate access to well-run and optimally provided forms of existing treatments; a situation that could be exacerbated by an increased use of deep brain stimulation to treat drug addiction.

Second, the history of neurosurgical treatment in psychiatry cautions against uncritically accepting "positive results" from uncontrolled and often selectively reported clinical case series [3]. For example, the two case reports of Parkinson's disease patients successfully treated with deep brain stimulation for dopamine dysregulation syndrome [4] need to be balanced against a larger study that found

that 12 of 17 such patients were unimproved or worse after deep brain stimulation [12]. Deep brain stimulation has also been reported to *induce* addictive behaviour in some cases [13]. And while ablative neurosurgery for heroin addiction reduced drug use in some patients in the short term, subsequent long-term follow-up found that it carried significant side effects and was not as effective as first thought [1]. These published case studies provide a weak evidence base to assess the safety and efficacy of deep brain stimulation in addiction [3].

Third, deep brain stimulation is often described as a "reversible" alternative to neurosurgery, but it is nonetheless an invasive intervention that carries significant risks [14]: 11% of patients have adverse events from surgery and 4% of Parkinson's disease patients suffer intracerebral haemorrhages [15]. Insertion of stimulating electrodes can cause serious infections and produce cognitive, behavioural, and emotional disturbances [15]. It can also produce irreversible psychosocial changes that can be harmful [14]. For the use of deep brain stimulation in the treatment of addiction to be justified, the benefit of the treatment needs to outweigh the damage that it may cause and the negative consequences of not providing the treatment. Evidence suggests that the very uncertain benefits of deep brain stimulation in alleviating the symptoms of addiction do not outweigh the known harms associated with the procedure, or the harm of not providing deep brain stimulation (on the assumption that other currently available treatments are provided to the highest standard) [16].

Fourth, deep brain stimulation for addiction is an expensive form of treatment for addictive disorders where access to existing treatment remains poor. Inability to pay for treatment and stigmatisation often discourage addicted persons from seeking treatment. An expensive neurosurgical treatment that costs around US\$50,000 (with maintenance costs of approximately US\$10,000 over the next few years) will utilise scarce health resources to treat a very small number of addicted patients with the income to pay for it, while failing to treat the majority.

When may a trial of deep brain stimulation be warranted in addiction?

For trials of deep brain stimulation to be justifiable in patients with addiction, the following requirements need to be met. First, there needs to be strong evidence that any participants in such trials suffer from a severely debilitating form of addiction that carries a high risk of morbidity or premature death and that has not responded to adequate trials of effective treatments. Second, there needs to be a reasonable expectation that

the intervention will improve the patients' quality of life. This should include preclinical evidence of likely benefit, evidence on the long-term effects of deep brain stimulation on patients with other psychiatric conditions (e.g., OCD and depression), and a good theoretical basis for stimulating the targeted brain region.

Accordingly, we believe that it would be premature to trial deep brain stimulation in the treatment of addiction on the basis of available animal models, the small number of selected case studies, and the evidence from uncontrolled studies of neurosurgery for heroin addiction. We have outlined above the type of research in animals and individuals required to make a case for undertaking trials of deep brain stimulation in the future [3]. We also support calls for the creation of a register of all cases treated with deep brain stimulation, as suggested recently [17], to minimise the potential of selective publication of good outcomes. However, even if these conditions are met and deep brain stimulation proves to be safe and effective in treating addiction, we suggest that the high costs involved make it a lower priority for public funding than trials of pharmacotherapies.

Abbreviation

OCD, obsessive compulsive disorder.

Competing interests

The authors declare that they have no competing interests.

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