Depression and Smart Brain Prosthetics

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NEURO 400 / Neuroscience Senior Seminar
Final Research Paper
27 April 2016
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Final Research Paper written for
Wheaton Journal of Neuroscience Senior Seminar Research
Neuro 400 / Neuroscience Senior Seminar
Wheaton College, Norton Massachusetts
27 April 2016

Introduction:

Depression is a common but serious mood disorder. It causes severe symptoms that affect how you feel, think, and handle daily activities, including sleeping, eating, or working. There are severely different branches of depression: persistent depressive disorder, perinatal depression, psychotic depression, seasonal affective disorder, and PTSD (National Institute of Mental Health). Depression can be caused by environmental factors but for the most part it is due to biological factors.

Biology of Depression:

Depression is caused by an array of factors. Causes of depression include, stressful life events, trauma to the head, and medical side effects from prescribed medications and chemical, imbalances (Harvard Health Publications 2009). There are many chemicals involved from inside and outside neuronal cells that make up the dynamic system that affect how people regulate mood and perceive (Harvard Health Publications 2009). Chemicals or neurotransmitters involved in depression, but not limited to, are dopamine, serotonin, and acetylcholine (Harvard Health Publications 2009).

Specific areas of the brain regulate mood. Nerve cell connections, growth and function of their circuits have a significant impact on depression. The main areas of the brain that play a role in depression are the hippocampus, thalamus and the amygdala (Harvard Health Publications
Hippocampus being smaller in people with depression is common because stress suppresses the production of nerve cells in that area. Research also suggests that ongoing exposure to stress hormones damages the production of nerve cells as well in the hippocampus (Harvard Health Publications 2009). The thalamus receives sensory information and relays to the cerebral cortex. One of the functions it relays is thinking and behavioral reactions; research suggests that impairments in the thalamus creates unpleasant thoughts and feelings (Harvard Health Publications 2009). The amygdala is part of the limbic system, which structures deep feelings of anger, pleasure, sorrow and arousal. Activity is this area of the brain is triggered when a person recalls an emotionally charged memory. Activity is higher when a person is sad or depressed (Harvard Health Publications 2009). This even continues after recovery from depression. All these areas of the brain are related to how depression works. Neurotransmitters in relation to these areas of the brain are believed to have significant impact on depression (Harvard Health Publications 2009). Smart brain prosthetics will put an end to the imbalances of the depressed brain.

**Smart Brain Prosthetics- What are they?**

Smart brain prosthetics is new and upcoming technology that will stop the symptoms of mental disorders (Goodman et al., 2012). Neural prosthetics have been around since the 1980s and have been used for treating movement disorders like Parkinson's disease. In that case, they use an open loop system. Open loop systems mean when the researcher puts this device in a specific region of the brain, they turn it on, and leave it in (Venkatraman, V. 2015). Open loop systems never stop working and are never turned off. They help make the tremors go away. Motor control is a simple function of the brain; mental disorders are complex (Venkatraman, V. 2015).
Currently, researchers are in the works in creating a closed-loop system in smart brain prosthetics to help treat mental disorders. These are different from open loop systems because they only perform an action when monitoring unusual neuronal activity (Andersen, Richard et al. 2011). When the implants detect unusual activity, they'll dampen those signals by stimulating the brain with electrical impulses. There is no exact spot or circuit for mental disorders like depression which makes it harder for the prosthetics to detect activity (Venkatraman, V. 2015). Instead, researchers look for patterns of neuronal activity across specific regions of the brain including the thalamus, amygdala and hippocampus (Venkatraman, V. 2015). They then map those patterns to outward expression/behavior. Modifying the signals of the unusual neuronal activity in those specific brain regions will eliminate symptoms of depression (Venkatraman, V. 2015).

**Smart Brain Prosthetics- How do they work?**

These new and improved smart brain prosthetics or implants will help push forward the end of depression. They are wireless, so there no wires protruding in the body. These implants are about the size of a matchbox and weighs only about 50 grams. They are made up of a “hub-spoke” design (see figure 1). The hub is made up with the microprocessor and a battery that is easily rechargeable through the skin; this will sit flush against the scalp so the person will not even know they have one (Venkatraman, V. 2015). There are five satellites, each with an electrode to access and modulate activity in a specific area of the brain. These electrodes are placed in the brain regions associated with depression (Venkatraman, V. 2015). When the prosthetics detect unusual activity in these brain region, the electrodes will therapeutically modify the chemicals until they are in a normal range (Venkatraman, V. 2015). A base station communicates with the implant telemetrically. Physicians will be able to see data from the
device right in their office. The main goal of this hybrid system is for the prosthetics to regulate the neurotransmitters of the brain causing depression (Venkatraman, V. 2015).

Figure 1: Smart brain prosthetics current design. There is a rechargeable battery and a base station (silver plate in the middle) to get energy. There are satellites with electrodes to modify brain activity (extensions coming off the base station) (Figure from: Venkatraman, 2015; http://www.betaboston.com/news/2015/05/25/mgh-is-working-on-smart-brain-implants-that-may-help-combat-depression-and-ptsd/)

Hybrid System:

Clinical trials are in the hopes of starting within the next couple years. So far though, these smart brain prosthetics for depression are looking like a new and improved way for people living with this mental disorder to get rid of their unwanted symptoms. This hybrid system will be irreversible if implanted because there is no way of removing the prosthetics without severely damaging the brain. There is not a clear path of whether there are positive or negative consequences to using these prosthetics. Possible negative consequences including the patient stroking or bleeding of the brain. If trials go as planned, it will be positive for the most part. These prosthetics are alternative way of treating depression without the use of psychotherapy or medications. The clinical trials are set up for military veterans right now with PTSD
If these trials go as planned, more trials will be open for the public who are living with depression (Ho, John et al. 2015).

Smart brain prosthetics are the future of treating mental disorders. There is still a lot more research to be done with them, for example making sure these electrodes detect the unusual brain activity. Clinical trials and possible participants volunteering for awake state trials will be the way to figuring out that tight coupling between the neural signature and behavior (Venkatraman, V. 2015). These are not the only neural implants in the works though. There are several other hybrid systems being tested currently for mental disorders. Stanford is working on a device that uses the mouse's own body to collect radio frequency energy (Adams, Amy 2015). The energy becomes trapped inside a chamber. The mouse essentially becomes a conduit, releasing the energy from the chamber into its body, where it is captured by a 2 mm coil in the device (Adams, Amy 2015). The mouse is using magnetic induction, wherein one coil of wire can transmit energy to another coil using magnetic fields (Adams, Amy 2015). Wherever the mouse moves, its body comes in contact with the energy, drawing it in and powering the device. Elsewhere, the energy stays tidily contained (Adams, Amy 2015). In this way, the mouse becomes its own localizing device for power delivery. This will help better understand and treat mental health disorders. (Adams, Amy 2015).

Conclusion:

There are a lot of hopes within the future for people living with mental disorders. It affects not just their mood but also daily activities, relationships, jobs and school work. The hybrid system of depression and smart brain prosthetics will enhance the lives of people living with depression.
References


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