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Engineering minds? Ethical considerations on biotechnological approaches to mental health, wellbeing and human flourishing

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Abstract

Our bodies can be designed and modified in accordance with our ideals of health and well-being. These increasingly targeted and personalized interventions will be more effective than current therapies. Here we review technologies to alter mood, and explore the ethics of bioengineering approaches to mental health.

Engineering happiness

In societies that are not struggling with basic needs, poverty or violent conflict, the pursuit of happiness has become one of the primary goals of our lives. The term "happiness" is widely used in everyday discourse to refer to a mental and emotional state in which individuals experience positive sensations of joy, contentment or satisfaction over a long period of time. Today it is also used as a theoretical construct for multidimensional models in contemporary social sciences, particularly in the field of positive psychology. Achieving moments of joy, a state of mental well-being and continued flourishing is challenging, as illustrated by the increase in the global burden of mental health disorders. [1] To respond to the perceived decline of mental health and wellbeing in many affluent societies, some are increasingly looking at biomedical research and biotechnology to find remedies to counter this worrying trend.

Emerging bioengineering approaches for controlling mood and mental disorders

Emerging brain stimulation approaches for treating mental health disorders that affect mood, such as depression or bipolar disorder, are repetitive transcranial magnetic stimulation (rTMS) [2], deep brain stimulation (DBS) [3], and Magnetic Seizure Therapy (MST) [4]. Similar to rTMS, MST is based on the magnetic stimulation of the brain, in this case to induce a seizure. Reflecting a general trend towards targeted interventions of specific neural circuits for modulating brain networks that support affective or cognitive functions, this emerging class of stimulation devices is also referred to as "electroceuticals" [5]. One important concept for achieving more precise and adaptive electroceutical interventions are closed-loop stimulation systems, i.e. devices that can both sense neural activity [6] or neurochemical signatures [7] and adapt their stimulation parameters accordingly. Experimental techniques such as optogenetics are becoming important tools to understand the neurobiological basis of mental disorders such as major depression. Optogenetics uses genetically encoded light-sensitive membrane proteins that allow for the precise manipulation of specific neurons in living animal models using light of specific frequencies. Progresses in optogenetics renewed general interest for understanding affective regulatory circuits in the brain, and opened up a completely new field of research within the general trend towards systems neuroscience and the multi-scale investigation of neural circuits. The transformative potential of optogenetics lies in the ability to specifically modify neural circuits at the cellular level, for example with "cellular-scale optoelectronics", which are deep brain devices composed of light emitting sources and precision sensors that can be remotely controlled [8]. These converging technologies for modifying brain circuits from the cellular to the large-scale network level will potentially make it possible to regulate dynamically changing emotions and mood as well as to calibrate longer-term states of wellbeing, happiness and flourishing in more effective and targeted ways.

"Moodification": Targeted and personalized interventions of mood and happiness

In contrast to current treatments, both closed-loop neuromodulation devices – which are already explored for the treatment of epilepsy [9] and deep-brain stimulation in movement disorders [10] – and precision gene editing could become important forms of personalized interventions with the aim of improving mental wellbeing and flourishing. Adaptive closed-loop systems, especially if they are using artificial neural networks or other AI-related algorithms, could allow for the instantaneous self-regulatory provision of a desired affective status. Neuromodulation devices that today deliver only electric stimulation will soon also allow for the targeted release of neurochemical signals or psychotropic drugs. In research, various devices are already used to record or stimulate the action potential of single neurons, and recently a proof of concept for a human hippocampal prosthetic (i.e. an artificial hippocampus organ) was developed. This could pave the way for the replacement of damaged brain tissues, in order to restore a person's ability of movement, or long-term memory [11]. In the coming years, the development of in-brain devices that could regulate or self-regulate the emotional needs of a person will be achievable. These devices will act as "doctors in the brain" [12], being able to receive both input information – producing a diagnosis – and producing output effects – translating into an instant therapeutic intervention, or generally a desired outcome. Finally, as our understanding of the genetics of mental health disorders will increase, so will our understanding of the association and linkage of genetic and epigenetic factors for sustained happiness, well-being and flourishing. This increased understanding may open avenues for germline interventions that are not primarily motivated by preventing severe mental illness but rather for what we could define as "genetic mood enhancement" – optimizing mood, happiness, well-being and flourishing.

Is a society of perpetually happy individuals desirable?

From a philosophical and ethical perspective, we can ask whether transforming ourselves into constantly satisfied and happy individuals is a desirable goal, and whether we want a society in which individual moods can be engineered as a matter of personal taste or societal expectations. Active devices that interact with the brain could allow applications ranging from detecting and confronting panic attacks in anxiety disorders to suppressing feelings associated with sadness to maintaining an individual's basal state of happiness. The responsible use of such interventions is of utmost importance as this kind of deliberate calibration of mental states could be misused in several ways that violate basic tenets of biomedical ethics and human rights (**Box 2**).

Besides its benefits, affective enhancement can have several downsides for the individual and for society. First of all, if we manage to achieve states of perpetual bliss, we may lose the very understanding of the meaning of specific moments of joy. Permanent serenity could also lead to a loss of alertness to stimuli coming from the environment and social realities, and the frequency and context in which we show certain emotions would likely impact the social dynamics based on affective behavioral cues that we display to others. This could have a broad impact for decision-making or determining the outcome of social interactions: consider for example political negotiations. Whether the self-reported state of happiness is associated with a decreased interest for society and the progression of humanity is a matter of debate [13]. This could certainly constitute an obstacle for finding common ground in addressing large-scale societal challenges such as climate change, poverty or social inequality, the latter of which could be further enhanced if the access to this type of affective enhancement would be only accessible for the rich, developed nations. Finally, it is debated whether positive mood is associated with creativity or not: an overly happy society that does not experience emotional downsides may become a less creative society, resulting in sociocultural stagnation.

Conclusion and outlook

Unprecedented biomedical and technological tools are becoming available to target mental disorders. The emergence of closed-loop neuromodulatory devices as well as the increasing potential and precision of genetic engineering seem to be inevitable. Over the next couple of decades these techniques will give us the possibility to regulate mood in a targeted and personalized manner, and therefore their potential application demands immediate attention and regulation. Such affective enhancement may profoundly change our society in different ways, including: impairing our ability to connect and participate in social life; an increase in risky behaviors; altered social interactions; a decrease in empathy for the plights and pains of others, less concern about social issues and a less creative and progressive society. Of course, these concerns about affective engineering need to be embedded in *theories of personal identity and the self* that acknowledge that identity cannot be simply reduced to our emotional states – and include our cognitive abilities, social relations and embeddedness in the environment. In addition, devices could be transformed into products aimed to manipulate emotions and characters of individuals for commercial or other purposes.

What should we do? First of all, we should continue our search for better treatment options to help those afflicted by mental disorders. At same time, we need to explore in a systematic and comprehensive way the ethical, legal and societal challenges of applying emerging technologies to engineering affective states. This will also need to include an appraisal of the anthropological and psychological dimensions and vital role of seemingly "negative" emotions such as fear or sadness. Once a robust moral and societal consensus on how to deal with affective engineering has emerged, it will need to be translated into policy. Given the increasingly global impact of technological innovations, international regulation and oversight should be worked towards as soon as possible.

In conclusion, engineering approaches may in the future have their place in mitigating dire states of unhappiness and suffering caused by mental health disorders, but there is no convincing reason in sight to expand this technology for everyday mood enhancement and states of perpetual bliss.

Box 1. Current treatments for mental health

The current understanding of mental health and of the regulation of mood is still rather limited. This is because our mental status is influenced by several interacting factors, of biological (e.g. genetic, epigenetic, neurodevelopmental), behavioral (e.g. lifestyle) and socioeconomic and cultural (e.g. social relations or poverty) nature. In spite of their complex pathogenesis, mental disorders that affect mood can be modulated by psychotropic medications, often in combination with psychotherapy. Although the precise mechanism of how psychotropic medications affect the function of neural circuits underlying mental health disorders is not fully understood, a widely adopted model is that they allow to increase presynaptic concentrations of catecholamines, indolamine or monoamine neurotransmitters (such as serotonin), by inhibiting either their neuronal uptake or their elimination following metabolic deamination. In addition, a variety of dietary, behavioral and physiological factors, such as physical exercise, sleep or social interactions have also been shown to influence mood [14], although their longer-term influence on happiness and mental well-being are not yet comprehensively understood. In addition to the therapeutic interventions, there are also bioengineering approaches to alter mood. For the treatment of major depression, these include Electroconvulsive Therapy (ECT), which consists of electrical stimulation of the brain while the patient is anesthetized. A similar treatment involves the electrical stimulation of the vagus nerve (Vagus Nerve Stimulation, VNS).

Box 2. Key ethical aspects concerning "affective engineering"

Several ethical aspects need to be discussed and disentangled in an anticipatory stance before affective engineering technologies becomes widely available. Key ethical aspects concern:

1. the purposes for which such technologies are to be used: restorative therapy, therapeutic or non-therapeutic human enhancement, or other (e.g. commercial or military, i.e. the potential for dual-use);
2. the norms that determine which mental states should be engineered, how these norms will be set, by whom and with what legitimation; this question arises at different levels – the individual user (who could also be a minor or legally incompetent), vulnerable groups (such as psychiatric patients but also criminals or dissidents), and more generally at the level of regulatory authorities (both national and international);
3. the long-term consequences of the use of affective enhancement technologies, with a view to safety and security, privacy, justice, and larger societal impact.

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