Journal of Cognitive Enhancement
https://doi.org/10.1007/s41465-018-0090-3

ORIGINAL ARTICLE

Responsible Cognitive Enhancement: Neuroethical Considerations

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Received: 26 June 2018 / Accepted: 20 August 2018

Abstract

Cognitive enhancement is the use of any (legitimate) means to reach one's personal best cognitive performance. Cognitive enhancement can help delay cognitive decline in the elderly. Along the same lines, training children could speed up the education and reduce the risk of behavioral deviance and pathology. Nonetheless, cognitive enhancement is one of the most widely discussed topics in neuroethics because it is considered by some authors to be "unnatural" and to create "positional benefits." In this opinion article, I will present examples of cognitive enhancement from the field of food supplements, pharmacology, and brain stimulation. I propose the idea of a *responsible* cognitive enhancement supported by clear mechanisms of action, that takes into account individual differences and that evaluates the far-reaching, sweeping claims from the media and the industry.

Keywords Cognitive enhancement · Neuroethics · Theory-driven · Tyrosine · Brain stimulation · Microdosing psychedelics

Introduction

Cognitive enhancement is the use of any (legitimate) means (e.g., meditation, smart drugs, brain stimulation, neurofeedback, physical exercise, or food supplements) to reach one's personal best. Cognitive enhancement can help compensate for cognitive decline in the elderly, which would prolong the time people can live autonomously and, thus, reduce the welfare costs for the time thereafter. Along the same lines, training children could "accelerate" the education of healthy individuals and minimize the risk of behavioral deviance and pathology, again with considerable savings for welfare and education systems.

Notwithstanding these potential benefits, cognitive enhancement is one of the most extensively discussed issues in neuroethics (Bostrom and Sandberg 2009). There are at least two ethical aspects to take into consideration. The first regards the "fairness" of the intervention. It has been suggested that techniques of cognitive enhancement may disregard human nature and dignity and encourage cheating behavior and an unrestrained tendency to perfectionism (Habermas 2003; Kass 2002). These worries are real given the growing use of cognitive-enhancing drugs, such as Modafinil (Colzato and Mourits 2017) and Ritalin (Colzato and Arntz 2017), by students to enhance their academic skills and output. It is not to exclude that in the future universities might consider banning the use of those drugs or to allow them only under certain circumstances (exams). The same applies not only to drugs but to commercially brain stimulation devices, which can be bought online without any restrictions (Steenbergen et al. 2016).

The second ethical aspect emerges from the discrepancy between two widely shared ethical principles underlying Western society: individual freedom and equality. Even though effective cognitive-enhancing programs can be regarded as a manifestation of individual freedom, they may collide with equality. Given that contemporary globalized societies are based on competition, which underlines individual skills and performance, cognitive enhancement might cause "positional benefits" by ameliorating one's social and economic status as compared to others.

Despite the fact that this could be regarded as a fair individual choice, it may have repercussions for general public expectations and standards. Indeed, a general public pressure to improve one's cognitive abilities could arise once a number of individuals have shown that this is possible. That is, the simple option to enhance one's cognitive abilities could increase social competition by boosting the pressure of always

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Published online: 06 September 2018

"being on top" and to work harder, longer, and more intensively, which in the end may exacerbate the problems one was initially aiming to solve. Further, as the probability to profit from cognitive-enhancing interventions may differ between individuals, the availability of enhancing programs may contribute to the emergence, and increase the size of, societal gaps (Bostrom and Sandberg 2009). Nevertheless, cognitive-enhancing interventions could be used as a way of decreasing, rather than increasing societal/social inequalities by allowing all, and not just the economically privileged individuals, to fully achieve their cognitive potential. This would not eliminate competition but create more equal terms (Savulescu 2009). Indeed, it is important to consider that the extensive use of cognitive-enhancing methods and the accompanying cognitive benefits might have important social benefits. Some studies estimate that boosting the average IQ of the world population by no more than 3% would reduce poverty rates by 25% (Schwartz 1994) and result in an annual economic gain of US $165–195 billion and 1.2–1.5% of the national gross domestic product (Salkever 1995).

Responsible Cognitive Enhancement

Kurt Lewin's claim that "nothing is as practical as a good theory" is the *leitmotif* of this opinion paper about cognitive enhancement. Whereas in the past the field of cognitive enhancement used mainly effect-driven approaches (that seek to demonstrate that an enhancing intervention can have an effect without explaining how it modulates the targeted function and why some people benefit more than others), this paper suggests a mechanistically oriented, theory-driven approach that tries to understand and explain individual differences to a degree that allows a comprehensive understanding of how a particular intervention modulates cognition. I argue that only a theory-driven enhancement is a *responsible* cognitive enhancement, because only if we understand the mechanism of actions can we make effective prediction about the direction of the intended intervention.

The present paper presents three different means to enhance cognition and is divided into three parts. The first is devoted to tyrosine (TYR), a neurotransmitter precursor that enhances cognition in young adults but impairs it in the elderly. The second and third parts take as examples "microdosing" psychedelics and commercial brain stimulation devices to underlie the necessity for an active role of scientists in evaluating the far-reaching, sweeping claims from the media and/or industry to achieve a responsible cognitive enhancement.

Tyrosine: Paradox Effects Across the Life Span

TYR is one of the most investigated amino acid. It is contained in many kinds of food, such as codfish, almonds, and milk. From a theoretical point of view, TYR is very interesting because it is the chemical forerunner of the neurotransmitter dopamine (Colzato 2017). TYR administration can augment dopamine levels in the brain (Cuche et al. 1985; Gibson and Wurtman 1977; Tam et al. 1990). Once it has passed the blood-brain barrier and is taken up by the appropriate brain cells, the enzyme tyrosine-hydroxylase (Daubner et al. 2011) converts TYR into L-DOPA and then into dopamine. In young adults, when the enzyme tyrosine-hydroxylase works properly, TYR administration has been found to be beneficial for dopaminergic-related functions such as working memory performance (Colzato et al. 2013). In a recent study, we took into account individual differences (i.e., genetic differences) in dopamine baseline levels to explain the effectivity of TYR. Indeed, the study showed evidence supporting the idea that TYR supplementation may function as a cognitive enhancer and compensate for unfavorable genetic predisposition (Colzato et al. 2016). In a new study, we wanted to examine the possibility that TYR, aimed at increasing dopamine levels, is likely to slow down, and (partially) compensate for the cognitive decline associated with the aging-related loss of dopaminergic supplies. In contrast to our expectations, our findings show detrimental effects of TYR on working memory suggesting that, in contrast to young adults (Colzato et al. 2013, 2014; Steenbergen et al. 2015), the administration of TYR in aging may be counterproductive.

How is it possible for TYR to be beneficial in young adults, but detrimental in old adults? TYR administration may be detrimental for performance when the dopamine system is impaired by a number of different factors, such as in aging. One of these factors is latent *Toxoplasma gondii* (*T. gondii*). This infection is known to impair the function of tyrosine hydroxylase and lead to abnormal conversion rates of TYR. Given the high incidence and prevalence of seropositivity of this infection (up to 77%) in aging (Wilking et al. 2016), TYR administration may have decreased performance in old adults because of their potential seropositivity of *T. gondii*. That is, it is possible that in seropositive individuals, the abnormal conversion rates of TYR drove our participants beyond optimality (i.e., in the inverted-U-shape function that catecholinergic functions follow) and impaired their working memory performance.

The example of TYR is important because it underlies the fact that only via understanding the mechanism of actions are we able to predict the direction of an intervention and to explain why in some cases an intervention is enhancing and in other cases is impairing cognitive functions.

Hype in the Media: Microdosing Psychedelics

Major newspaper articles worldwide are reporting on the rising number of professionals using small doses of psychedelics (e.g., magic mushrooms, truffles, or peyote) to enhance their productivity and creativity at work. A notable example is the use of small doses of LSD by employees in Silicon Valley, as a "productivity hack" (Glatter 2015). This emerging phenomenon is referred to as microdosing, with dosages around one tenth of recreational doses.

Even though in the media microdosing psychedelics is already portrayed as a valid cognitive enhancer, no studies have investigated the quantitative effects of it. Indeed, so far, the only evidence is based on qualitative studies which are based on self-reports and are known to suffer from validity problems due to participants' inaccurate memories, differences in vocabulary and verbal skills, and unintentional or willful distortions of subjective experiences (Schwarz 1999).

Classical psychedelics such as psilocybin are known to augment the serotonergic system (Tylš et al. 2014) and to enhance mental flexibility (Boulougouris and Robbins 2010), the main ingredient of creativity. Creativity is commonly defined as the ability to generate ideas, solutions, or products that are both novel and appropriate (e.g., Amabile 1996; Sternberg and Lubart 1999). Given that (a) microdosing psychedelics is presented in the media as "a matter of fact" substance to boost creativity and (b) the theoretical link between cognitive flexibility and serotonin, we quantitatively investigated the effects of microdosing truffles during microdosing events of the Psychedelic Society of The Netherlands. We examined the effects of psychedelic truffles on two creativity-related problem-solving tasks: the Picture Concept Task assessing convergent thinking, and the Alternative Uses Task assessing divergent thinking. A short version of the Raven's Progressive Matrices task was administered to measure potential changes in fluid intelligence. We tested the participants twice: once before taking a microdose (pre-test) and once 90 min after the ingestion (post-test). Both convergent and divergent thinking performance were enhanced after a non-blinded microdose, while fluid intelligence was unaffected (Prochazkova et al. 2018). Even though this study provides quantitative support for the cognitive-enhancing properties of microdosing psychedelics, future research has to confirm these preliminary findings in more rigorous placebo-controlled study designs.

The example of microdosing psychedelics makes it clear how important it is for a responsible cognitive enhancement to scientifically test claims made by the media.

Commercial Brain Stimulation Devices

A recent initiative supported by several eminent research institutes and scientists pleaded for a more critical and active role of the scientific community in evaluating the sometimes far-reaching, sweeping claims from the brain training industry with regard to the impact of their products on cognitive performance (Max Planck Institute on Human Development, Stanford Center on Longevity 2014). Following this eminent recommendation, we examined whether and to what degree the commercial transcranial direct current stimulation (tDCS) headset *foc.us* improve cognitive performance, as advertised in the media (Steenbergen et al. 2016).

We showed that prefrontal cortex stimulation delivered using the commercial *foc.us* tDCS headset (v.1) does not enhance but impairs the ability to monitor and update information in working memory (Steenbergen et al. 2016). Even if the consequences of long-term or frequent use of the *foc.us* device are yet to be demonstrated, our results provide strong support for a responsible cognitive enhancement which calls for the scientific community to play a more critical and active role in validating and testing far-reaching claims made by the brain training industry.

Conclusion: Moving Toward a Responsible Cognitive Enhancement

Most cognitive-enhancing programs have a one-size-fits-all design and presuppose that people benefit from the intervention more or less the same way and to more or less the same degree. However, in this paper, I showed evidence suggesting this is not always plausible. I propose that the efficiency of cognitive-enhancing interventions will often be modulated by life span and inter-individual differences, including pre-existing neurodevelopmental factors and differences with a genetic basis. Accordingly, only enhancing programs that are tailored to individual abilities, skills, and needs are likely to succeed. Only a theory-driven cognitive enhancement is a responsible cognitive enhancement. Only a mechanistically oriented, theory-driven approach will allow for the design of individualized cognitive enhancement interventions required to make such interventions successful for the recipient at an individual level, and to make welfare more affordable at a societal level. Further, to achieve a responsible cognitive enhancement, I plead the scientific community to play a more critical and active role in validating and testing far-reaching claims made by the media and/or industry.

Funding Information The work by Lorenza S. Colzato is supported by a research grant from the Netherlands Organization for Scientific Research (NWO; Vidi grant no. 452-12-001).

Compliance with Ethical Standards

Conflict of Interest The author declares that he has no conflict of interest.

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