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Review

Botox for the brain: enhancement of cognition, mood and pro-social behavior and blunting of unwanted memories

Reinoud de Jongh[a,*], Ineke Bolt[b,c], Maartje Schermer[b], Berend Olivier[a]

[a]*Department of Psychopharmacology, Utrecht Institute for Pharmaceutical Sciences and Rudolf Magnus Institute of Neuroscience, Utrecht University, Utrecht, the Netherlands*
[b]*Medical Ethics and Philosophy of Medicine, Erasmus Medical Center, Rotterdam, the Netherlands*
[c]*Ethics Institute, Utrecht University, the Netherlands*

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Abstract

It has been suggested that the recent rapid developments in the fields of neuroscience and psychopharmacology have increased the possibilities for pharmacological enhancement of mental functioning. Here, evidence is reviewed which shows that drugs acting on a variety of neurotransmitter systems can indeed enhance cognition, and to a lesser extent mood and pro-social behavior. Moreover, it seems possible to interfere with the (re)consolidation of traumatic memories. There are, however, a number of caveats: first, as cognition-enhancing drugs can simultaneously exert both linear and quadratic (U-shaped) effects, doses most effective in facilitating one behavior could at the same time exert null or even detrimental effects on other cognitive domains. Second, individuals with a 'low memory span' might benefit from cognition-enhancing drugs, whereas 'high span subjects' are 'overdosed'. And finally, evidence suggests that a number of trade-offs could occur. For example, increases of cognitive stability might come at the cost of a decreased capacity to flexibly alter behavior. A short overview of ethical issues raised by the use of cognition and mood enhancing drugs demonstrates the tremendous variety in views and opinions regarding the subject.

Keywords: Cognitive enhancement; Mood enhancement; Memory consolidation; Pro-social behavior; Neuroethics

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*Corresponding author. Now at the Institute of Psychology, Erasmus University Rotterdam, Rotterdam, the Netherlands. Tel.: +31 10 4088713; fax: +31 10 4089009.
E-mail address: dejongh@fsw.eur.nl (R. de Jongh).

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1. General introduction

Enhancement can be defined as ''interventions designed to improve human form or functioning beyond what is necessary to sustain or restore good health'' (E.T. Juengst; in: Parens, 1998, p. 29). Humans appear to have an existential need for self-improvement. Drugs, such as the stimulant caffeine, have been used for this purpose for at least a thousand years (Mehlman, 2004). Some, the so-called *transhumanists,* consider enhancement a laudable goal, or even a moral duty. Human nature, they say, is a 'work-in-progress, a half-baked beginning that we can learn to remold in desirable ways' (Bostrom, 2003). In contrast, *bioconservatives* fear that enhancement technologies will undermine our human dignity, that we might lose what it means to be human.

It has been suggested that the recent rapid developments in the fields of neuroscience and psychopharmacology have increased the possibilities for enhancement of mental functioning, e.g. improving memory, mood, or even intelligence. Here, we review and critically evaluate the available evidence. We will focus only on those drugs that play a major role in ethical discussions, either because they are reported to be effective as cognitive- or mood enhancers, or because they show promise as future targets for enhancement. First, we will focus on cognition-enhancing drugs: to what extent can they improve our short- and long-term memory (LTM), or our executive functioning (a cognitive system that controls and manages other cognitive processes and is involved in planning, cognitive flexibility, abstract thinking and inhibiting inappropriate actions)? Second, we will consider the enhancement of mood and pro-social behavior. And third, we will discuss drugs that prevent the consolidation or reconsolidation of unwanted (traumatic) memories.

From this, we will attempt to extract general principles of cognitive enhancement that underlie the common phenomena occurring across different neurotransmitter systems and with different pharmacological agents. These general principles (such as trade-offs) might prove to be a barrier to the practical or commercial use of pharmacological enhancers and should therefore be taken into account in ethical discussions. Finally, we will consider the ethical concerns that are raised by the use of cognitive and mood enhancers, in light of the perhaps more realistic expectations of the effects of these drugs.

2. Cognitive enhancement

2.1. Currently available enhancers

2.1.1. Donepezil

Widely cited in both ethical discussions and popular scientific articles on cognitive enhancement, is the finding that donepezil improved the retention of training in healthy pilots tested in a flight simulator (Yesavage et al., 2002). Donepezil (Aricept®) is an acetylcholinesterase inhibitor indicated for mild to moderate Alzheimer's disease. Acetylcholinesterase inhibitors exert their effects by inhibiting the breakdown of acetylcholine, which increases the amount of acetylcholine in the synaptic cleft that can