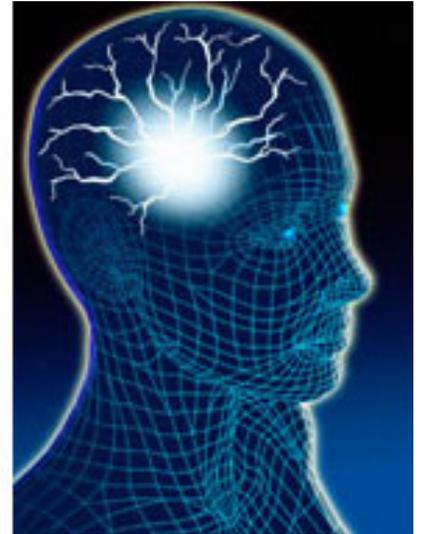


Enhancement of Cognition

Nick Bostrom

Faculty of Philosophy, Oxford University
Director, Oxford Future of Humanity Institute



Faculty of
Philosophy

Enhancement of cognition

- Cognitive enhancement aims at amplifying or extending the abilities of the mind through internal or external hardware or software.
- Until recently, only internal software in the form of trained efficient mental algorithms and the general enhancing effects of paper-based information management was available.
- Setting aside social epistemic enhancements such as
 - ❖ Peer review
 - ❖ Reputation systems
 - ❖ Information markets
 - ❖ Patent law
 - ❖ Etc.



Animal models

- Genetic enhancement of memory has been reported, based on over expression of a subunit of the NMDA receptor of mice (Tang et al. 1999)
- Similarly learning was increased by over expressing a brain growth protein (Routtenberg et al. 2000) or signaling pathway (Wang et al. 2004)
- Other experiments have found ways of promoting the growth of more cerebral cortex during foetal development (Chenn 2002, Chenn & Walsh 2002)



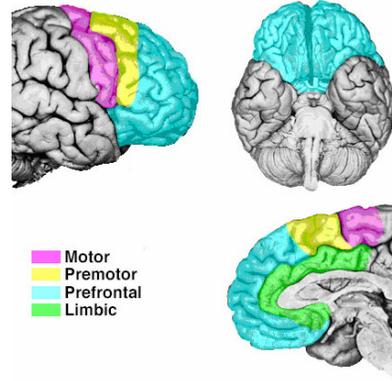
Learning

- Cognition enhancing drugs have been studied since the early 80's, although it has been known far longer that certain stimulants could improve learning.
- Today we have several families of memory enhancing drugs affecting different aspects of the learning and encoding process:
 - ❖ stimulants (Lee & Ma 1995)
 - ❖ nutrients and hormones (Martinez & Kesner 1991)
 - ❖ cholinergic agonists (McGaugh & Petrinovic 1995, Levin 1992, Buccafusco et al. 1995)
 - ❖ the piracetam family (Mondadori 1996)
 - ❖ ampakines (Concar 1997, Lynch et al. 1997, Ingvar et al. 1997)
 - ❖ consolidation enhancers (Lynch 2002)
- It should be noticed that learning enhancement might also be useful for unlearning phobias and addictions (Pittman 2002, Hall 2003), potentially allowing memory modification.



Executive function

- Drugs improving executive function – working memory, attention control – have been harder to achieve
- But some progress have occurred here too (Mehta 2000, Elliott 1997, Kimberg, D'Esposito & Farah 1997, Turner 2003).
- Given that these functions are closely linked to what is commonly seen as intelligence, they may be the first step towards true intelligence enhancing drugs.



Alertness

- Traditional stimulants have a host of risks and side effects
- New forms of alertness and sleep-regulating drugs such as Modafinil appear to enable high-performance function with little risk of direct side effects and addiction (Teitelman 2001, Myrick et al. 2004).
- Control of diurnal rhythms using the natural hormone melatonin (Cardinali et al. 2002)



Creativity

- Although the neuropsychology of creativity is not understood at this point, there appears to be ways to stimulate it.
- One way appears to be a judicious lowering of inhibitions. A study (Norlander & Gustafson 1996) demonstrated how a mild dose of alcohol could improve the result of a creative design process when taken during the “incubation period” when the test subjects presumably let their subconscious mull over the problem.
- Some case studies of brain damage (Giles 2004, Raloff97) also suggest that a lowering of inhibition can unleash creative abilities.
- It is not implausible that reversible changes of this type could be achieved through drugs or transcranial magnetic stimulation (Snyder et al. 2004).



Pre- and perinatal enhancement

- By giving choline supplementation to pregnant rats the performance of their pups was enhanced, apparently by changes in neural development (Meck, Smith & Williams 1987, Mellott et al. 2004).
- Given the ready availability of choline such prenatal enhancement may already (inadvertently) take place.
- Deliberate changes of maternal diet may hence be seen as part of the cognitive enhancement spectrum.

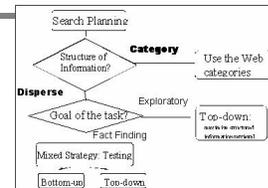


Brain-computer interfaces



- Multielectrode recordings from more than 300 electrodes permanently implanted in the brain are currently state-of-the art, and, on the software side, computers learning to interpret the signals and commands (Nicolelis et al 2003, Carmena et al. 2003, Shenoy et al. 2003).
- Early experiments on humans have shown that it is possible for profoundly paralyzed patients to control a computer cursor using just a single electrode (Kennedy & Bakay 1998)
- Cochlear implants are already widely used, and there is ongoing research in artificial retinas (Alteheld et al. 2004) and functional electric stimulation for paralysis treatment (von Wild et al. 2002).
- Experiments in localized chemical release from implanted chips also suggest the possibility to use neural growth factors to promote patterned local growth and interfacing (Peterman et al. 2004).
- Such implants are not currently intended for enhancement purposes (and unlikely to be desirable for the near future)

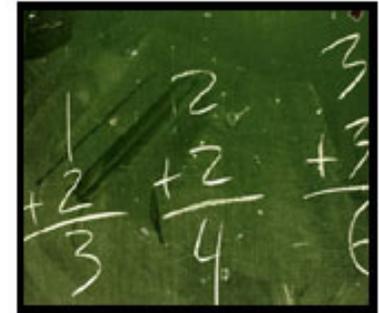
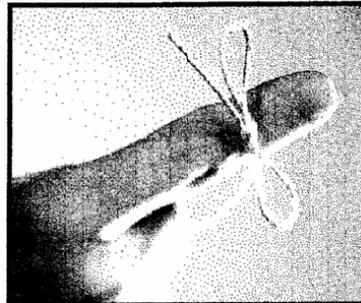
Cognitive strategies



- While the performance increases from the above forms of enhancement are statistically significant, far greater enhancements can be seen through the use of efficient cognitive strategies
- These have often not been discussed in the same terms as biological modifications.
- Memory arts (Patten 1990) can produce enormous capacity increases in memory of structured information, orders of magnitude greater than the effect of cognition enhancing drugs.
- Mental training can significantly improve both performance (Nyberg et al. 2003) and long-term health (Barnes et al. 2004). This includes:
 - ❖ Adjustments of arousal levels (Nava et al. 2004), showing the link between emotional modification and cognitive enhancement
 - ❖ Mental training has been used among athletes for a long time (Feltz & Landers 83) and for rehabilitation (Jackson et al. 2004)
- Such techniques of training-based performance enhancement are widespread and enjoy a broad acceptance in society, but at their core they correspond to deliberate modification of the neural networks of the brain.

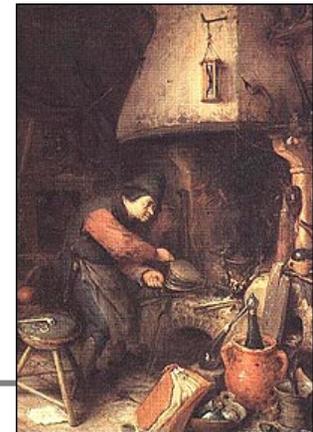
External systems

- External hardware and software systems can significantly improve effective cognitive power.
- Wearable computers (Mann 1997) and ubiquitous computing (Weiser 1991) provide intimate contact with the digital world, which in turn can take over a variety of mental tasks:
 - ❖ personal organizers
 - ❖ information visualization
 - ❖ expert systems
 - ❖ symbolic math programs
 - ❖ decision support tools
 - ❖ information searching
 - ❖ various forms of automated agents, e.g. remembrance agents (Rhodes & Starner 1996) act as a vastly extended associative memory.
- A well-designed environment can enhance proactive memory (Sellen et al.1996). Such systems can both provide new capabilities and amplify existing cognition.



Future prospects

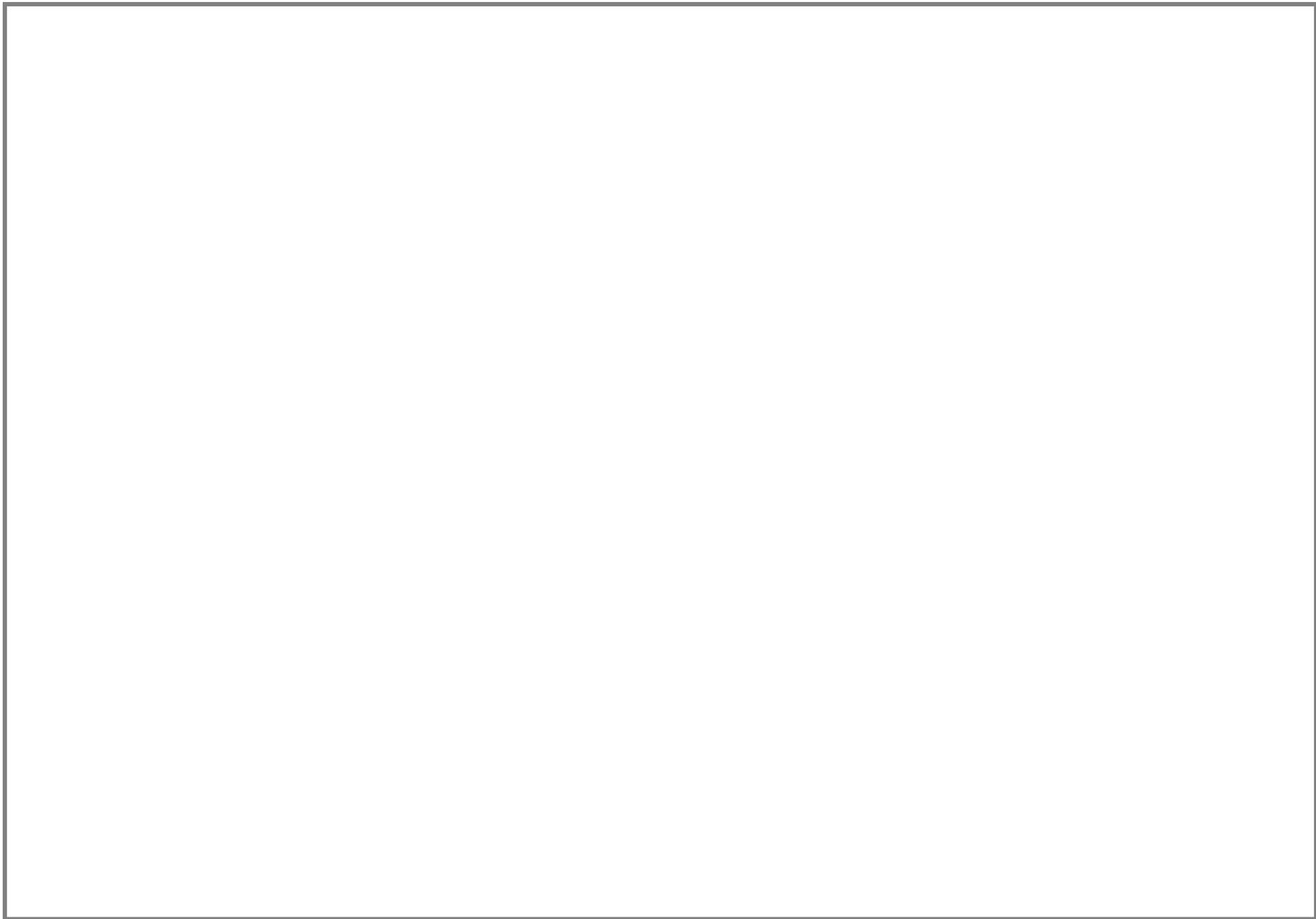
- While the fruits of cognition are unfathomably complex, some of the mechanisms producing them are surprisingly simple and amenable to modification or support.
- It appears likely that within the next 10-20 years we will gain a much deeper understanding of brain development, plasticity and the interplay between the emotional and cognitive systems, including the beneficial developmental changes that occur in the brain during enriched rearing.
- Given the advances in rational drug design, targeted gene therapy, and external information and computing systems, we will have both the tools and the know-how of where to apply them for cognitive enhancement.
- Further out, developments in artificial intelligence and neural interfaces may produce much more dramatic advances.



Ethical issues in cognitive enhancement



1. Interventions that affect the next generation
2. The social effects of widespread use of enhancement
3. Whether the use of cognitive enhancement would constitute a form of “cheating”
4. The appropriateness of using drugs to control behavior in minors
5. Instrumentalization of human person and of human relations



Levels of concern

- Level 0.* Objections based on empirical claims to the effect that it is, and will remain, impossible or infeasible. (“It can’t be done.”)
- Level 1.* Objections based on empirical and normative claims that attempts would be too risky, or too expensive, or too psychologically distracting. (“It’s too difficult.”)
- Level 2.* Objections based on empirical and normative claims about social consequences that would follow from the success, for example concerns about social inequality, discrimination, or cultural degeneration. (“It would be too bad for society.”)
- Level 3.* Objections based on normative claims about the value of enhanced capacities. (“It is worse to live with enhanced capacities.”)
- Level 4.* Objections based on agent-relative normative reasons against human beings transforming themselves in these ways or bringing new persons into existence with enhanced capacities. (“It wouldn’t be good for us to live with enhanced capacities or right for us to create beings with enhanced capacities.”)

Why aim for better understanding?

- Who wouldn't want to remember names and faces better, to be able more quickly to grasp difficult abstract ideas, and to be able to “see connections” better? Who would seriously object to being able to appreciate music at a deeper level?
- The goal is clearly good and very important
- This is reflected e.g. by
 - ❖ The vast resources society allocates to education
 - ❖ The effort many people invest in developing their talents, e.g. musical, mathematical, aesthetics, narration, humor, eroticism, spirituality etc.
 - ❖ Whenever we imbibe a cup of coffee to increase our alertness or when we regret our failure to obtain a full night's sleep because of the detrimental effects on our intellectual performance
 - ❖ Regulations on lead paints
 - ❖ The fact that “brilliant” and “ingenious” are terms of praise
 - ❖ Official and unofficial diet advice

Status quo bias?

Whether a general ‘improvement’ in height, strength, or intelligence would be a benefit at all is even more questionable. To the individual such improvements will benefit his or her social status, but only as long as the same improvements are not so widespread in society that most people share them, thereby again levelling the playing field... What would be the status of Eton, Oxford and Cambridge if all could go there?... In general there seems to be no connection between intelligence and happiness, or intelligence and preference satisfaction. ... Greater intelligence could, of course, also be a benefit if it led to a better world through more prudent decisions and useful inventions. For this suggestion there is little empirical evidence. (Holm, 1994)

Crucially, though, despite the fact that parents may want their children to be ‘intelligent’, where all parents want this any beneficial effect is nullified. On the one hand, intelligence could be raised to the same amount for all or, alternatively, intelligence could be raised by the same amount for all. In either case no one actually benefits over anyone else... [The] aggregate effect, if all parents acted the same, would be that all their children would effectively be the same, in terms of outcome, as without selection. (Birch, 2005)