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Promises and Perils of Cognitive Performance Tools: A Dialogue

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Promises and Perils of Cognitive Performance Tools: A Dialogue

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Cognitive performance tools are evolving and their application is expanding rapidly. Although these tools promise significant advantages, they also raise a number of significant ethical and social concerns. This paper first provides an overview of various cognitive performance tools. Subsequently, there is a dialogue between Viirre on the one hand and Baylis and Downie on the other. Together, they explore the promises and perils of cognitive performance tools available now, or in the near future (perhaps within the next ten to twenty years). The authors conclude there are potential benefits with the development and use of cognitive performance tools. Care must be taken, however, with respect to the ways in which such tools may not serve the interests of individuals and communities.

INTRODUCTION

In Gazzaniga, cognition is broken down into the following elements: attention, memory, language, speech, emotion, consciousness, and higher cognitive functions (1). Higher cognitive functions include reasoning and problem solving skills, the generation and management of mental images, and mathematical and logical skills. All of these cognitive functions are amenable to study, and the mechanisms in the brain that underlie them are actively being researched through conventional empirical educational research, as well as research into fundamental brain activities.

This paper briefly describes existing and emerging neurotechnologies. This overview is followed by a discussion of ethical issues associated with the use of cognitive performance tools. The ethics discussion (which leaves aside the familiar of informed choice, truth-telling, privacy and so on) is framed as a dialogue between the authors. First, Erik Viirre reflects on the possible benefits of cognitive performance tools and then Françoise Baylis and Jocelyn Downie respond. Then, Baylis and Downie reflect on the possible harms associated with these tools, and Viirre responds. Viirre is a clinician-scientist, technologist, and a strong proponent of the development of cognitive technologies. Baylis is a philosopher with a specialization in bioethics. Downie is a law professor specializing in health law and ethics. Together, Baylis and Downie have experience in the regulation of novel technologies and share a particular interest in neuroethics. Thus, the print conversation below reaches across disciplines and aims to model respectful and constructive dialogue to advance conversation on the ethics of developing and using cognitive performance tools.

COGNITIVE PERFORMANCE TOOLS

Currently, researchers in cognitive science and neuroscience are developing a range of neurotechnologies, including brain imaging systems, neuropharmaceuticals, and neural implants as tools for altering cognitive function. It is anticipated that some of these neurotechnologies will be used alone or in conjunction with other technologies to correct a deficit in cognitive function or to improve a cognitive ability that is already within the range of normal.

Brain Imaging Systems

Currently it is possible to generate brain images using a variety of technologies, including functional magnetic resonance imaging (fMRI), positron emission tomography (PET), electro-encephalography (EEG), and magneto-encephalography (MEG). These different neurotechnologies generate various kinds of information about the brain's structure and function that can be used to determine the appropriate treatment for a range of congenital, metabolic, and other diseases and disorders. For example, fMRI and PET are used to document brain activity using hemodynamic measures (i.e., blood flow) whereas EEG and MEG are used to measure electromagnetic changes during brain activity.

As the capacity for spatial and temporal resolution of structural and functional imaging technologies improves, it is expected that there will be better resolution of the blood flow and electromagnetic fields in the brain. In time, it is also expected that with the increasing efficiency of computing technology it will be possible to provide calculations related to cognitive activity in near real time. Eventually, with the decreased cost of computing power, neuroimaging technologies could be widely available for a broad range of applications.

Technological developments in brain activity measurements are already being used to improve computer-based training (CBT) aimed at altering cognitive performance (2). CBT programs for improving memory, language, and mathematical abilities in children are already available and widely marketed as computer games. In the near future, such programs may be improved, repackaged, and remarketed for a broader audience across the age and intellectual spectrum with the explicit therapeutic or enhancement objective of maintaining or improving cognitive function (e.g., memory training programs for Alzheimer's patients). Eventually, the programs may be able to use brain imaging technologies to monitor brain activity in real-time to ensure that each action taken by an individual engaged in CBT will have maximum learning efficacy. For example, information about neural states that are relevant to training (such as fatigue and confusion) may be conveyed to the computer system delivering the CBT and the program could then be adjusted in real-time to more precisely meet the needs of the individual being trained.

Not only might general neural states be detected, but even the intended meaning of utterances might be observable (3). For example, techniques already exist to detect planned movement commands of animals and humans, such as moving a limb to the left or the right (4). Ultimately, in humans, abstract concepts such as the meaning of "too" versus "two" may be detectable. With the ability to detect biomechanical plans and abstract concepts, human-machine interfaces would have great breadth and scope.

In time, newer neural imaging technologies may also provide higher resolution of coding events in the brain. The brain is a highly interconnected network of neurons that convey information via electrical signals. Experiments using optics technology have shown in vitro that coded signals from neurons can be detected with light, using controlled light signals and measurements of the reflected light (5). More recent experiments in humans, where light is passed into the head and reflected back to detectors, have also shown the potential for detecting signals in the human brain (6). Eventually, optics technology may enable us to assess action potentials from small groups of neurons in small volumes of the brain, and advanced techniques may even enable us to record the activity of single neurons. Although there will be enormous volumes of data and signal processing required to manage such recordings, they could provide useful high resolution images of brain activity.

In the future, there may also be well-catalogued libraries of brain activities related to behavior produced through the use of imaging systems. These libraries may enable cognitive performance experts to characterize the cognitive status of an individual and, on this basis, to recommend strategies for cognitive improvement. For example, at present, changes in the organization of brain signals in people with autism can be detected (7). Eventually this information might be useful for developing a range of interventions. While our ability to generalize data obtained from groups of individuals to a single individual may be uncertain, these libraries might nonetheless provide useful information.

Neuropharmaceuticals

There may soon be new classes of pharmaceuticals that will maintain attention and alertness in the face of stress or sleep deprivation. These medications could be taken orally, inhaled into the lungs, or introduced via the nasal membranes so as to rapidly enter the bloodstream. Through these molecules, prolonged periods of enhanced cognitive ability may become possible (although sleep and recuperation would most likely still be necessary). The familiar use of caffeine to maintain alertness and improve mental performance could be extended to molecules that are matched to an individual's genetic profile or to the task that he or she is undertaking. Pharmaceuticals may also be developed to enhance cognitive abilities in training, such as memory and learning (e.g., through improving protein action).

Neural Implants

Implants into the brain can be electronic, cellular, molecular, or genetic. Electronic implants that alter the performance of the auditory system, the visual system, and motor control (for conditions like Cerebral Palsy) are already available (8). Meanwhile, electronic implants to augment higher order cognitive functions, such as memory, are currently being designed. For example, bioengineers in the United States are working on a prosthetic microchip to replace the hippocampus, the part of the brain responsible for long-term memories. There have been in vitro animal studies and the hope is to move to clinical trials in which neural prostheses might be used to replace damaged or diseased brain tissue in humans (9). Further, electronic implants may be created that enable direct communication between the brain and a computer, with the computer being able to draw linguistic content from the signal received from the brain. Eventually, electronic implants that transfer information directly from neurons to a communication system, linked to a computer designed to carry out signal interpretation on data coming from the brain, may be available. The computer would interpret the intended action or meaning of the signals and then transmit the interpretation to another person through a visual image or sound.

Cellular implants, involving the grafting of cells directly into the brain, aim to treat focal neurological deficits, such as Parkinson's Disease, and soon may be able to treat more diffuse conditions of the brain, such as multiple sclerosis. For example, small groups of fetal adrenal cells are now being implanted into the failing movement control areas of the brains of people with Parkinson's Disease. The implanted cells provide a replacement supply of neurochemicals directly into the region of the brain that needs them. The return of normal amounts of the neurochemicals in some patients allows the return of normal movement control (10).

With molecular implants, a device that can store and slowly release neurochemicals into specific regions of the brain is surgically implanted. As many of the chemicals that are important in the brain are protein molecules, it is expected that as we learn more through proteomics about how proteins are created, how they work, and how they are controlled, it will be possible to intervene in protein expression during cognitive activities. For example, in the future, specific protein molecules for memory enhancement may be delivered to specific locations from small reservoirs that slowly release the relevant proteins. Already, protein molecules are being released throughout the brain to treat some of the symptoms of dementia and other neurological deficits (11).

Finally, genetic implants may become available to correct single gene defects affecting cognitive performance through transcription/translation technologies (12). Diseases such as Huntington's Chorea are the result of a single genetic error in a person's DNA. The disease results in uncontrolled movements of the body. To correct this motor disorder, DNA that might correct Huntington's Chorea could be introduced into the brain using viral vectors. The viruses might be able to directly invade the neural cells, alter their incorrect genetic code, and thereby change their action.

Combination and Convergence of Cognitive Performance Tools

The neurotechnologies described above are being developed as of this writing in 2006. Some of the technologies, such as advanced neuropharmaceuticals, will be on the market in a few years. Other technologies, such as individually designed genetic implants, may take an additional five, ten, or more years to realize. Once available, these technologies likely will not be used in isolation and it is to be expected that we will witness a scientific convergence of nanotechnology, biotechnology, information technology, and cognitive science. For example, assessment of genetic status may be integrated with behavioral and neurophysiological measures derived from brain imaging, and may be responded to with pharmaceutical and genetic interventions. Drug-delivery systems may be developed to provide neurochemicals to enhance computer-based training mediated by real-time imaging. Genetic interventions may enable people with genetic defects to be trained by cognitive performance software. Following diagnostic neuroimaging and genetic testing, pharmaceuticals may be combined with genetic implants in an effort to enhance cognitive performance. Genetic technologies may be combined with monitoring of neural activity and intracellular products to understand the effects of a person's environment on cognitive status.

AN ETHICS DIALOGUE: THE PROMISES

Against this backdrop of technological advances, we now move to consider the potential benefits and harms associated with the development and use of neurotechnologies to alter cognitive capacities.

A. Improved Cognition

Viirre: Through research in neuroscience and cognitive science, a variety of improvements in cognitive function will be possible. These include increased attentiveness, memory, linguistic expression, mathematical and decision-making skills, control and expression of emotions, and abilities to manipulate abstract concepts, mental sounds, and mental images. With cognitive enhancement, people will be better able to take advantage of, and enjoy the benefits of, higher education. In meritocracies based on abilities and outcomes, one would expect that such people would be better citizens and leaders. Such cognitively altered individuals would have an increased ability to solve problems and identify opportunities. They would also have increased reasoned compassion and willingness to serve those in need. As a result, more resources would be made available to meet the needs and interests of those who are disadvantaged.

Baylis and Downie: While the equation of ignorance and immorality has a long history, in our view, it is possible to 'know the good' and still not 'do the good' (13). Therefore, we are not persuaded that improved cognitive function will lead to increased reasoned compassion which in turn will translate into actions in the interests of others. Through higher cognitive function, one may better understand the needs and interests of others who are disadvantaged. It does not follow, however, that one will be any more likely to care about the fact that those needs and interests are not being met, or that one will be any more likely to act in such a way as to advance the needs and interests of others. The link between improved cognitive performance and helping others has not been established. For example, there is no evidence that members of Mensa are more community-minded than individuals with lower cognitive function. One may ’know’ the needs and interests of others, but not consider oneself morally obliged to serve these needs or interests. Then again, one may ‘know’ the needs and interests of others, believe that there is an obligation to promote these needs and interest, and simply lack the will to do so (14-23). Similarly, there is no evidence to support the belief that persons with developmental disabilities are any less moral in their conduct. For example, persons with very low cognitive function may well have the ability and will to serve the needs and interests of those who are disadvantaged.

Further (and unfortunately), we do not live in pure meritocracies where merit is understood in terms of objectively ascertainable moral ideals. Even if cognitive performance improvements could be realized in the population-at-large, we may not end up with better leaders. Leadership, where linked to holding power (e.g., political leadership), is determined in large part by access to money and other forms of privilege rather than cognitive ability. Hence, even if we were able to improve cognitive abilities, there is no reason to expect that this would have a positive impact on governance (24). Indeed, the opposite may well result. For example, improved understanding of others’ vulnerabilities might lead some to exploit those vulnerabilities (25). Furthermore, “meritocracies based on abilities and outcomes” are not necessarily benign. Clearly, the selection of particular abilities and outcomes as meritorious is a normative exercise with normative consequences. For example, a gang might base its leadership structure on the ability to kill or injure without personal moral anguish. This sort of meritocracy would actually work to compound moral wrongs.

B. Increased Creativity

Viirre: By increasing the speed and accuracy of interaction with computing systems, increasing memory and cognitive capacity, and potentially increasing the means of generating creative thinking, neurotechnology could lead to better problem-solving skills and the identification of new combinations of physical reality, laws of nature, and abstract concepts.

Further, through machine-mediated communication (see “improved communication” section below), team members will be able to communicate and collaborate at increased velocity and with increased variety. In addition to the conventional channels of communication, these adjunctive channels will be available to deliver information at the discretion of the users.

Baylis and Downie: Improving memory, cognitive capacity, and creative thinking are laudable goals. Caution is advised, however, lest we ignore the potential negative consequences of enhancing these abilities. Consider memory, for example. Psychopharmaceuticals can be used to manipulate the formation, storage, and retrieval of conscious episodic memory and non-conscious emotional memory. However we do not fully understand whether, and if so how, altering pathological emotional memory may result in the disruption of positive episodic and emotional memory. Memory erasure and prevention could result in a loss of both harmful and beneficial memory as when, for example, efforts to reduce pathological fear results in a loss of normal responses to fearful stimuli in our natural and social environment (26).

We also worry that machine-mediated communication may restrict creativity, as communicative ability will be limited by that which the machine can detect, interpret, and transfer and which can, in turn, be interpreted by the users.

C. Improved Communication

Viirre: Improving the accuracy with which we are able to determine brain states and neural activities could eventually lead to improved machine-mediated communication between individuals. Machine-mediated communication would involve the detection of the speaker's emotional and mental states and the delivery of information about these states to the recipient to assist him or her in better understanding what the speaker is attempting to communicate. For example, if a speaker were tired and having difficulty explaining subtly nuanced arguments, a recipient might be confused and interpret the speaker's ideas incorrectly. However, if the recipient understood, through machine-mediated communication, that the speaker was having difficulty, the recipient could reinterpret the communication or ask for further clarification. Initially, machine-mediated communication might function in an open loop fashion where machine outputs would accompany conventional communication. In time, however, as speakers and recipients understood the influence of neural state detector machines on interpersonal communication, they could, in turn, learn how to influence the relevant outputs, and the machine could become an alternative means of effective communication, perhaps analogous to sign language or text messaging.

It is anticipated that future machine-mediated communication will be extremely efficient at communicating neural states, thereby heightening the level of communication. The hope would also be to increase ways of displaying and communicating concepts, along with their emotional nuances, in order to increase interpersonal interaction. It may well be, however, that the effort required by technology developers to detect fine distinctions of meaning and train this into machines would be enormous, in which case short-cuts or restrictions may limit the range of expression possible through machine-mediated mechanisms.

Baylis and Downie: We understand communication to be a complex activity between sender and receiver. In very general terms, information is encoded, transmitted, received, and interpreted with the goal of fostering understanding between the sender and receiver (27). We readily grant that machine-mediated communication between individuals likely will increase the volume of information encoded and the velocity of information transmitted. Machine-mediated communication likely will also have a positive effect on the efficiency of information transfer (subject, of course, to the quality of the programming of the machine). For example, machine-mediated communications could be sent while the intended receiver was busy or asleep and stored for access at a later time.

Despite these benefits, however, we doubt that machine-mediated communication will improve interpretation or understanding, as these require the exercise of judgment on the part of the receiver, who must attribute meaning to the information encoded, transmitted, and received. Understanding is not reducible to registering a maximum amount of stimuli or information (28). Indeed, machine-mediated communication may well compromise understanding, especially if such communication ultimately prevents the development of interpersonal skills and abilities.

Consider, for example, the use of e-mail. E-mail is infamous for compromising communication, even when content is accurately encoded and effectively transmitted. Why? Because the text received may not accurately convey tone or other emotive content. Many people will have had the experience of seriously misinterpreting an e-mail communication because of the absence of interpretive signals such as tone of voice, facial expression, and other forms of body language. Indeed, sometimes the way in which something is expressed is more important than what is being expressed; this explains, in part, why some people append symbols called emoticons that replace facial expressions (for example, smiling faces) to their e-mail messages. But this is little more than a compromise – an effort on the part of humans to compensate for the limitations of (admittedly low level) machine-mediated communication.

Further, while machine-mediated communication between individuals may be quicker and more efficient, it is also likely to be more impersonal. Again, e-mail serves as a useful example. With this technology we have increased the number and speed of discrete moments of interaction between people and yet few will disagree with the claim that this increase has been accompanied by a decrease in personal contact associated with in-person meetings (29) and telephone calls (30). We fear that some means of communication will be increased at the expense of others valued for their interpersonal nature. We also fear that some means of communication will be increased at the expense of some means of expression. In our view, we should worry about the risks that machine-mediated communications will crowd out or reduce the use of other valuable and valued forms of communication (31).

Consider another technology and its possible indirect impact on relationships. With the development of lie detection technology, we may have improved communication with regard to truthfulness. However, the broad availability of lie detection technology may reduce the level of trust needed and experienced in various intimate, collegial, professional, and other relationships. A key component of many human relationships may thus be diminished or lost.

D. Increased Possibilities for Individual Expression and Increased Individuality

Viirre: By improving cognition, increasing creative possibilities, and enhancing abilities to express ideas and emotions, there will be increased possibilities for individual expression. At the same time, common features of human life (a desire for, and an appreciation of, children; compassion for others; excitement with achievement; and sadness for loss) will remain common. Increased individuality and cognitive ability in the face of shared emotions will improve the ability to communicate emotions and find new means of communicating them.

Baylis and Downie: Why assume that increased possibilities for individual expression will lead to more individuality, not less? Indeed, developments in cognitive performance tools may lead to greater homogeneity rather than greater individuality (24, 32, 33). For example, where performance can be shaped by pharmaceuticals, diversity of performance may be less well tolerated and individuals may be pressured to use enhancement tools in order to realize socially valued norms with regard to performance. At present, it appears that those who are too active are medicated with methylphenidate and those who are too passive are medicated with fluoxetine. As we treat the ends of the spectrum, we slowly change the realm of tolerable (and tolerated) behavior.

It is also important to question the assumption that the common features of human life include a desire for children, compassion for others, excitement with achievement, and sadness for loss. Perhaps all that we have in common is birth and death. If these are the common features of human life, then surely we don't want to suggest that these features will be enhanced with the use of cognitive performance tools.

E. Increased Resistance to Internally Generated Negative States of Mind

Viirre: Signals indicating failures of the nervous system can be detected through neurotechnologies, and it is possible that emotional and central nervous system disorders such as depression, anxiety, addiction, dementia, schizophrenia, Parkinson's Disease, tinnitus, and dizziness all have specific metrics. If so, identifying these metrics could have significant potential therapeutic benefits. For example, cognitive behavioral therapies appear to be reasonably effective in reducing the symptoms associated with conditions such as depression and anxiety. If there were neural markers for some of these conditions, therapists might be able to design more appropriate therapeutic regimens and better judge how effective they are. Further, available automated approaches to treating poorly functioning neural systems might be improved if there were specific metrics for the underlying condition. Consider, for example, software for treating children with language delay. Children with specific deficits in their ability to process sounds are trained through simple games to improve that neural function. Such training results in a global improvement in their language ability because of their improved ability to process spoken words.

In the future, it will be interesting to see if conditions that are regarded by some as moral failures, such as sloth, anger, greed, and addiction, will be similarly amenable to detection and reduction through management techniques guided by neurotechnology.

Baylis and Downie: The preceding paragraph illustrates a concern we have with the use of cognitive performance tools. In our view, there is the risk that certain cognitive states will unjustifiably be deemed moral failures, deviant, inappropriate, or abnormal, and that individuals manifesting those cognitive states will be forced to change. For example, anger may be a healthy and morally appropriate emotional response to certain situations, not a "moral failure." Also, addiction may be better described as an illness, not a "moral failure" (34).

In response, one might reasonably argue that society currently identifies a range of behaviors as moral failures and seeks to control these behaviors through the school system (teaching children basic moral values), the health system (treating persons who engage in deviant social behaviors) and the judicial system (imprisoning convicted criminals). As such, why object to more effective means of achieving the same end? We believe that the use of cognitive tools to correct "moral failures" is more fraught with perils and vulnerable to abuse. We recommend a careful analysis of the normative assumptions that may drive the use of cognitive performance tools in correcting deemed "moral failures."

F. Increased Resistance to Externally Generated Negative States of Mind

Viirre: The ability to expect, understand and resist various forms of indoctrination should be the outcome of increased cognitive abilities. At the very least, higher cognitive abilities should enable people to identify and rationally resist inappropriate programs of thinking. As well, improved thinking abilities should enable people to examine their own emotional responses and see how inappropriate motivations or desires lead to acceptance or rejection of indoctrination.

Baylis and Downie: The underlying assumption that cognitive performance tools will be used only to improve higher thinking and cognitive abilities rather than to shape them negatively is deeply problematic. For example, these tools could as easily be used to make indoctrination more effective, not easier to detect and resist (35-36).

G. Improved Ethical Conduct

Viirre: It will be most interesting to see the influence of neurotechnology on ethical conduct. At the very least, one would hope that increased thinking ability would result in increased (more effective) learning about ethics, which in turn would increase ethical thoughts and actions. Law and morality are taught in our institutions of higher learning, and with increased cognitive abilities one might reasonably expect better learning in each of these domains. As well, an improved ability to understand the thoughts and emotions of others should lead to improvements in ethical behavior. If the depths and nuances of thinking and feeling in various hypothetical and real-life situations can be better understood, then perhaps ethics will have a better footing.

Groups and societies with higher intelligence understand that violence is not an effective means of interaction. They demonstrate improved ethics and thereby assure their survival. Societies that have brutal levels of violence among their members (and hence low levels of morality) do not survive, suggesting that ethical behavior within societies is a fitness factor in a Darwinian sense.

Baylis and Downie: We take issue with the claim that there is a causal relationship between increased thinking ability and improved ethical thoughts and action (37). Similarly, we object to the view that there is a causal relationship between understanding the thoughts and emotions of others and increased ethical behavior. As noted earlier, though some believe that 'to know the good is to do the good', we do not share the view that immorality is reducible to ignorance alone (38).

Also problematic is the claim that there are "societies with higher intelligence." Where is the evidence to support the claim that such societies exist? And if they do exist, where is the evidence that their higher intelligence has resulted in improved ethics? Certainly, it is difficult to see the correlation between higher intelligence and ethical behavior among individuals in our society, perhaps because there are far too many confounding factors to allow inferences of a causal relationship.

AN ETHICS DIALOGUE: THE PERILS

A. Increased Inequality and Marginalization

Baylis and Downie: If we assume that there are many positive benefits associated with the use of cognitive performance tools, then it is reasonable to ask pointed questions about autonomy and equity (32-33, 39-41). First, there are questions about who will likely avail themselves of these technologies and whether this will be a matter of choice (24, 42). For example, will the use of such tools be available to all on an elective basis? Or, will their use be limited to those who can purchase them in the market place (43)? From another perspective, will the use of such technologies be imposed by an autocratic government that wants to improve its competitive advantage by increasing its population's cognitive capabilities (44)? Or, will individuals nominally have a choice, but ultimately have no meaningful option other than elective enhancement if they wish to remain competitive (43)?

Concerns of this nature have already been raised by others with respect to the possible future uses of genetic enhancement technologies (45-48). First among these concerns is the risk of widening the present social divide between the haves and the havenots, as differences between social groups increasingly become tied to differences in socio-economic status, if only the rich can purchase technologies to augment their cognitive abilities (45-48). The worry here is that even as the cost of certain technologies may decrease with time, the latest, more sophisticated technologies will likely always be at a premium and thus beyond the reach of the least well off. In this way, the rich are able to secure a competitive advantage in school and in the workplace. In time, this privileged access to cognitive performance tools would further entrench the current social divide that might otherwise be thought of as temporary (i.e., amenable to change on the basis of effort, ability, and opportunity).

A second set of ethical concerns cluster around the theme of global equity (49-50), especially if we imagine that cognitive performance tools will only be available to affluent people in the developed world. It is possible (some would say likely) that intellectual property regimes throughout the world will have a limiting impact on access to cognitive performance tools.

Viirre: The views expressed above regarding access to cognitive performance tools appear to assume that the tools may have negative applications and be used against individuals, or that the tools may have positive applications and be the source of increasing inequality in society. Do these possible negative consequences outweigh the possible good? How can 'good versus evil' purposes and effects be managed? Whose job is it to manage these things? Being a beneficiary of, and an optimist about, technology, I would like to reiterate that increased intelligence is good and may lead to increased capacity for altruism and imaginative sympathy. The work of Jonathan Glover supports this point of view (51). He suggests that genetic engineering to raise our intellectual capacity may enable individuals and groups to transcend traditional intellectual limitations and reach higher levels of sophistication, allowing us to hope that "our history of cruelty and killing is part of a primitive past, to be left behind as civilization develops" (51). Improved existence through collaboration presumes that one is individually better off if one's society is improving. The idea that improved cognitive ability will improve society may be too much to hope for, but it is certainly worthy of consideration.

Technologists' putative ethical lapses in the development of nuclear energy are often put forward as a cautionary tale. More recent examples may be more instructive, however. Consider, for example, how the widespread use of information technology has put more power in the hands of individuals or non-governmental groups. Increased thinking ability and knowledge about thinking and emotion seems to me a priori to be a good thing.

Political reality does not absolve scientists and technologists of their responsibility for the tools they develop. Indeed, it is the responsibility of those who create technology to anticipate nefarious versus beneficent uses of their inventions. Unintended consequences are legion in human history and so dialogue is essential. Indeed, if a scientist or technologist takes the position of a neutral observer, he or she, in effect, paves the way to unintended or unwanted uses of scientific and technologic developments. Given the complexity of neurotechnologies, their developers will need to educate society about the capabilities and limitations of their work. At this point, the neurotechnology community is so busy just trying to make things work, that there has been little time to explain the work to the general public. Fortunately, discussions are beginning.

B. Increased Stigmatization and Discrimination

Baylis and Downie: Above, we briefly considered issues of autonomy and equity, on the assumption that cognitive performance tools will be perceived as a good that people will want to avail themselves of and may be prevented from doing so for financial or other reasons. We now temper this assumption and consider the risks associated with uses that are not unequivocally positive. One risk is that the use of such tools will result in increased discrimination and stigmatization (24, 32). Consider, for example, the use of brain imaging for the purpose of lie detection to assess whether an individual has lied about his sexual orientation on an application to the military or the Catholic priesthood.

While the law prohibits some discrimination it does not necessarily prevent it, so we should be alert to the risks of the potential subsequent discriminatory use of certain neurotechnologies.

Viirre: The worry that scientific achievements may be used to enhance dogmatic thinking is certainly plausible. At the same time, however, it is important to note how science can help to undermine dogmatic thinking. For example, there is evidence that conditions such as gender identity have the same mental standing as, say, preferred means of learning. This sort of data can help to promote diversity of thinking. From another perspective, the status of 'thoughts' in society will likely require an explosive change in philosophical and political thinking when thoughts (previously in the exclusive realm of the private) become accessible to others (52). We cannot know where the argument will go, and I fear some outcomes. Again, it appears to me that there is a need for political will and that technologists will have an important role in the discussions that need to occur.

C. Increased Government Control of Individuals

Baylis and Downie: The risk that cognitive performance tools will be used for brain or mind control is not hard to imagine (24). Consider, for example, the possible use of neuropharmaceuticals by military personnel to dull feelings of empathy, so as to make it easier (and so more likely) for them to participate in torture in the context ofinterrogating military prisoners. Here, it is worth noting, in passing, that much neuroscience research is funded by the US military. There are, of course, benign interpretations of such support but there are also more sinister ones.

Viirre: Unfortunately, lack of empathy is far too common among humans. One might suppose that historically humans have tended to identify with a local tribal group in order to preserve genetic heritage and for this reason have attacked other tribes. Thus, there may be some genetic basis for lack of empathy. Having empathy for those outside our group is necessary for survival in the modern world, however, where mutual annihilation is all too possible. Neuroscience research by the United States military and other forces around the world aims to improve cognitive performance in the complex tasks required with modern military systems. Further, in this era of peacekeeping, dealing with insurgencies and working among populations that express little empathy for foreign groups, there is the need for smarter, more understanding individuals who can interact with local individuals on a more productive basis than swinging the point of a gun. While a speculative "lack of empathy" pill or even terrible forms of torture might be delivered through neuroscience research, such research efforts seem all too unnecessary.

CONCLUSION

There are potential benefits to be realized through the development and use of cognitive performance tools. There is the risk, however, that such tools may be used in ways that are inappropriate or even dangerous to individuals and communities. The possible misuse of cognitive performance tools cannot be sidestepped by claiming that knowledge and technology are value neutral and that scientists and technologists have no role or responsibility in helping to determine the appropriate use of the knowledge or the technologies they develop. Knowledge production and technology development may not be separated from their future uses. While we may ultimately support the development and use of some cognitive performance tools, much more careful reflection is needed.

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