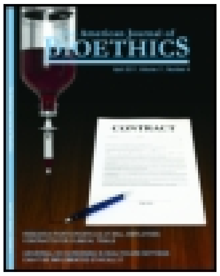

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Neuroethics and National Security

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Target Article

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Science is driven by technical innovations, and perhaps nowhere as visibly as in neuroscience. In the past decade, advances in methods have led to an explosion of studies in cognitive (Gazzaniga et al. 2000), affective (Panksepp 1998; Davidson et al. 2003), and social neuroscience (Cacioppo et al. 2002; Cacioppo et al. 2006). Using technologies that can noninvasively record or stimulate activation in the human brain, recent studies have begun to elucidate the neuroscience of complex human social behaviors, such as love (Aron et al. 2005; Bartels and Zeki 2000), trust (Adolphs et al. 1998; King-Casas et al. 2005; Kirsch et al. 2005; McCabe et al. 2001), fairness (Knoch et al. 2006; Sanfey et al. 2003; van't Wout et al. 2005), extraversion and neuroticism (Canli et al. 2001; Canli et al. 2002; Fischer et al. 1997; Wassermann et al. 2001), deception (Davatzikos et al. 2005; Kozel et al. 2004; Kozel et al. 2005; Langleben et al. 2005; Montague et al. 2002; Phan et al. 2005), empathy (Avenanti et al. 2005; Avenanti et al. 2006; Carr et al. 2003; Singer et al. 2004b; Singer et al. 2006), consumer preferences (McClure et al. 2004), and even moral decision-making (Anderson et al. 1999; Greene et al. 2001; Moll et al. 2002; Singer et al. 2004a). With these rapid developments has come concern for the implications of their applications outside the laboratory (Illes 2006; Marcus 2004), and, with that concern, the "arrival" of neuroethics (Kennedy 2004). This article concerns the potential uses of neuroscience research and methods to issues related to national security.[1]

Can neuroscience help the United States deal with national security-related problems? If so, how, and what are the potential ethical, legal and social consequences of its use? These were some of the questions discussed at a meeting held at Tufts University in September 2006 ("The Neuroethics of Homeland Security," Tufts University, Medford, MA, September 29, 2006). This article represents some of the

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1. The term *national security* is broad and generally refers to the ability of a nation-state to defend its territorial integrity and independence from an external threat; a nation would be high in national security if it can successfully do so, low if it cannot. This definition is how organizations such as the United Nations (see Daes 1990) and most political scientists use the term. Although some use the terms *homeland security* and *national security* synonymously, they differ in both connotation and denotation. *Homeland security* is a subset of national security, and deals with those efforts focused directly on the protection of territorial integrity, such as the safeguarding of borders or the screening of travelers within the United States. *National security* has a broader focus, and refers to the indirect protection of homeland security by the projection of force abroad, such as when the United States and coalition partners attacked the Taliban in Afghanistan. In this article, we are as much concerned with national security as homeland security. In the contemporary context, the largest threat to United States national security is that posed by non-state organizations using terrorist tactics possibly involving weapons of mass destruction, so many of our discussions will be about terrorism.

key themes discussed that day. We believe neuroscience applications might be useful to national security, but we are concerned about the possibility that they may be deployed prematurely and without sufficient attention to the ethical, legal, and social issues they raise. This paper is structured into three sections. In the first section, we provide a brief overview of some key neuroscience brain mapping technologies. In the second section, we highlight some current work using these technologies that will likely become relevant for future national security applications. In the third section, we discuss neuroethical challenges as they relate to scientific, ethical, legal and public concerns. We conclude with a call for greater partnership between neuroscientists, ethicists, and governmental decision-makers. We believe that the continuing involvement of neuroscientists and others interested in neuroethics will be essential to the appropriate uses of these technologies in national security.

TOOLS IN HUMAN BRAIN MAPPING

A comprehensive overview of contemporary tools in neuroscience and related fields that may be relevant to national security is beyond the scope of this article. Instead, we will briefly highlight two sets of technologies, noninvasive brain imaging and brain stimulation methods, that are currently used to map the human brain (for more detailed overviews of these technologies, see Aine 1995; Friston 2005; Stern and Silbersweig 2001; Turner and Jones 2003). Research that may relate these technologies to national security is already underway, as indicated by the fact they have attracted funding support from the Defense Advanced Research Projects Agency (DARPA, Arlington, VA) (Moreno 2006).

Noninvasive Brain Imaging

Several technologies are now available to measure activation in the human brain based on its magnetic, optical, metabolic, and electrical properties. These technologies differ from each other in spatial and temporal resolution, which constrains the kinds of research questions they can address. They also differ from each other with respect to cost, operator training, required support infrastructure, portability, and movement restrictions on the participant, all of which constrain the kinds of national security scenarios they can address.

For example, some technologies are quite expensive, require highly-trained staff and extensive support facilities, are stationary, and depend critically on the participant remaining still during the scan. These technologies may therefore be most useful in national security scenarios involving facilities that conduct routine scanning of motivated and cooperating individuals, such as applicant screening for governmental positions that would require security clearance, or perhaps screening of business travelers who would seek to obtain a "trusted traveler" certification from the Department of Homeland Security (Washington, DC).

Two examples for these types of technologies are functional magnetic resonance imaging (fMRI) and positron emission tomography (PET). fMRI requires a very large magnet and PET requires a nearby cyclotron to generate radioactive isotopes with very short (minutes to hours) half-lives. Both require highly trained supporting staff (doctorate-level physicists and/or chemists, technicians, computer programmers, experts in data analysis). In both cases, the participant is placed inside the core of the scanner and asked to keep his or her head still while responding to various stimuli during some cognitive task. The two technologies differ in important ways, however. Most neuroscientists favor fMRI because, unlike PET, fMRI does not require the injection of radioactive labels into the participant and because it has superior spatial resolution (down to 1 mm^3) and temporal resolution (down to 2 to 3 seconds with rapid event-related fMRI). In contrast, the compounds used in PET can bind to neurotransmitter receptors, glucose (which is used by energy-hungry neurons), or other neurochemicals of interest. The location of these compounds in the brain can be detected by their radioactive decay. Because PET thus can be used to measure concentrations of brain metabolites, it offers the opportunity to gain unique insights into neurochemistry of behavior.[2]

Other technologies, such as electroencephalography (EEG) and near infrared spectroscopy (NIRS), are much less expensive, can be operated by one individual with modest training (i.e., a technician), are portable, and may allow the participant to be mobile. These technologies may eventually be most useful in national security scenarios involving field applications. Probably the oldest brain mapping technology is EEG, which records the electrical activity of neurons through electrodes placed on the scalp, which pick up the summed electrical activity of neurons. Although the temporal resolution of EEG is excellent (on the order of milliseconds), its spatial resolution is very poor (several centimeters).[3] Furthermore, although a participant in an EEG study is free to sit without restraint in a chair, movements that affect the scalp such as jaw-clenching can significantly degrade the signal. An alternative method only recently applied in cognitive neuroscience is NIRS.[4] Similar to EEG, NIRS measures brain activity through the scalp, but it does so using optical recording technology. NIRS emits light in the near-infrared range (700 to 1000 nm) and records the oxygen absorption of blood in the brain. Compared to EEG, it has superior spatial resolution (4 cm depth), but much poorer temporal resolution (approximately 5 seconds). The NIRS system is very portable (about the size of a desktop computer, but the detectors may eventually be integrated

2. A close relative of fMRI is magnetic resonance spectroscopy, which can also be used to detect neurochemicals. However, unlike PET, magnetic resonance spectroscopy cannot as yet image the entire brain, but is restricted to small areas of interest.

3. Measurement of brain activity with maximum spatial and temporal resolution would require the simultaneous use of fMRI and EEG. Although not trivial, current efforts are underway to integrate these two approaches for optimized brain mapping (see DuRousseau 2004; Horwitz and Poeppel 2002).

4. NIRS has been used outside cognitive neuroscience for decades, such as studies of the heart or of tumors.

into wearable systems such as helmets) and is not affected by movements that affect the scalp.

Noninvasive Brain Stimulation

In contrast to the large variety of neuroimaging technologies, noninvasive brain stimulation primarily relies on two technologies, transcranial magnetic stimulation (TMS) and transcranial direct current stimulation (tDCS). Both technologies are relatively inexpensive (particularly tDCS) and fairly compact (the TMS system takes up the space of a large stereo system, whereas the tDCS system can be as little as a handheld computer). At this point, a technician must operate TMS and tDCS; however, for some applications, it is possible to envision modifications of these technologies into systems that can be self-administered and contained in portable helmets or similar constructions. TMS and tDCS could therefore be used in many different kinds of environments, including use in the field or in temporary installations. However, for repetitive use of multiple pulses of TMS, the availability of medical safety devices is recommended should there be a rare instance of an inadvertently induced seizure, which may restrict the use of TMS in some settings.

Whereas brain imaging technologies measure the activation generated by the brain during cognitive processing, noninvasive brain stimulation *induces* changes in brain activation. This technology could therefore play a significant role in national security applications that seek to alter a person's brain state that may impact behavior. For example, stimulation could be used to alter a person's social behavior or attitudes (Knoch et al. 2006, as discussed later in text), which could be helpful in interrogations, or brain stimulation could be used to improve cognition in sleep-deprived soldiers (discussed in the following text).

TMS and tDCS take advantage of different electromagnetic principles to noninvasively influence neural activity. TMS (Walsh and Pascual-Leone 2003) uses rapidly alternating magnetic fields in a hand-held coil that is positioned over the subject's scalp (i.e., no skin or direct brain contact is necessary and no electrical current is directly applied to the body surface). The magnetic field passes through the skull and into the brain where it induces small currents in the cortex that can affect neural processing during a task. Although the brain region underneath the coil receives the strongest stimulation, the effects of the TMS are not limited to this targeted region. Other connected brain regions may also be affected and may perhaps even be more critical to any observed behavioral changes than the targeted region itself. The interpretation of TMS data should therefore be conducted with cognizance of these caveats. The focality of the effects is determined by the geometry of the TMS coil employed. Of presently available coils, small 8-shaped coils provide the most focal stimulation, with a spatial resolution of approximately 5 mm. Each TMS pulse is extremely brief and affects the targeted brain cortex for a few tens of milliseconds. Therefore, TMS offers very good spatial and temporal resolution for cognitive neuroscience studies (Pascual-Leone et al. 2000). Because the brain itself has no pain receptors, TMS can be administered easily in an outpatient setting, although certain safety guidelines should be followed to minimize the risk of adverse effects, particularly of inducing unintended seizures (Machii et al. 2006). Seizures can be induced in individuals who have a history of epilepsy, who are taking medications that alter cortical excitability, or who are exposed to long-duration trains of TMS pulses at high frequencies (Wassermann 1998). TMS provides a valuable tool for 1) interventional neurophysiology applications, modulating brain activity in a specific, distributed brain network to manipulate behavior, as well as for 2) focal neuropharmacology delivery, through the release of neurotransmitters in specific networks and the induction of focal gene expression, both of which may yield specific behavioral impact (Walsh and Pascual-Leone 2003). Depending on the TMS stimulation parameters, activation in the cortex can be increased or reduced. In practice, TMS can influence (either improve or diminish, depending on the parameters and target region) many brain functions, including directing physical movement, visual perception, memory, reaction time, speech and mood (George and Belmaker 2000; Grafman 2000; Pascual-Leone et al. 2002; Walsh and Pascual-Leone 2003).

tDCS works differently from TMS. During tDCS, low amplitude direct currents are applied via scalp electrodes and penetrate the skull to enter the brain. Although the currents applied do not necessarily elicit action potentials, they can still influence the level of excitability of individual neurons. Currently, DC stimulation is applied with a constant current source attached via patch electrodes (surface areas from 25 to 35 mm^2) to the scalp surface. Currents usually range in magnitude from a constant 0.5 to 2 mA, and are applied from seconds to minutes. The electrodes can be simple saline-soaked cotton pads or specifically designed sponge patches covered with conductive gel. There is no complex circuitry comprising the stimulators, and in its simplest form a DC source is placed in series with the scalp electrodes and a potentiometer to adjust for constant current.

CURRENT WORK RELEVANT TO NATIONAL SECURITY

Current work using the technologies previously described could become relevant to national security in the near future (for a more comprehensive overview of these and other technologies that could be used to enhance national security, see Moreno 2006). This article outlines different scenarios for the application of each of these technologies, based on their current validity and the availability of peer-reviewed public data.

Background Checks and Security Clearances

As previously noted, some brain imaging technologies, such as fMRI and PET, are quite expensive and require highly-trained staff and extensive support facilities. A likely scenario for use of these technologies is therefore in a stationary central facility (versus placement across many field offices or on the battlefield). Such a facility may be charged with conducting routine background checks of individuals who seek some form of governmental security clearance and are therefore motivated to comply with task instructions. In this scenario, a reliable method for detecting deception could have enormous value in national security. "Lie detectors" have been used since the development of the polygraph more than 80 years ago, but, as a panel of the National Academy of Sciences (Washington, DC) concluded, polygraph tests lack evidence to justify their use in this kind of screening (Committee to Review the Scientific Evidence on the Polygraph 2003). Newer methods of lie detection are under development, using neuroimaging techniques to look for patterns of brain activity correlated with deception.

A recent set of studies using functional neuroimaging has focused on the detection of brain activity associated with deception (Davatzikos et al. 2005; Kozel et al. 2004; Kozel et al. 2005; Langleben et al. 2005; Montague et al. 2002; Phan et al. 2005). In most standard laboratory settings, volunteer subjects are scanned after they are instructed to make either truthful or deceptive responses to questions (e.g., Kozel et al. 2005). Data analyses for the group as a whole show greater activations in brain regions associated with working memory and executive control of cognitive resources during lies than during truthful responses (suggesting that it is perhaps more work for the brain to lie than to tell the truth). However, there are large individual variations in the size and degree of activation areas and in the location of activated sites, which limit the ability to make strong predictions for any single person. These individual differences may be caused by statistical noise and thus may be minimized with improved experimental designs in the future, or these differences may be caused by some underlying inter-subject variability, such as brain morphology, motivation, training, mood state, personality, or some unknown variable. Newer work is now focusing on improving the accuracy of detecting deceptive behavior from individual subjects (DuRousseau 2003; Langleben et al. 2005).

The existing data are still very preliminary. For example, these methods have not yet been tested on large and diverse groups of subjects. They have not been tested in real world situations versus very artificial experimental settings. There is a lack of published research regarding possible countermeasures (as discussed later in text). Furthermore, current research on deception tends to use healthy subjects without a history of mental illness or criminal activity. It is unknown whether the brain mechanisms of deception in these individuals generalize to other populations.[5] Considering these serious limitations, there is currently insufficient evidence that these technologies are reliable, and yet one firm, No Lie MRI, is currently marketing fMRI-based lie detection, and another, CEPHOS Corporation (Pepperell, MA) is planning to enter the market soon.

Interrogations and Countermeasures

Compared with fMRI and PET, the lesser cost, ease-of-use, and space requirements of EEG or NIRS make these technologies potentially useful in a field office, a temporary installation, or perhaps even on the battlefield. They might therefore be useful in the interrogation of enemy soldiers or individuals suspected of terrorist activities.

If a suspect is believed to have committed an attack against the United States, he or she may have "guilty knowledge" of the details of that attack that an innocent person would not posses. In this scenario, an interrogation protocol known as the *guilty knowledge test* (GKT) may be useful. One highly touted method measures a pattern called an event-related potential (ERP), specifically the P300 wave, which is characteristically expressed when the brain responds to a familiar stimulus. ERP is measured via electrodes placed on the surface of the scalp, similar to EEG. The GKT works by presenting three types of visual stimuli to suspects: 1) *the probe*, a picture that is known to be familiar to the suspect, such as a family member or famous actor; 2) *the distracter*, a picture that are unfamiliar and irrelevant to the crime, such as a room or items the person has never seen; and 3) *the target*, a picture that is specific to the crime scene, such as the room where the crime took place or other details the perpetrator would have seen. Then, only a person with guilty knowledge would exhibit a corresponding P300 in response to the last stimulus. The drawback of this approach is that it requires the interrogator to have extensive knowledge of the crime (in this case, unique information about the attack) and a stimulus set that is uniquely familiar to the perpetrator. This approach may therefore not be useful for scenarios in which the interrogator does not have unique attack information or in which the suspect may have an innocent reason for having the knowledge (for example, having seen a news photograph of a terrorist leader; again, the difficulty here is to find a stimulus that is *uniquely* known to the perpetrator).

As noted previously, a very significant limitation of the work on lie detection is the lack of published research regarding the efficacy of possible countermeasures. Under real world conditions, such as during an interrogation, the suspect may use any number of countermeasures. Failing to follow task instructions would render the GKT or the fMRI scan meaningless. In an MRI, simply rolling the eyes around or continuously moving the head during the test would completely invalidate the result. Other countermeasures may be mental or physical in nature and include actions such as counting backwards by a small number, silently rehearsing a memorized story, curling the toes, or alternately tightening and relaxing the sphincter. All these methods work to redirect the examinee's mental focus away from the interrogation questions and have been shown to be quite successful at fooling the interrogator (Honts and Kircher 1994). To begin to address the problem of countermeasures, Human Bionics, LLC (Purcellville, VA), has developed a system known as the *Malicious Intent Detection System* (MINDS), which uses a GKT protocol similar to existing approaches but also monitors the examinee's electrophysiology to detect when countermeasures are used during the interrogation. The mere act of using countermeasures during interrogation is a strong indication of malicious intent.

5. Indeed, we already know that the brains of violent psychopathic individuals respond differently to emotional stimuli, compared with controls (Birbaumer et al. 2005; Blair 2003; Dolan 2002; Kiehl 2001; Veit et al. 2002).

A significant limitation remains that there is little published peer-reviewed research on the P-300 GTK test. Yet, one firm is already marketing deception testing using ERP detection of P-300 signals (Brain Fingerprinting Laboratories [Seattle, WA]), and claims that "the system has been extremely accurate in all studies, field tests, and actual cases conducted at the Federal Bureau of Investigation, a US intelligence agency, the police departments and with other organizations and individuals" (available at http://www.brainwavescience.com/research.php, accessed February 27, 2006). In the absence of peer-reviewed open-access data, these claims are impossible to verify.

Augmented Cognition

Improving the mental functioning of military, intelligence, or homeland security personnel—whether at ground level or the highest levels of government—could also improve national security. DARPA's Augmented Cognition (AugCog) Program seeks to find new ways to assess the brain and respond to variability in a human's cognitive status while he or she performs complex real world tasks (Marshall 2005; Mathan and Dorneich 2005; Moreno 2006). For example, one could use noninvasive brain imaging methods (such as EEG or NIRS) to obtain an accurate read of a soldier's level of alertness, and this information could be sent to a computer that regulates the amount of information presented to the soldier or activates a process to restore alertness if needed (Moreno 2006).

DARPA's AugCog program has led to the development of several artifact removal and mitigation strategies that now allow the use of real-time systems with capability for attentional queuing and redirection of cognitive resources using auditory, graphic, and somatosensory stimuli (DuRousseau et al. 2005). AugCog has already developed a number of civilian applications. For example, in a learning scenario during which a student becomes drowsy, a tactile stimulation device can be used to cue the individual that important information is being sent, or, alternatively, information flow stops and a video clip of a comedian might play for a few minutes to change the arousal state and improve performance (Berka et al. 2005; Mathan and Dorneich 2005). Further research using reliable EEG indices of cognitive function at the individual level has been presented by Connolly and D'Arcy (2000) for measuring language comprehension in adults and children, by Jung et al. (1997) for measuring alertness, and by Thatcher et al. (2005) for using quantitative EEG to accurately predict performance on intelligence tests. With the help of AugCog, EEG-based cognitive assessment methods and multimodal mitigation strategies have shown that performance improvements of more than 200% are possible during complicated military training exercises (Bruns et al. 2005; Scalf et al. 2005).

Portable brain imaging technologies could be combined with portable brain stimulation technology to enhance cognitive ability (Theoret et al. 2003). For example, TMS has been shown to improve learning (Grafman and Wassermann 1999; Pascual-Leone et al. 1999) and attention (Chambers et al. 2006; Hilgetag et al. 2001). Depending on the stimulation parameters, TMS and tDCS could enhance or suppress the activity in the targeted brain region and thus modulate activity throughout a distributed network of cortical and subcortical structures, ultimately leading to transient behavioral modification (Theoret et al. 2003).

Social Behavior

In addition to enhancing cognitive function, noninvasive brain stimulation techniques could also be of potential use in altering social behavior. For example, by changing brain states associated with hostility, trust, empathy, or cooperation, TMS and other neurotechnologies[6] could be used to improve the social relationship between interrogators and suspected terrorists (ethical considerations are discussed later in text). Of course, we have been manipulating the behavior of others for the whole of our evolution as social animals. At an individual level in our interpersonal relations, we manipulate each other's wishes, patience, value judgments, and beliefs with our attitudes and communication. The question is whether TMS (or tDCS) offers the promise (and the potential danger) of more guided, selective, and effective means of manipulation.

One study has recently shown that TMS can alter social behavior in response to perceived unfairness (Knoch et al. 2006). The study was based on the so-called *Ultimatum Game*, in which one player ("A") is given a certain amount of money and has the option to share any portion of it with a second player ("B"). If B accepts the offer, each gets the assigned money. If B refuses the offer, neither gets any money. Although classic economic theory predicts that B should accept any money offered to him (even a little money is better than none), in practice most players will rather refuse an offer that is perceived to be unfair. In essence, they will prefer to punish player A's unfair behavior, even if it hurts their economic self-interest. Knoch et al. (2006) directed TMS at a specific brain region (the right dorsolateral prefrontal cortex [DLPFC]) and showed that its application substantially reduced subjects' willingness to reject their partners' intentionally unfair offers. The finding suggests that following TMS stimulation of the right DLPFC, subjects are less able to resist the economic temptation to accept these offers. Importantly, these same subjects still judge such offers as very unfair, which indicates that the right DLPFC plays a key role in the implementation of fairness-related behaviors.

If TMS can be used to alter such complex social decision-making processes, then it may be possible to use it to alter a host of other social behaviors. Results in ongoing studies suggest that if TMS or tDCS are used to increase, rather than suppress activity in the right DLPFC, the modulation of behavior can be opposite, with subjects rejecting most offers

6. There are other means to alter social behavior, for instance vasopressin and oxytocin both affect social behavior (e.g., Depue and Morrone-Strupinsky, 2005; Insel and Young 2001; Keverne and Curley 2004; Kirsch et al. 2005; Kosfeld et al. 2005; Storm and Tecott, 2005).

in the Ultimatum Game (even those they judge relatively fair) and displaying similarly unselfish behaviors in other decision-making games. However, the current state of the science is still very preliminary, and rushed application in real-world conditions would be inappropriate; the test subject population has been limited, as has the nature of the social interactions examined. Furthermore, most of the beneficial effects of TMS or tDCS are short-lived, and a great deal of work remains to be done to test their interaction with behavioral and pharmacological interventions. Importantly, the brain is not very good at being passive and the effects of noninvasive brain stimulation critically depend on the state of activation of the brain at the time of that stimulation. Thus it is critical to understand the integrated nature of brain function while having the goal of achieving specific and controlled behavioral effects. The challenge is to find the optimal brain state for the behavioral and physiological interventions intended to achieve a given impact. Towards this aim, combination of TMS or tDCS with other brain imaging techniques (e.g. EEG or fMRI) might be necessary. There are also obvious ethical considerations, as discussed later in text.

NEUROETHICS CHALLENGES

Neuroethics is concerned with the ethical, legal and social policy implications of neuroscience (Illes 2006; Illes and Bird 2006). This broad perspective identifies numerous challenges to the ethical application of neuroscience to national security. It is worth repeating here that the conference participants concurred that much of what is known in neuroscience is, in fact, not ready for application to many national security operations, and that prevention of inappropriate application of neuroscience to national security is as important as highlighting its potential usefulness. In addition to these scientific challenges, there are also significant ethical and legal challenges, as well as a concern for the need to engage the general public.

Scientific Challenges

As we reiterated throughout the previous sections, one key scientific challenge is the preliminary nature of the existing data. The research described has been conducted in artificial laboratory environments.[7] Clearly, there are issues of *relevance*: assessment of the relevance of neuroscience capabilities to national security will require further investigations with variation in experimental design, subject characteristics, and situational variables (including more extreme levels of motivation, stress, and jeopardy).

There also are issues of *application*: the conference identified significant gaps that must be addressed before the methods, tools and principles of neuroscience can be usefully applied to problems faced within the domain of national security. These gaps include: 1) the lack of standardized research methodologies for most of the applications reviewed in this conference; 2) the preponderance of a small number of studies, using small samples, for many methods and tools that might be of use; 3) study designs that assume experimental control over stimulus conditions, subject selection, and participant cooperation that may not exist in field applications; and 4) participants who may not be representative of subjects encountered in operational situations. A field experimental approach (Morgan et al. 2000; Morgan et al. 2001; Morgan et al. 2006) is one way to address some of these challenges, and the model of the scientist working in conjunction with field operatives on a problem of mutual interest—with the engagement of appropriate legal and ethical expertise—is one that will allow for many of these issues to be worked out.

Ethical Challenges

Our overview of some potential applications highlights several ethical concerns. For example, use of neuroimaging technologies in lie detection (be it in the context of routine background checks or interrogations of terrorist suspects) raises ethical concerns about privacy, in addition to its technical limitations (Wolpe et al. 2005). Use of systems designed to augment cognition raises ethical concerns about self and personhood (Chatterjee 2004; Dees 2004; Farah et al. 2004; Illes and Racine 2005). Use of TMS or chemical agents to alter behavior raises ethical concerns about free will, autonomy, and agency (Dees 2004; Farah 2004; Farah et al. 2004; Fuchs 2006).

With such a wide range of ethical concerns, how can one develop a heuristic for ethical application development? In one respect, many of the issues in neuroethics and national security can probably be tackled (morally speaking) using the traditional tools of ethical analysis plied in the military ethics trade. For instance, just war theory has proven to be a useful—although perhaps neither comprehensive nor consistent—tool for analyzing moral issues in warfare. Traditionally, just war theory is divided into *jus ad bellum* (justice before the conflict), *jus in bello* (justice in the conflict) and *jus post bellum* (justice after the conflict), with the third area being the most neglected of the trio. *Jus ad bellum* would have us ask when we can justifiably go to war by, for example, reminding us that war ought to be a proportional act of last resort, declared by a proper authority, with the right intentions and the ultimate aim of peace, among other things. *Jus in bello* emphasizes that our actions while waging war ought to produce more good than harm and be directed only (or at least only intentionally) against combatants. *Jus post bellum* reminds us of our obligations towards reconstruction and reconciliation when reestablishing the peace (see Johnson 2001 for discussion of all three). These tools have developed out of a long tradition of ethical consideration that itself emphasizes the familiar approaches to ethics of utilitarianism (producing the greatest happiness for the greatest number), deontology (respecting rights and duties) and virtue theory

7. A notable exception is the work of Andrew Morgan, who has conducted physiological studies of soldiers as they experience survival training in the military (Morgan et al. 2000; Morgan et al. 2001; Morgan et al. 2006).

(being good people as we do these things) (see Casebeer 2003).

While the traditional tools of ethical analysis will continue to be useful, the neuroethics and national security challenge does complicate things considerably and may push these tools to their breaking point unless they are intelligently rebuilt. Consider, for instance, the distinction between combatant and noncombatant. This is a basic distinction of critical importance for the use of violence as a means to resolve conflict: we have very different obligations to civilians versus combatants on a battlefield. In the past, determining who was a combatant was very difficult, but the presence of uniforms and other markers of combatant status at least helped. But, to use a homely example, consider a world in which fMRI at a distance enables us to detect malevolent intention (not that anything like this is remotely possible anytime soon): suddenly, we are able to detect the pacifist in the midst of the enemy lines, fighting only because she is coerced (and, let us suppose, she is not truly fighting as she is firing above our heads). What are we to do now? Issues that have always been complicated become even more so in light of how neuroscience advances could revolutionize our understanding of such things as malevolent intention, possibly imposing new moral obligations on us and at the very least giving us pause regarding whether traditional distinctions can be so easily held.

Legal Challenges

The legal questions raised by some of these methods are themselves quite complex. The application of both the United States Constitution and international law to some national security issues has been controversial in recent years. The use of novel methods from neuroscience will raise a whole different set of controversies under those and other legal regimes about privacy, voluntariness, and government power. The use of reliable lie detection by the United States government, for example, would raise thus far unanswered legal questions under at least the First, Fourth, Fifth, Sixth, and Eighth Amendments to the Constitution (Greely 2004), as well as similarly difficult questions under international law, including the Law of War (Odeshoo 2004). In the normal course of affairs, the legal system would not deal with those questions until the technologies were in use; where development of the technologies may involve long and expensive processes, this may be too late.

The American legal system also lacks any good method for regulating these technologies. There is no regulatory body that has both the jurisdiction and the expertise to help us to determine whether these technologies are "safe and effective," as the United States Food and Drug Administration does for new drugs and medical devices, and to determine the conditions under which even safe and effective methods should be used.

Public Concerns

Given the attacks on September 11, 2001, and military operations in Afghanistan and Iraq, the public is well aware of a heightened threat of terrorism.[8] As a consequence, the public has generally accepted inconvenience and increased government intrusion in areas that are clearly linked to the perceived threat. For example, the 9/11 plot involved the use of commercial airplanes as weapons; thus, air travelers have adjusted to the need for more intensive passenger screening. There is a willingness to provide fingerprints, iris scans, and other biometric data to obtain a more secure form of identification, such as a passport, since the 9/11 perpetrators exposed weaknesses in the existing border security and immigration system.

However, the public has demonstrated increased concern as government action begins to conflict with personal privacy and individual choice. The traveling public has reacted negatively to the use of x-ray technology at airport checkpoints that can "see" beneath clothing. It is intolerant of terrorism watch lists that yield high false positives (without a system that allows law-abiding victims to be easily removed from information databases). Resistance becomes acute if security measures appear more onerous than the threat itself. Despite the still unresolved 2001 anthrax letters addressed to members of the Congress and news media, even medical professionals widely rejected government and employer mandates regarding the anthrax vaccine.

To further illustrate the importance of public acceptance in national security initiative, consider the fate of DARPA's "Total Information Awareness" (TIA) program, later changed to "Terror Information Awareness." In 2002, the Director of DARPA's Information Awareness Office, retired Admiral John Poindexter (formerly President Ronald Reagan's National Security Advisor), was seeking to uncover terrorists by analyzing large amounts of information; the hope was that the United States would be able to detect and monitor terrorist activities using novel methods of pattern detection as applied to both public and private databases. When the program's content was revealed, public outcry— driven primarily by concerns about privacy and civil liberty—led to congressional action to cancel funding for TIA as such (Cable News Network 2003; USA Today 2003). One of the more controversial components of TIA was the Futures Markets Applied to Prediction (FutureMAP) program which would have established a futures market in terrorist acts, encouraging investors to bet small amounts of money on whether a terrorist act was going to take place. This program would use a preliminary $8 million budget to establish a market in the prediction of terrorism, but was cancelled owing to moral concerns that it encouraged people to profit from the deaths of others and may have even encouraged terrorism. While reasonable people can disagree regarding whether TIA and FutureMAP were praiseworthy ideas, the fact that they did not survive public discussion

[8]While we focus primarily on the United States, we should keep in mind that ethical norms and sensitivities can vary greatly across cultures. For example, Paladin (1998) discussed neuroethics in the context of Islamic culture; Fukushi et al. (2006) discussed the role of neuroethics in Japan; and Illes et al. (2005) discussed the need to engage the international public in public debates on neuroethics.

—especially when that discussion was mostly about ethical and moral concerns—should highlight the need for informed and critical discussion about the ethical issues surrounding the application of the neurosciences to national security.

As potential neuroscience applications related to national security emerge, high public skepticism should be anticipated and must be thoroughly and thoughtfully addressed. Public acceptance of new innovation that, for example, suggests the capability to detect malicious intent and shape behavior will depend on perceptions of the urgency of the threat and the demonstrated relevance of the neuroscience application to national security. Constitutional issues notwithstanding, the public may understand the need for the Central Intelligence Agency under limited circumstances to remotely interrogate an individual to identify suspected terrorists. The same cannot be said of the Internal Revenue Service.

A NEED FOR PARTNERSHIP

Among the many challenges to the application in neuroscience tools for national security, a central one is the (currently limited) partnership between neuroscientists and government officials. In one regard, there is a lack of neuroscience expertise at high levels of decision-makers and policy-makers in Washington; the norm is for these individuals to be engineers, physicists, and attorneys.[9] In another regard, there is the frequent unwillingness of the scientific community itself to engage in dialogue with people who work in defense and intelligence agencies, out of the belief that working with such individuals promotes a political agenda that is perceived as misguided, wrong or even dangerous. The "disillusionment" of the academic community, encountered by many during their own training on campuses that turned away defense funding during the Vietnam War, unfortunately will not serve to help the misapplication of tools and techniques.

The fact that neuroscience may not yet be ready for application to national security does not mean that the neuroscience community should not be engaged in the development of the partnership of science and operations. Similar to behavioral and social sciences, neuroscience is vulnerable to the inappropriate application of tools to problems (for example, the use of particular voice stress analysis devices in field operations without evidence of their validity or utility) that may result in harm, to both the progress of the science but more importantly, to those whose lives might depend on successful deployment. The appropriate application—and the appropriate resistance to application—requires the full engagement of an expertise that resides only within the scientific community (Kitcher 2003).

A partnership of science and national security practitioners will encounter significant challenges, but none that are insurmountable—in fact, several of these already exist in industry and medicine. These challenges include: 1) training and evaluation of practices of institutional review boards to appropriately protect study participants while allowing for important research to be conducted; 2) setting up the necessary infrastructure to protect the privacy and confidentiality of study participants; this may be of special concern when incarcerated persons are study participants, and information acquired in the course of a study might be vulnerable to acquisition by a court or legal system that might want to use the information against the study participant; 3) ownership of the information acquired, especially when the study topics impinge on areas or persons of interest to the government so that there is a perceived need within the government to classify information; 4) the likelihood that the scientist will be required to acquire security clearances that will then make it impossible for him or her to share the findings with colleagues in unclassified settings; and 5) how to provide peer review of the work done. Many of these issues are related, of course. The view of the participants at the conference was that the latter issues are especially significant, because good science serving national security interests cannot be conducted in the absence of open discussion and review.

The partnership between scientists and governmental policy-makers needs to also be expanded to include ethicists. This is critical because the ramifications of neuroscience research are not limited to the brain as an organ, but also concern the human mind, and with it a host of ethically-complex themes such as agency and free will that we only touched on briefly in this article. What is needed is a three-way partnership between individuals with expert understanding of issues related to neuroscience, ethics, and national security. The potential for ethical use of neuroscience in defense of national security is there, but its implementation cannot be accomplished without the concerted efforts and participation of each of these groups.

9. One exception here is Dr. Kathy Olsen, a neuroscientist who was Science Director of the Office of Science and Technology Policy (Washington, DC) and now is Deputy Director of the National Science Foundation (Arlington, VA).

REFERENCES

Adolphs, R., D. Tranel, and A. R. Damasio, 1998. The human amygdala in social judgment. *Nature* 393(6684): 470–474.

Aine, C. J. 1995. A conceptual overview and critique of functional neuroimaging techniques in humans: I. MRI/FMRI and PET. *Critical Reviews in Neurobiology* 9(2–3): 229–309.

Anderson, S. W., A. Bechara, H. Damasio, et al. 1999. Impairment of social and moral behavior related to early damage in human prefrontal cortex. *Nature Neuroscience* 2(11): 1032–1037.

Aron, A., H. Fisher, D. J. Mashek, et al. 2005. Reward, motivation, and emotion systems associated with early-stage intense romantic love. *Journal of Neurophysiology* 94(1): 327–337.

Avenanti, A., D. Bueti, G. Galati, et al. 2005. Transcranial magnetic stimulation highlights the sensorimotor side of empathy for pain. *Nature Neuroscience* 8(7): 955–960.

Avenanti, A., I. M. Paluello, I. Bufalari, et al. 2006. Stimulus-driven modulation of motor-evoked potentials during observation of others' pain. *Neuroimage* 32(1): 316–324.

Bartels, A. and S. Zeki. 2000. The neural basis of romantic love. *Neuroreport* 11(17): 3829–3834.

Berka, C., D. J. Levendowski, P. Westbrook, et al. 2005. Implementation of a closed-loop real-time EEG-based drowsiness detection system: effects of feedback alarms on performance in a driving simulator, 85–95. *Proceedings of the 1st International Conference on Augmented Cognition*. Lawrence Erlbaum Associates, Inc.

Birbaumer, N., R. Veit, M. Lotze, et al. 2005. Deficient fear conditioning in psychopathy: a functional magnetic resonance imaging study. *Archives of General Psychiatry* 62(7): 799–805.

Blair, R. J. 2003. Neurobiological basis of psychopathy. *British Journal of Psychiatry* 182:5–7.

Bruns, A., K. Hagemann, M. Schrauf, et al. 2005. EEG- and context-based cognitive-state classifications lead to improved cognitive performance while driving, 53–67. *Proceedings of the 1st International Conference on Augmented Cognition.* Lawrence Erlbaum Associates, Inc.

Cable News Network. 2003, July 29. Amid furor, Pentagon kills terrorism futures market. Atlanta, GA: Cable News Network. Available at http://www.cnn.com/2003/allpolitics/07/29/terror.market/

Cacioppo, J. T., G. G. Berntson, R. Adolphs, et al., eds. 2002. *Foundations in Social Neuroscience*. Cambridge, MA: MIT Press.

Cacioppo, J. T., P. S. Visser, C. L. Pickett, et al., eds. 2006. *Social neuroscience: people thinking about thinking people*. Social Neuroscience Series. Cambridge, MA: The MIT Press.

Canli, T., H. Sivers, S. L. Whitfield, et al. 2002. Amygdala response to happy faces as a function of extraversion. *Science* 296 (June 21): 2191.

Canli, T., Z. Zhao, J. E. Desmond, et al. 2001. An fMRI study of personality influences on brain reactivity to emotional stimuli. *Behavioral Neuroscience* 115(1): 33–42.

Carr, L., M. Iacoboni, M. C. Dubeau, et al. 2003. Neural mechanisms of empathy in humans: a relay from neural systems for imitation to limbic areas. *Proceedings of the National Academy of Sciences USA* 100(9): 5497–5502.

Casebeer, W. D. 2003. *Natural ethical facts: evolution, connnectionism, and moral cognition*. Cambridge, MA: MIT Press.

Chambers, C. D., M. G. Stokes, N. E. Janko, et al. 2006. Enhancement of visual selection during transient disruption of parietal cortex. *Brain Research* 1097(1): 149–155.

Chatterjee, A. 2004. Cosmetic neurology: the controversy over enhancing movement, mentation, and mood. *Neurology* 63(6): 968–974.

Committee to Review the Scientific Evidence on the Polygraph. 2003. *The polygraph and lie detection*. Washington, D.C.: The National Academies Press.

Connolly, J., and R. D'Arcy 2000. Innovations in neuropsychological assessment using event-related brain potentials. *International Journal of Psychophysiology* 37: 31–47.

Daes, E.-I. A. 1990. *Freedom of the individual under law: an analysis of article 29 of the Universal Declaration of Human Rights*. (No. Sales No. E89 XIVS) New York, NY: United Nations Publication.

Davatzikos, C., K. Ruparel, Y. Fan, et al. 2005. Classifying spatial patterns of brain activity with machine learning methods: Application to lie detection. *Neuroimage* 28(3): 663–668.

Davidson, R. J., K. R. Scherer, and H. H. Goldsmith, eds. 2003. *Handbook of affective sciences*. Series in Affective Science. Oxford, UK: Oxford University Press.

Dees, R. H. 2004. Slippery slopes, wonder drugs, and cosmetic neurology: the neuroethics of enhancement. *Neurology* 63(6): 951–952.

Depue, R. A., and J. V. Morrone-Strupinsky. 2005. A neurobehavioral model of affiliative bonding: implications for conceptualizing a human trait of affiliation. *Behavioral and Brain Sciences* 28(3): 313–350; discussion 350–395.

Dolan, M. 2002. What neuroimaging tells us about psychopathic disorders. *Hospital Medicine* 63(6): 337–340.

DuRousseau, D. 2004. fMRI compatible electrode and electrode placement techniques. U.S. Patent Number 6,708,051, Patent date: March 16, 2004.

DuRousseau, D. R. 2003. Intelligent deception verification system. Utility Patent Application Number: 10/736,490, Submitted: Dec 15, 2003, Pub. No: US 2004/0143170A1, Pub. Date: Jul 22, 2004.

DuRousseau, D. R., M. A. Mannucci, and J. P. Stanley. 2005. Will augmented cognition improve training results? *Proceedings of the 1st International Conference on Augmented Cognition*. Lawrence Erlbaum Associates, Inc.

Farah, M. J. 2004. Neuroethics: A guide for the perplexed. *Cerebrum* 6(4): 29–38.

Farah, M. J., J. Illes, R. Cook-Deegan, et al. 2004. Neurocognitive enhancement: what can we do and what should we do? *Nature Reviews Neuroscience* 5(5): 421–425.

Fischer, H., G. Wik, and M. Fredrickson. 1997. Extraversion, neuroticism and brain function: A PET study of personality. *Personality and Individual Differences* 23(2): 345–352.

Friston, K. J. 2005. Models of brain function in neuroimaging. *Annual Review of Psychology* 56(1): 57–87.

Fuchs, T. 2006. Ethical issues in neuroscience. *Current Opinion in Psychiatry* 19(6): 600–607.

Fukushi, T., O. Sakura, and H. Koizumi. 2007. Ethical considerations of neuroscience research: The perspectives on neuroethics in Japan. *Journal of Neuroscience Research* 57(1): 10–16.

Gazzaniga, M. S., E. Bizzi, I. B. Black, et al., eds. 2000. *The new cognitive neurosciences*. Cambridge, MA: The MIT Press.

George, M. S., and R. H. Belmaker, eds. 2000. *Transcranial magnetic stimulation in neuropsychiatry*. Washington, DC: American Psychiatric Press, Inc.

Grafman, J. 2000. TMS as a primary brain mapping tool. In *Transcranial magnetic stimulation in neuropsychiatry*. H. Belmaker, and M. S. George, eds., 115–140. Washington, DC: American Psychiatric Press.

Grafman, J., and E. Wassermann. 1999. Transcranial magnetic stimulation can measure and modulate learning and memory. *Neuropsychologia* 37(2): 159–167.

Greely, H. 2004. Prediction, litigation, privacy, and property: Some possible legal and social implications of advances in neuroscience. In *Neuroscience and the law: brain, mind, and the scales of justice*. B. Garland, ed., 114–156. New York, NY: Dana Press.

Greene, J. D., R. B. Sommerville, L. E. Nystrom, et al. 2001. An fMRI investigation of emotional engagement in moral judgment. *Science* 293(5537): 2105–2108.

Hilgetag, C. C., H. Theoret, and A. Pascual-Leone. 2001. Enhanced visual spatial attention ipsilateral to rTMS-induced 'virtual lesions' of human parietal cortex. *Nature Neuroscience* 4(9): 953–957.

Honts, C. R. and J. C. Kircher. 1994. Mental and physical countermeasures reduce the accuracy of polygraph tests. *Journal of Applied Psychology* 79(2): 252–259.

Horwitz, B., and D. Poeppel. 2002. How can EEG/MEG and fMRI/PET data be combined? *Human Brain Mapping* 17(1): 1–3.

Illes, J., ed. 2006. *Neuroethics: Defining the issues in theory, practice, and policy*. Oxford, UK: Oxford University Press.

Illes, J., and S. J. Bird. 2006. Neuroethics: A modern context for ethics in neuroscience. *Trends in Neurosciences* 29(9): 511–517.

Illes, J., C. Blakemore, M. G. Hansson, et al. 2005. Science and society: International perspectives on engaging the public in neuroethics. *Nature Reviews Neuroscience* 6(12): 977–982.

Illes, J., and E. Racine. 2005. Imaging or imagining? A neuroethics challenge informed by genetics. *American Journal of Bioethics* 5(2): 5–18.

Insel, T. R., and L. J. Young. 2001. The neurobiology of attachment. *Nature Reviews Neuroscience* 2(2): 129–136.

Johnson, J. T. 2001. *Morality and contemporary warfare*. New Haven, CT: Yale University Press.

Jung, T. P., S. Makeig, M. Stensmo, et al. 1997. Estimating alertness from the EEG power spectrum. *IEEE Transactions on Biomedical Engineering* 44(1): 60–69.

Kennedy, D. 2004. The arrivals of neuroethics. *Science* 306(5695): 373.

Keverne, E. B., and J. P. Curley. 2004. Vasopressin, oxytocin and social behaviour. *Current Opinion in Neurobiology* 14(6): 777–783.

Kiehl, K. A., A. M. Smith, R. D. Hare, et al. 2001. Limbic abnormalities in affective processing by criminal psychopaths as revealed by functional magnetic resonance imaging. *Biological Psychiatry* 50(9): 677–684.

King-Casas, B., D. Tomlin, C. Anen, et al. 2005. Getting to know you: Reputation and trust in a two-person economic exchange. *Science* 308(5718): 78–83.

Kirsch, P., C. Esslinger, Q. Chen, et al. 2005. Oxytocin modulates neural circuitry for social cognition and fear in humans. *Journal of Neuroscience* 25(49): 11489–11493.

Kitcher, P. 2003. *Science, truth, and democracy*. Oxford, UK: Oxford University Press.

Knoch, D., A. Pascual-Leone, K. Meyer, et al. 2006. Diminishing reciprocal fairness by disrupting the right prefrontal cortex. *Science* 314(5800): 829–832.

Kosfeld, M., M. Heinrichs, P. J. Zaks, et al. 2005. Oxytocin increases trust in humans. *Nature* 435(7042): 673–676.

Kozel, F. A., K. A. Johnson, Q. Mu, et al. 2005. Detecting deception using functional magnetic resonance imaging. *Biological Psychiatry* 58(8): 605–613.

Kozel, F. A., T. M. Padgett, and M. S. George. 2004. A replication study of the neural correlates of deception. *Behavioral Neuroscience* 118(4): 852–856.

Langleben, D. D., J. W. Loughead, W. B. Bilker, et al. 2005. Telling truth from lie in individual subjects with fast event-related fMRI. *Human Brain Mapping* 26(4): 262–272.

Machii, K., D. Cohen, C. Ramos, et al. 2006. Safety of rTMS to non-motor cortical areas in healthy participants and patients. *Clinical Neurophysiology*

Marcus, S. J., ed. 2004. *Neuroethics: Mapping the field*. Washington, D.C.: Dana Press.

Marshall, S. P. 2005. Assessing cognitive engagement and cognitive state from eye metrics. *Proceedings of the 1st International Conference on Augmented Cognition*, 23–38. Lawrence Erlbaum Associates, Inc.

Mathan, S., and M. Dorneich. 2005. Augmented tutoring enhancing simulation based training through model tracing and real-time neurophysiological sensing overview. *Proceedings of the 1st International Conference on Augmented Cognition*. Lawrence Erlbaum Associates, Inc.

McCabe, K., D. Houser, L. Ryan, et al. 2001. A functional imaging study of cooperation in two-person reciprocal exchange. *Proceedings of the National Academy of Sciences* 98(20): 11832–11835.

McClure, S. M., J. Li, D. Tomlin, et al. 2004. Neural correlates of behavioral preference for culturally familiar drinks. *Neuron* 44(2): 379–387.

Moll, J., R. de Oliveira-Souza, P. J. Eslinger, et al. 2002. The neural correlates of moral sensitivity: A functional magnetic resonance imaging investigation of basic and moral emotion. *Journal of Neuroscience* 22(7): 2730–2736.

Montague, P. R., G. S. Berns, J. D. Cohen, et al. 2002. Hyperscanning: simultaneous fMRI during linked social interactions. *Neuroimage* 16(4): 1159–1164.

Montague, R. 2006. *Why choose this book? How we make decisions*. Dutton.

Moreno, J. D. 2006. *Mind wars: Brain research and national defense*. New York, NY: Dana Press.

Morgan, C. A., 3rd, A. Doran, et al. 2006. Stress-induced deficits in working memory and visuo-constructive abilities in Special Operations soldiers. *Biological Psychiatry* 60(7): 722–729.

Morgan, C. A., 3rd, G. Hazlett, et al. 2001. Symptoms of dissociation in humans experiencing acute, uncontrollable stress: A prospective investigation. *American Journal of Psychiatry* 158(8): 1239–1247.

Morgan, C. A., 3rd, S. Wang, et al. 2000. Plasma neuropeptide-Y concentrations in humans exposed to military survival training. *Biological Psychiatry* 47(10): 902–909.

Odeshoo, J. 2004. Truth or dare? Terrorism and "truth serum" in the post-9/11 world. *Stanford Law Review* 57: 209.

Paladin, A. V. 1998. Ethics and neurology in the Islamic world. Continuity and change. *Italian Journal of Neurological Sciences* 19(4): 255–258.

Panksepp, J. 1998. Affective neuroscience: The foundations of human and animal emotions. Oxford, UK: Oxford University Press.

Pascual-Leone, A., N. J. Davey, J. Rothwell, et al., eds. 2002. *Handbook of transcranial magnetic stimulation*. London, UK: Arnold.

Pascual-Leone, A., F. Tarazona, J. Keenan, et al. 1999. Transcranial magnetic stimulation and neuroplasticity. *Neuropsychologia* 37(2): 207–217.

Pascual-Leone, A., V. Walsh, J. Rothwell, et al. 2000. Transcranial magnetic stimulation in cognitive neuroscience: virtual lesion and neurochronometry. *Current Opinion in Neurobiology* 10:232–237.

Phan, K. L., A. Magalhaes, T. J. Ziemlewićz, et al. 2005. Neural correlates of telling lies: a functional magnetic resonance imaging study at 4 Tesla. *Academic Radiology* 12(2): 164–172.

Sanfey, A. G., J. K. Rilling, J. A. Aronson, et al. 2003. The neural basis of economic decision-making in the Ultimatum Game. *Science* 300(5626): 1755–1758.

Scalf, P. E., K. I. Erickson, S. J. Colcombe, et al. 2005. Training effects on the neural circuits that support attention and multi-task performance. *Proceedings of the 1st International Conference on Augmented Cognition*, 153–156. Lawrence Erlbaum Associates, Inc.

Singer, T., S. J. Kiebel, J. S. Winston, et al. 2004a. Brain responses to the acquired moral status of faces. *Neuron* 41(4): 653–662.

Singer, T., B. Seymour, J. P. O'Doherty, et al. 2004b. Empathy for pain involves the affective but not sensory components of pain. *Science* 303(5661): 1157–1162.

Singer, T., B. Seymour, J. P. O'Doherty, et al. 2006. Empathic neural responses are modulated by the perceived fairness of others. *Nature* 439(7075): 466–469.

Stern, E. and D. A. Silbersweig. 2001 Advances in functional neuroimaging methodology for the study of brain systems underlying human neuropsychological function and dysfunction. *Journal of Clinical and Experimental Neuropsychology* 23(1): 3–18.

Storm, E. E., and L. H. Tecott 2005. Social circuits: Peptidergic regulation of mammalian social behavior. *Neuron* 47(4): 483–486.

Thatcher, R. W., D. North, C. Biver, et al. 2005. EEG and intelligence: Relations between EEG coherence, EEG phase delay and power. *Clinical Neurophysiology* 116: 2129–2141.

Theoret, H., M. Kobayashi, A. Valero-Cabre, et al. 2003. Exploring paradoxical functional facilitation with TMS. *Supplements to Clinical Neurophysiology* 56: 211–219.

Turner, R., and T. Jones. 2003. Techniques for imaging neuroscience. *British Medical Bulletin* 65: 3–20.

USA Today 2003, September 25. Pentagon's 'terror information awareness' program will end. Available at http://www.usatoday.com/news/washington/2003-09-25-pentagon-office_x.htm

van 't Wout, M., R. S. Kahn, A. G. Sanfey, et al. 2005. Repetitive transcranial magnetic stimulation over the right dorsolateral prefrontal cortex affects strategic decision-making. *Neuroreport* 16(16): 1849–1852.

Veit, R., H. Flor, M. Erb, et al. 2002. Brain circuits involved in emotional learning in antisocial behavior and social phobia in humans. *Neuroscience Letters* 328(3): 233–236.

Walsh, V., and A. Pascual-Leone. 2003. *Neurochronometrics of mind: Transcranial magnetic stimulation in cognitive science*. Cambridge, MA: MIT Press.

Wassermann, E. M. 1998. Risk and safety of repetitive transcranial magnetic stimulation: report and suggested guidelines from the International Workshop on the Safety of Repetitive Transcranial Magnetic Stimulation, June 5–7, 1996.*Electroencephalography and Clinical Neurophysiology* 108(1): 1–16.

Wassermann, E. M., B. D. Greenberg, M. B. Nguyen, et al. 2001. Motor cortex excitability correlates with an anxiety-related personality trait. *Biological Psychiatry* 50(5): 377–82.

Wolpe, P. R., K. R. Foster, and D. D. Langleben. 2005. Emerging neurotechnologies for lie-detection: Promises and perils. *American Journal of Bioethics* 5(2): 39–49.