Military Neuro-Interventions:

Solving the Right Problems for Ethical Outcomes

by Shannon E. French and Jacob A. Sandstrom

Neuro-interventions are a category of procedures that include invasive and non-invasive ways of affecting the human brain, either temporarily or permanently, in order to help reverse the negative effects of damage that affects brain activity or to enhance cognitive abilities in some way. With some exceptions, interventions for repair or rehabilitation are generally seen as ethically uncomplicated, as they are focused on restoring the individual to a previous level of function after an injury or illness. However, interventions aimed at enhancing or improving cognitive abilities in individuals who have not suffered any loss of function tend to raise more eyebrows. Repairing damage is well within the usual parameters of medical professionals' activities, while elective efforts to improve healthy people can provoke some questions, especially if the procedures in question carry their own risks. Nevertheless, various elective enhancement procedures are already common, such as Lasik eye surgery, and there are fields that have shown great interest in neuro-interventions for enhancement, rather than repair, including professional sports and the military.

Neuro-interventions for the military hold both promise and perils as a means of enhancing troop performance. On one hand, despite purported benefits, attempts to narrowly focus on *skill acquisition* may do more harm than good. Chief among these potential harms is the possibility of unintentionally subverting moral reasoning by suppressing a certain neural network, leading to a reduction in empathy and increased tendencies towards dehumanization of the self and others. On the other hand, attempts to increase more general mental *agility* using neuro-interventions, such as enhancing the ability of troops to cycle between the competing neural networks[1] involved in ethical decision-making, may actually produce a healthier balance between empathy and analytic focus on

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task completion. This could reduce the negative effects of dehumanization on troops, allowing them to function better in combat, shift between combat roles and more empathy-requiring actions (such as rendering aid or engaging with civilian populations), and experience healthier transitions after deployments.

These possible benefits are enticing, but they can be realized only if military leaders maintain necessary restraint in employing neuro-interventions in specific, strategic ways. While skill acquisition is undoubtedly an important aspect of training, those skills are of little use without the ability to make effective, ethical decisions to direct the use of those skills. Above all, no neuro-intervention procedures should be adopted that do not solve existing or emerging problems identified by commanders in the field. Adding the complications of new technology to units without solving concerns they actually experience or can clearly see on the horizon is a non-starter from an ethical leadership perspective as well as a common strategic error that ought not to be repeated.

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Developing neuro-interventions will always be a double-edged sword. While there is ample opportunity to learn about and improve cognitive function, the temptation to silo research into skill-based applications looms, if for no other reason than that such applications are easy to describe to funders. Yet rushing in that direction could be unwise. In the pages that follow, we will consider the respective merits of strict skill-based neuro-interventions and agility-based neuro-interventions as they apply to the military in the context of current governmental efforts to increase neuroplasticity.

Targeted Neuroplasticity Training

In 2016, the Biological Technologies Office of the Defense Advanced Research Projects Agency (DARPA) announced its Targeted Neuroplasticity Training (TNT) program, which seeks to "enhanc[e] cognitive skill learning in healthy adults by using noninvasive peripheral neurostimulation to promote synaptic plasticity in the brain," and "elucidate the anatomical and functional map of the underlying neural circuitry involved in regulating synaptic plasticity."[2] This program, part of DARPA's larger "BRAIN Initiative," is among a number of projects described in the public domain involving military applications of neuro-interventions. These include the Restoring Active Memory, which can aid in the formation and retrieval of memories in those with traumatic brain injuries, as well as Revolutionizing Prosthetics and HAPTIX, which develop brain-controlled prosthetics and provide naturalistic feeling respectively.[3] These generally-acceptable technologies that seek to repair neural damage stand in contrast with other, bolder projects, such as Neural Engineering System Design, which aims to "develop an implantable neural interface able to provide unprecedented signal resolution and data-transfer bandwidth between the brain and the digital world."[4] Seeking to top even Facebook's attempts to create a pseudo-hive mind on the order of the Borg Collective,[5] Neural Engineering System Design could theoretically construct a true collective intelligence, which would generate a fresh collection of ethical quandaries. Though the TNT does not seem to present such extreme consequences, we are wary that its effects could be equally troublesome, if not carefully guided, given current understandings of cognitive neuroscience and moral decision-making.

As DARPA notes, TNT is unique. Unlike previous attempts to restore lost functions, the TNT program seeks to "advance capabilities

in healthy individuals," including language acquisition and marksmanship abilities.[6] The program is divided into two phases; "deciphering" neural mechanisms to develop nerve stimulation technologies, and employing that technology in training exercises to "measure improvements in the rate and extent of learning."[7] Using neurostimulation that activates peripheral nerves, the technology is expected to increase brain plasticity—the brain's ability to adapt and change throughout life—to enhance learning. If the project is successful, it will reduce the "cost and duration of the Defense Department's extensive training regimen, while improving outcomes."[8] These appear to be agreeable goals, as a matter of policy and as a general aim for research. Yet, DARPA's focus seems to be solely on skill-based applications of neuro-interventions, which may not adequately address the real challenge facing the military: the mental agility to make decisions on when to employ particular skills (e.g. does a given moment require marksmanship or diplomacy?). Moreover, a strict skill-based focus may be actively detrimental to agility.

Opposing Neural Networks and Hard Skill Acquisition

Past empirical research indicates that human decision-making involves two competing neural networks: the empathic network, and the analytic network.[9] Because one network suppresses the other, 'good' decision-making requires the agility to cycle between the networks effectively. Since we ask our soldiers to be both highly empathic and highly analytic,[10] a neuro-intervention aimed at studying and encouraging this agility would be immensely beneficial, as it would increase 'good' decision-making as a byproduct. Additionally, improved agility would help individuals resist getting 'stuck' in one or the other neural network. This matters, because the psychological effects of the brain over-engaging either one of the networks include symptoms of depression and other negative impacts on mental health.

Skill-based improvements present a different set of byproducts. Assuming the effort is successful, an increase in skill acquisition would be the primary result. Yet, a potential secondary result is the suppression of one of the two neural networks, depending on the task at hand. In the military application, one goal of TNT is improving marksmanship, a highly analytical skill that requires intense focus, concentration, and precision. Ideally, marksmen are not only acutely aware of their target but understand—based some combination of empathic and analytic reasoning—that they are justified in targeting that individual. Yet the process of aiming and firing relies almost exclusively on calculated, analytic thinking. If the TNT program, using peripheral neural stimulation, were to improve marksmanship by suppressing the empathic neural network and amplifying the analytic neural network, we are concerned of adverse effects both of dampening empathy and of remaining in one network for extended periods of time. In terms of solving the right problems, is it a bigger concern for commanders of combat units that troops are not hitting their chosen targets, or are the real issues target selection and avoiding moral injury? Put simply, better marksmen are not truly helpful to mission success if they shoot the wrong people and/or suffer debilitating post-combat trauma. Merely making more efficient killers cannot be the goal.

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Neuroplasticity training, requiring nerve stimulation, is expected to increase the rate at which one learns. However, DARPA has explicitly noted that it will not consider contractors aiming at increasing memory

functions in the TNT project, as those are "out of scope"[11] of the endeavor. We wonder whether memory considerations should be within the scope of TNT's aims. Indeed, memory function has been featured in other BRAIN Initiative projects, but it seems particularly relevant with the development of TNT training. TNT purports that a significant amount of new learning will occur; an obvious question is whether the skills will be retained. In one potential scenario, the TNT training would be extremely effective in providing new skills in the short term, but in the long-term, participants will see a return to normal skill levels. In order to retain the skills, repeated neuro-interventions would be necessary to maintain levels found immediately post-intervention. Interventions might even need to be made on deployment. If memory is insufficient to retain the additional learned skills and recurring interventions are necessary, we question the sustainability and long-term effects of the interventions and suggest that they be considered in studies before TNT is implemented. Otherwise, the intended 'enhancements' would more likely impede mission success.

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Assuming that maintaining high levels of analytic skill requires recurring stimulation of the analytic neural network, we posit that the continued stimulation of this network could lead to decreased agility to cycle between the empathic and analytic networks with time. We recognize that this is a hefty assumption, yet the potential risks appear to justify taking this concern seriously. Recent work in neuroethics emphasizes the vital importance to ethical behavior (and ethical leadership) of being able to access equally and cycle smoothly between neural networks:

> [L]eaders [need] to actively work on achieving a dynamic balance between the perspectives offered by two opposing networks in the human brain. When this balancing act is accomplished, true ethical leadership is given an opportunity to emerge. However, when an individual privileges one perspective over the other, shows poor judgment in deploying these different perspectives, or attempts to blend the two perspectives in a way that breaches neurobiological constraints, then ethical failure become inevitable with time.[12]

Especially in the dynamic domains of modern warfare, soldiers often have to be intensely analytic one moment and empathetic the next. If the ability to cycle between networks has atrophied or is blocked, this may not be possible. As Anthony I. Jack and other researchers have shown,[13] there is also direct harm that can result from staying too long in one of the two opposed neural networks, such as depression, dissociation, and other psychiatric disorders. For healthy brain function, a balance must—and can be—obtained. Dr. Jack explains:

> [W]hile the research indicates that we cannot be both analytic and empathetic at the same time, a key feature of our neural function is that we are constantly cycling between these two networks. This natural cycling between analytic and empathetic mental modes is part of what is disrupted in individuals with mental disorders. Tasks temporarily and partially disrupt this natural cycling, pushing us more into one mode or the other for more sustained periods. However, we know that when a task is used to push healthy participants into one mode, and they are then given a task-free break, they tend to compensate by cycling deeper into the opposing mode the harder they

were pushed away from it.[14] Therefore, no absolute obstacle is presented by the mere fact that individuals are required to make use of both modes in a particular working context. In fact, provided the switching between modes is well managed, this is likely to be more healthy and sustainable, and less fatiguing, than a work environment that only calls on one of these cognitive modes. The trick is just managing the switching between modes – ensuring that one is in the appropriate cognitive mode to effectively tackle the task at hand. This requires attending to appropriate cues and the possession of a broader cognitive model that allows us to make good use of those cues.[15]

Consider this analogy: you slam a car into a gear, forcing it into one function, and you keep it in that single gear for an extended period. At first, the damage is not apparent, nor is it debilitating for the automobile. Yet, consistently forcing the car into that gear and keeping it there would cause lasting damage, such that either the transmission would be unable to shift into gear properly, or it would be unable to shift out of a particular gear. This is not to say that a five-speed transmission compares perfectly to the complex neural networks of the human brain. Yet one cannot help but question whether neuro-interventions would have a similar result when the brain attempts to "shift" between networks. One primary concern with skill-based neuro-interventions is that they appear to fall into this "gear-jamming" category of our moral decision-making "transmission." Skill-based neuro-interventions have the potential to force the brain to operate in one gear (i.e. analytic or empathic networks) while another gear (i.e. the dormant network) may be needed for sound, ethical decision making (or, most likely, the ability to cycle smoothly between networks).

The result of remaining in one network not only causes individual harm but may lead to grave societal ills. As Dr. Jack alludes to, psychopaths suffer from a distinct lack of empathy, the result of remaining in a highly analytic state and being unable to shift into the empathic neural network. Lacking this ability, psychopaths tend to externalize blame, in addition to being egocentric, fearless, coldhearted, and manipulative.[16] As a result, psychopathy can cause difficulty in forming healthy relationships with others and with society. While most individuals exhibiting psychopathic traits never cause harm to others, there have been many infamous psychopaths—serial killers, serial arsonists, and the like—who have caused massive harm because of their inability to engage the empathic neural network. Improving a skill like marksmanship beyond what normal practice can obtain through neuro-interventions is certainly not worth the cost, if it could increase the number of psychopaths in society.

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Likewise, there is danger in remaining in the empathic neural network for extended periods of time. Hyper-empathy can be equally debilitating as hyper-analytic focus, and can also cause severe strain on healthy relationships. As a result of being unable to engage the analytic network, many hyper-empathetic individuals find themselves "taking on other people's feelings" in order to "live their experience," which can be off-putting to others.[17] Moreover, this can cause lasting psychological harm to the individual, including crippling depression and anxiety. Though TNT does not seem to focus on amplifying the empathic network, we wish to underscore the risks of trauma that would arise if an intervention caused an individual

to remain in the empathetic network for an extended period of time. In the military context, this could be especially troublesome, as a hyper-empathetic individual might feel the need to take on the trauma of other troops, and be unable to make effective decisions as a result. On a more positive note, perhaps neuro-interventions could help those naturally suffering from psychopathy or hyper-empathy achieve a better balance of their neural networks and reduce the resultant societal impact.

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Soft Skills from Neuro-Interventions

We have been focusing on the potential for using neuro-interventions to improve marksmanship, which raises some red flags. As previously noted, the other main area of interest for the TNT project has been using such interventions to assist troops in more rapidly and effectively acquiring second language skills. The ability to speak other languages is most often seen as a soft skill; one that requires some level of empathetic engagement with others. At the same time, language acquisition also has analytic elements. It may be that, unlike attempts to improve marksmanship, enhancing second language acquisition skills could have a positive effect on mental agility and the ability of the subject's brain to cycle between neural networks in a healthy way.

The benefits of increasing second language acquisition among troops can been seen as much more wide-ranging than improving marksmanship. The U.S. military frequently relies on close partnerships with formal allies and civilian populations who do not speak English. Better communication could make these partnerships much more effective. Despite its fictitious nature, *Star Trek*'s Universal Translator provides a useful, analogous case. As Mark E. Lasbury notes in *The Realization of Star Trek Technologies*:

> [T]he Starship Enterprise is a place where very different individuals participate in reasoned discussion and take definitive actions. Clearly understanding each other is a matter of life and death. They each speak passionately for their preferred course of action or shout out commands that must be followed to the last syllable, yet Kirk is from Iowa and Picard from France. Mr. Scott calls Scotland home, La Forge hails from Somalia, and Ensign Sato is Japanese.[18]

Evidently, many technologies that once seemed distant and only plausible in a science fiction/fantasy setting are now nearly at our disposal. Neuro-interventions in the military that facilitate a similar common understanding as the imagined Universal Translator could be useful in joint missions, while also helping soldiers better understand the context in which they are engaged. That said, unlike in *Star Trek*, there is a question of whether such drastic saturation is practical or possible given logistical and budgetary constraints.

Another question that must be asked is whether rapid second language acquisition through neuro-intervention might have the negative unintended consequence of subverting other benefits that come from the slower-paced more traditional methods of second language learning. For instance, having to gradually immerse oneself in a new language might provide deeper understanding of the associated culture than it would be possible for anyone to achieve if neuro-stimulation of some kind were able to radically speed up that process. While this is an important question to ask, it must be

balanced against the negative consequences of fewer troops having any second language skills at all. In other words, while it might be ideal to allow troops the time to gradually acquire integrated second language skills and the associated cultural understanding, it may still be far preferable to have more troops quickly spun up to be at least able to communicate to some degree in a relevant second language than not to have that capacity at all. We certainly do not want "the perfect to be the enemy of the good," as the old expression goes.

Serving with Neuro-enhancements

Beyond the direct impact of the neuro-interventions themselves, in the military context (and beyond), we must be concerned with the effects of living and working as and with enhanced individuals. How would military units function if some members were enhanced, and others were not? How would the enhanced and unenhanced regard one another, and what impact would this have on unit cohesion? Would units with enhanced troops always require enhanced officers? What would the experience for future troops be like if some of their enhancements were temporary, or the effects of neuro-interventions ebbed and flowed during deployments? These are just a few of the questions that must be confronted before any rush to implement these procedures with serving members of the military.

If certain troops have been administered a neuro-intervention to improve skill "x," while their superiors have not, one can imagine the tension that could naturally arise. We also suspect that it would create a new power differential within individual ranks if some troops are enhanced, while others are not.[19] Alternately, there could be situations in which the superior has been administered a neuro-intervention that increases the power differential. In this situation, one would expect to see a disconnected superior who is resented by his/her subordinates. Again, the question must be asked, what problems are these neuro-interventions intended to solve? It is not at all clear that military missions are failing due to a lack of enhanced super-soldiers. On the other hand, many missions have been compromised by poor unit cohesion and bad leadership.

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Life after Neuro-enhancements

Post-Enhancement Distress Syndrome is a new term (obviously echoing Post-Traumatic Stress or Post-Traumatic Stress Disorder)[20] that was devised to cover a wide range of negative reactions that might be experienced by individuals following bioenhancements, including the type of neuro-enhancements that concern us here. Post-Enhancement Distress Syndrome can arise in a number of ways. In one scenario, a soldier is given a neuro-enhancement during active service but is not allowed to retain the enhancement (or the specific version of the enhancement) upon return to society, resulting in distress. In another, the soldier is enhanced in a way that is irreversible, such that when they return to society, they are unable to reintegrate, resulting in distress. The same can be said for military-grade prosthetics and other military technologies that dramatically alter the individual's experience of the world.

Fictionalized versions of what it is like to be enhanced (and unenhanced) have been helpfully explored in various works of fiction (especially science fiction), from Daniel Keyes' well-known short story and novel *Flowers for Algernon*, to the film "Gattaca," to the TV series "Chuck." What the creators of these works help us imagine is the trauma and alienation that being enhanced or unenhanced might provoke. It can already be difficult for combat veterans to

adjust to ordinary civilian life after the highly adrenalized experience of an active deployment. Now suppose that some veterans are given neuro-interventions that actually enhance their abilities during their service (or a particular deployment), and then they must revert to their previous, unenhanced levels of competence. The sense of loss - not only of ability, but of identity as a special person with unique capacities - could be psychologically crippling. We are calling this the Flowers for Algernon Effect. Someone suffering from the Flowers for Algernon Effect might feel tremendous depression and despair from losing abilities that made them feel special and useful.

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Would the answer be to provide the means for enhanced troops to remain enhanced after their service? That possible solution would then cause another problem, both for veterans and society in general, in that it would introduce two distinct types of humans: the enhanced and the unenhanced. We are calling this the Gattaca Effect. This, too, would build on an already existing problem; namely, that some combat veterans (or veterans in general, as well as those currently serving) at times feel alienated and apart from the society they have pledged to serve. This oft-discussed phenomenon is sometimes associated with the language of "sheep, sheepdogs, and wolves,"[21] employed by Lieutenant Colonel Dr. Dave Grossman in his book *On Killing*. Although it is by no means universal, some who fight can come to see themselves as "sheepdogs," with civilians being hapless "sheep" who need protection from deadly enemies, or "wolves." This mindset is antithetical to healthy warrior transitions post-service, and when taken to extremes can even threaten civilian control of the military. The concern with the Gattaca Effect is that having troops who are given not just specialized training and experiences but actual bioenhancements might increase their sense of detachment from (and possibility superiority over) unenhanced civilians. At the same time, unenhanced civilians might become fearful of troops and veterans with enhancements, thus pulling the civil-military gap even wider.

The TV show "Chuck" tackles both the Flowers for Algernon Effect and the Gattaca Effect, as various characters on the show experience both enhancement through neuro-interventions and the loss of those enhancements. The conclusions the writers draw might provide some insight for real-life management of these issues. For example, in playing out the thought experiment, they make a compelling case that the pre-existing character and psychology of the enhanced individual is the key to how the Flowers for Algernon Effect or the Gattaca Effect will play out for that individual and those with whom he interacts. The clear suggestion is that not everyone is suited to being enhanced, and that in order to reduce the chances of negative results, careful advanced screening would be necessary.

This is not a new thing for the military, of course. Many specialized roles require certain character types and psychological profiles. Not everyone who serves is suited to be a sniper, or a SEAL, or an intelligence officer. To avoid some of the predictable pitfalls of employing enhancements, one wise course would be to consider them only for select individuals, and not as a tool that could be given without significant and lasting negative consequences to wide swaths of service members. This would mean

that the TNT project should not aim to make all infantry better marksmen through neuro-interventions, for these reasons as well as those previously raised. Even rapid second-language acquisition might best be reserved for a limited number of people in specific roles.

Further Ethical and Legal Issues with Neuro-interventions

Since neuro-interventions are so novel, it is unclear how these technologies will integrate with existing laws, norms, and the established Just War criteria. In combat, strict skill-based enhancements appear to present greater potential for indiscriminate use unless adequate guidance is given. In the absence of an accompanying enhancement in decision-making ability, troops and leaders may use enhancements for greater harm than good. This, in turn, could lead to atrocities in war that would not have been possible otherwise. While members of the military receive training in the Law of Armed Conflict, Just War Theory, the Geneva Conventions, and are given rules and guidelines to abide by, skill-based neuro-interventions do not clearly align with most explicit, established provisions. It appears that adaptations will be necessary to accommodate these technologies as they emerge; however, as with most codes and laws, changes will take time and fine-tuning. In the interim, it is possible that troops will have to rely on their own judgment—or their superiors' judgment—of the best approximation of what is just and what is not. Are neuro-enhancements proportional? Are they discriminate enough? While not the focus of this paper, these questions require further investigation and critical examination.

The impacts of neuro-interventions are neither exclusive to the military, nor limited to one's time in active duty. Given that cognitive enhancements and neuro-interventions are becoming a subject of research (and not just a radical pipedream), it is not unreasonable to assume that there will soon be applications in society as a whole. As with most technologies of this scale and importance, it is also safe to assume there will likely be military-grade and civilian-grade forms of neuro-interventions, such as TNT. This divide is especially important when considering whether to employ skill-based neuro-interventions.

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Neuro-interventions that focus on developing particular skills, as with some other forms of voluntary bio-enhancements, can introduce additional points of failure. While technology can provide an advantage in conflict, it is not a sufficient condition to yield guaranteed success. Some technologies can, even when employed properly, be extremely clumsy and haphazard, especially when they do not easily integrate with other technologies and daily organizational practices. There is a reason that Bluetooth-enabled salt shakers are not found on every suburban kitchen table; the investment of time and effort it takes to operate the gadget does not justify the results. The amount of money spent could be used to purchase multiple conventional versions, which would still fulfill their fundamental purpose effectively. Likewise, the success of technology in the military context depends on many factors, including convenience, usability, and practicality. In combat, technological superiority is among these factors, but depending on the situation, geography, command climate, strategy, and the troops' ability to adapt to changing circumstances, it is unclear whether technological superiority is paramount. While "bringing a knife to a gunfight" is understood

as likely to yield an unfavorable outcome, pitting conventional forces against forces with neuro-interventions will not necessarily follow the same pattern. Additional technology does not equal victory, and in many instances it can introduce new vulnerabilities. There are many historical examples of the higher-tech side in an asymmetrical conflict being defeated by their low-tech opponents.[22] Claims that neuro-interventions are the best option for improving training tend to ignore the fact that many military training programs are highly effective at honing skills in a reasonable amount of time, but that programs are woefully underfunded. "Bread and butter" training may be a harder sell, but in actuality, investment in conventional training may be as or more effective as taking the neuro-intervention route, while avoiding some of the potential drawbacks of tech-driven bioenhancement.

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Thus far, we have refrained from an outright renunciation of all neuro-interventions. Yet there are a few conditions under which such programs would be justified. If the same criticisms of skill-based neuro-interventions, such as the potential for harm to troops (including Post-Enhancement Distress Syndrome) and society, was found to apply to all forms of neuro-interventions, the ethical choice for military leaders would be not to pursue neuro-interventions. Even a technology that reliably reduces the cost in terms of time and funding of essential military training is not worthwhile if it comes at a severe cost in terms of harm to troops and to their missions. By pursuing a technology that reduces the costs of training in the short-term but causes harms in the mid- to-longer term, we fall into a trap: pushing problems to the future is neither sustainable nor prudent. To that end, we further hold that with any type of neuro-intervention, if there is potential for generational or reproductive harms, the technology should not be employed until such time that the neuro-intervention is definitively proven to be safe across multiple generations.

Animal-based and twin studies about the heritability of neurological changes suggest that there is potential for DARPA's TNT program to cause lasting generational effects.[23] That is, alterations made in the brains of troops by the proposed interventions might be passed on to their offspring. If the effects of a neuro-intervention, especially one that suppresses specific networks in the brain, are generational, we hold that such an intervention is irresponsible and unethical, as it causes undue harm to future generations without consideration for their wants or needs.[24] As such, generational concerns should be given due weight in deciding whether to pursue specific neuro-interventions, regardless of the level of involvement or type of intervention. Informed consent is already fraught in the military context, but it adds another layer of complexity if troops may be "voluntold" to undergo neurological interventions that might affect the mental abilities of their unborn children.

Conclusion: Recommendations

Our goal has not been to answer all the ethical questions raised by the possible adoption of neuro-interventions by the military, but rather to raise and draw attention to some of them to highlight the fact that further discussion and analysis is required. We hope we have accomplished that aim. There is much work to be done to align new technology with the just war tradition and ensure that appropriate legal protections are in place for both military and civilian populations. While we acknowledge that skill-based neuro-interventions may lead to greater and more rapidly-acquired specialization

and skill levels within the military (which is not inherently problematic), they may disrupt current power and command structures to the point of being more trouble than they are worth. Even more worryingly, they may cause significant and lasting unintended harms, if the interventions improve a hard skill (e.g. marksmanship) at the cost of dampening empathy and other essential capacities needed for healthy social interactions. Some of these harms may not only affect active troops and mission accomplishment but could easily spread to veteran and civilian populations and further disrupt civil-military relations. We concede that, if applied equally to all service members, some neuro-interventions to enhance a limited set of softer skills (such as second language acquisition) could be more beneficial than not and raise significantly fewer concerns. However, overall, neuro-intervention directed towards the acquisition of specific skills appears to be a misguided pursuit. Funds would be better spent supporting more traditional training methods for skill acquisition.

Agility-based neuro-interventions seem to have much greater promise. They may produce better leaders among (and of) troops who are able to cycle effectively between neural networks, and we do not anticipate the same power disruptions as with skill-based interventions. Where applied (whether to all, or some members of the military at each level), we posit that there would be in increase in ethical leadership. Agility-based interventions increase the ability of troops to make sound decisions, such that the analytic and empathic networks are used appropriately, and can be accessed more efficiently that would be naturally accessible.

Agility-based cognitive enhancements also have practical applications outside of the military. Moreover, they theoretically create fewer issues for military members after they are no longer in active duty and can in fact ease the transition to civilian life and post-service productivity and success. Some skill-based cognitive efficiencies (i.e. language and arguably marksmanship) have civilian applications, yet they do not have the universal applicability of agility-based enhancements.

Forcing a healthy brain that already cycles between networks into one network or another and using technology to stimulate that network beyond levels normally achieved through common skills training is potentially troubling. While particular skills such as marksmanship are highly analytic, it does not follow that gains in marksmanship should come through neuro-interventions if such interventions might damage mental health and/or inhibit ethical sensitivity. Focusing on increasing marksmanship by activating the analytic network may be an effective means to a specific end (greater precision hitting targets), but it could also lower inhibitions and the disrupt the ability to discriminate between legitimate and illegitimate targets. As such, it is not a gain that makes sense, particularly in most modern combat contexts (where discrimination is arguably the more essential skill). Such an intervention would be, in essence, solving the wrong problem, while introducing new potential harms.

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Despite the fact that skill-based neuro-interventions may save valuable time and resources during training, the potential for causing lasting harm to troops and society at large outweighs the benefits. It makes more sense to apply the promise of neuro-interventions to increasing the ability of troops to cycle effectively between neural networks, so that they can perform the diverse tasks assigned to

them better and at less cost to their mental health. We do not need better marksmen. We need more discriminating marksmen. The right kind of neuro-interventions will increase resiliency in troops and provide society-wide benefits. The wrong kind will create more problems than it solves, for present and future generations. Before programs like TNT get further down the field, it is essential for ethicists, legal experts, military professionals, and all interested parties to engage in open and transparent dialogue in academic circles and the public sphere about the full range of their ethical, legal, and social implications. ***IAJ***

NOTES

1 See Shannon E. French and Anthony I. Jack, "Dehumanizing the Enemy: The Intersection of Neuroethics and Military Ethics," David Whetham, editor, *Responsibilities to Protect: Perspectives in Theory and Practice,* The Netherlands and Boston: Brill/Martinus Nijhoff Publishers, 2015.

2 "DARPA-BAA-16-24: Targeted Neuroplasticity Training (TNT)." Defense Advanced Research Projects Agency. April 1, 2016. https://www.fbo.gov/utils/view?id=28f410382e338b4b4fc0ecd104d440aa, p. 3.

3 "DARPA and the Brain Initiative." Defense Advanced Research Projects Agency. https://www.darpa.mil/program/our-research/darpa-and-the-brain-initiative.

4 Ibid.

5 For more on the development of similar technologies, see Mark E. Lasbury *The Realization of Star Trek Technologies: The Science, Not Fiction, behind Brain Implants, Plasma Shields, Quantum Computing, and More*. Switzerland: Springer International Publishing, 2017.

6 "TNT Researchers Set Out to Advance Pace and Effectiveness of Cognitive Skills Training." Defense Advanced Research Projects Agency. April 26, 2017. https://www.darpa.mil/news-events/2017-04-26.

7 Ibid.

8 "Targeted Neuroplasticity Training." Defense Advanced Research Projects Agency. https://www.darpa.mil/program/targeted-neuroplasticity-training.

9 Shannon E. French and Anthony I. Jack, "Neuroethics, Dehumanization, and the Prevention of Moral Injury," *Moral Injury Reader*, edited by Douglas Pryer, Eugene, OR: Cascade Books (Wipf & Stock), 2018.

10 Ibid.

11 "DARPA-BAA-16-24: Targeted Neuroplasticity Training (TNT)," §1.1.2.

12 Kylie Rochford, Anthony Jack, Richard Boyatzis, and Shannon E. French. (2016). Ethical Leadership as a Balance Between Opposing Neural Networks. Journal of Business Ethics. 10.1007/s10551-016-3264-x.

13 See for example A.I. Jack, A.J. Dawson, K.L. Begany, R.L. Leckie, K.P. Barry, A.H. Ciccia, A.Z. Snyder (2012) fMRI reveals reciprocal inhibition between social and physical cognitive domains. *Neuroimage* 66C:385-401.

14 M. Pyka, C.F. Beckmann, S. Schoning, S. Hauke, D. Heider, H. Kugel, V. Arolt, C. Konrad (2009)

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15 The research shows that these two modes, corresponding to different 'hardwired' neural systems, can be flexibly deployed and that there are individual differences in our propensity to adopt one cognitive mode or the other. For instance, males who evidence more hostile sexism towards women show less activity in empathetic brain regions when they are shown sexualized images of attractive women (see reference). Similarly, humanizing and dehumanizing narratives influence which mode one adopts when viewing depictions of others (see ref 36). Adopting one mode or the other would not usually be a conscious choice, but it is influenced by culture, personality and training. Reference: Mina Cikara, Jennifer L. Eberhardt, and Susan T. Fiske (2011) From Agents to Objects: Sexist Attitudes and Neural Responses to Sexualized Targets. Journal of Cognitive Neuroscience 2011 23:3, 540-551.

16 See Scott O. Lilienfeld and Michelle R. Widows. *Psychopathic Personality Inventory (PPI).* Psychological Assessment Resources, 1990.

17 Marcia Reynolds. "Can You Have Too Much Empathy?" Psychology Today. April 15, 2017. https://www.psychologytoday.com/us/blog/wander-woman/201704/can-you-have-too-much-empathy.

18 Mark E. Lasbury. *The Realization of Star Trek Technologies: The Science, Not Fiction, behind Brain Implants, Plasma Shields, Quantum Computing, and More*. Switzerland: Springer International Publishing, 2017, p. 167.

19 See "Ethics of Human Enhancement: 25 Questions & Answers," F. Allhoff, P. Lin, J. Moor, J. Weckert, *Studies in Ethics, Law, and Technology*, 2010.

20 Giordano, Howlander, and Shook appear to have first used this acronym in "Enablement: A Neuroethical and Legal Course between the Scylla of Treatment and Charybdis of Enhancement" (Taylor & Francis Online, 2013), although they spell it out as "post-enablement distress syndrome". The meaning and usage are the same, however, and the authors have heard it used in professional contexts as "post-enhancement distress syndrome."

21 Lieutenant Colonel Dave Grossman, *On Killing: The Psychological Cost of Learning to Kill in War and Society*, Boston: Little, Brown and Company, 1996.

22 For several examples see French, Shannon E., and Lindsay, Lisa N. "Artificial Intelligence in Military Decision-Making: Avoiding Ethical and Strategic Perils with an Option-Generator Model," Bernard Koch and Richard Schoonhoven, editors, *The Ethical Implications of Emerging Technologies in Warfare,* The Netherlands and Boston: Brill/Martinus Nijhoff Publishers, forthcoming 2020.

23 See for example Nick Bostrom and Anders Sandberg, "Cognitive Enhancement: Methods, Ethics, Regulatory Challenges," Sci Eng Ethics (2009) 15:311–341.

24 Tim Mulgan, *Future People: A Moderate Consequentialist Account of our Obligations to Future Generations*, Oxford: Oxford University Press, 2008.