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Scientific Letter

A Framework to Assess the Military Ethics of Human Enhancement Technologies

Key Points

- Human enhancements may be achieved through devices or drugs that augment or modify human performance.
- Militaries have used enhancements for years to improve soldier performance.
- Science and technology progress in human enhancements have outpaced regulatory policies.
- Emerging enhancements may raise ethical questions and face policy barriers that impede their development, evaluation and eventual adoption by the Canadian Armed Forces (CAF).
- It is imperative to consider the military ethical issues raised by human enhancement technologies before they are adopted by the CAF.
- A framework was developed to assess the military ethical issues associated with human enhancements.
- Identifying potential ethical issues early will enable policymakers to design policies that ensure the safe and ethical use of human enhancements, and will also allow the CAF to be prepared to deal with enhanced adversaries.

Background

Human enhancement has been defined in the literature in various ways.¹⁻³ We define it herein as any science and technology (S&T) approach that temporarily or permanently modifies or contributes to human functioning. S&T efforts to enhance human health and performance are not new; vaccines (considered enhancements because they augment the immune system's ability to protect against disease) have been used since the 18th century.⁴ Human enhancements permeate many aspects of society. Wearable health monitors like FitBits, which can inform changes in behaviour to improve health,^{5,6} are used by millions of people worldwide. Enhancements are also used by professionals such as healthcare workers and athletes. Physicians are often early adopters of technological enhancements. For example, surgeons have piloted head-mounted augmented reality displays like Google Glass to consult with external colleagues during complex medical procedures, and to instantly view patient data hands-free.^{7,8} Athletes have many enhancements at their disposal, including cooling gloves that increase strength and endurance,⁹ and caps with sensors to alert them when they may be concussed.¹⁰ Whether they are used for increased well-being, enhanced healthcare, or improved athletic performance and safety, interest in human enhancements is pervasive, perhaps because they promise to increase our quality of life.



Human enhancements also have the potential to improve military capabilities by increasing soldier safety and performance. As in the civilian world, the use of human enhancements in the military is not new. Night vision goggles and thermal imagers that enable soldiers to see in low light and complete darkness, respectively, have been used for decades.^{11,12} Immersive virtual reality (VR) is used by soldiers to develop and practice their skills,¹³ and shows potential for improving emotional resilience¹⁴ in simulated environments before deployment. These enhancements have clear benefits, are non-invasive, and pose minimal risk to the user. However, more invasive enhancements currently being developed could pose greater risks. For example, while still years away from use in operations, technology implanted directly into the brain that enables hands-free control of external robotic devices could lead to serious ethical issues.¹⁵⁻¹⁷ Particularly important to consider during development are the complex ethical questions that may arise with the military use of emerging technologies. Ethics is a fundamental component of Canadian military ethos^{*}, with National Defence's *Statement of Ethics* defining specific values and obligations that Canadian Armed Forces (CAF) members must adhere to within the profession of arms, and in their role in the social order[†]. As emerging enhancements become more invasive and complex, they may have the potential to compromise these values and obligations and in such cases become a military ethical dilemma.

Advancements in human enhancement are progressing at a much faster pace than policy development regulating their use. This disparity can lead to gaps in our knowledge about the potential ethical, social, and legal issues associated with the use of new enhancements by the CAF.¹⁸⁻²¹ While there is much discussion about the ethics of soldier enhancement,¹⁸⁻²⁴ there is a paucity of research on ethical issues pertaining to the use of specific emerging technologies of potential interest to the CAF. A comprehensive ethics assessment framework that can be used by policymakers, stakeholders, and scientists to identify ethical issues that may arise with the use of human enhancement technologies would have utility for DND/CAF. This approach will help to ensure that: a) design characteristics of enhancements that could lead to ethical issues during their use are identified and potentially resolved by S&T developers early in development; b) policies for the use of enhancements are designed such that potential ethical issues that could arise with their use are avoided, thus upholding responsible and safe use in an operational environment; and c) the CAF will be informed about the dangers that may be encountered by enhanced adversaries.

Considerations for Identifying Ethical Issues that Could Arise When Using Human Enhancement Technologies on the Battlefield

We have generated a comprehensive list of key questions and principles, identified from a review of the literature, that can be used to identify potential ethical issues that could arise with the use of a human enhancement technology by the military (see Figure 1). This list raises questions that, if not considered or addressed by modifications to technology design or in policies regulating technology use, could trigger ethical problems on the battlefield. Some of the principles identified pertain to existing national and international laws and policies, while others are related to biomedical research ethics tenets. Globally, war is governed by the Law of Armed Conflict (LOAC), which is a set of legal principles designed to protect those affected by conflict and regulate means of warfare. Under the LOAC, military action must meet military necessity, use force that is proportional to the objective obtained, treat combatants and prisoners of war humanely, and must not target civilians.^{25,26}

^{*} As outlined in *Duty with Honour: The Profession of Arms in Canada*, produced by the Government of Canada.

[†] This definition of ethics is modified from *The Warrior's Way: A Treatise on Military Ethics* by Richard A. Gabriel.

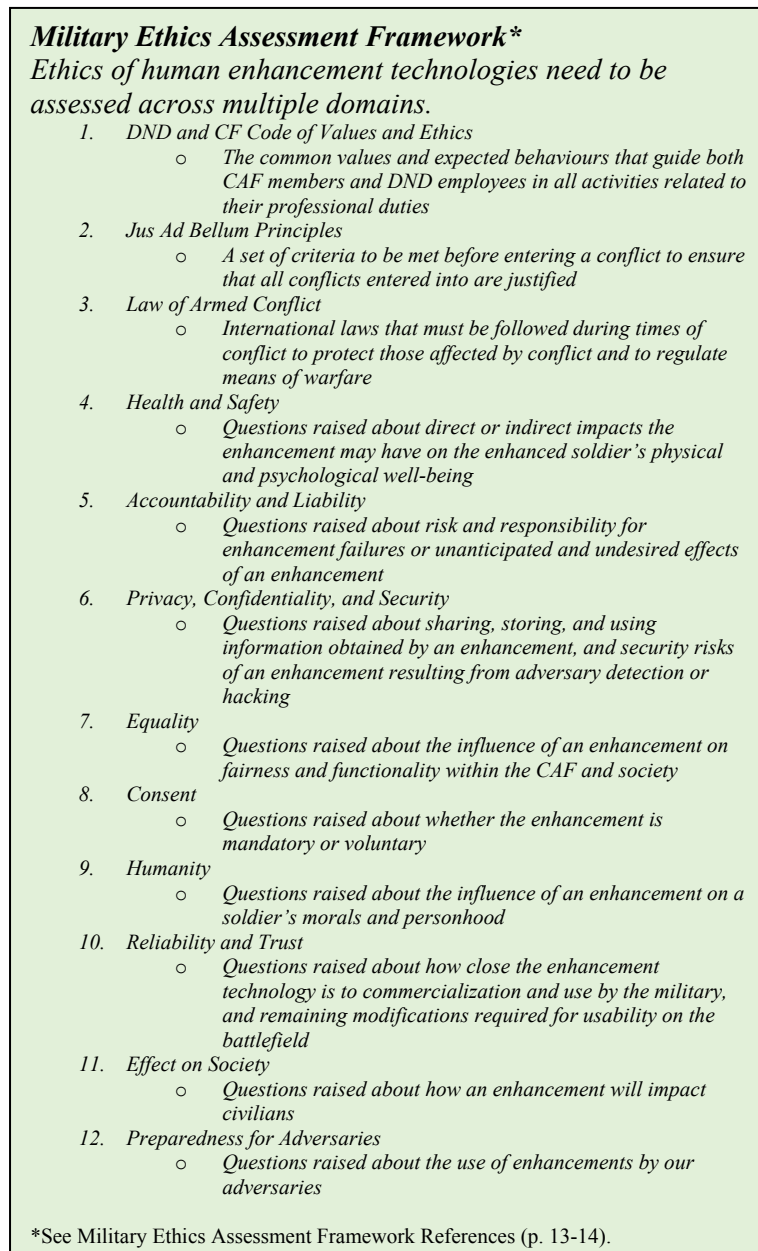


Figure 1: Military Ethics Assessment Framework.

In Canada, the DND and CF Code of Values and Ethics defines values and behaviours that Canadian military members must adhere to, including respecting Canadian law, serving Canada above self, and observing core values such as integrity, stewardship and courage.²⁷ Human enhancements of soldiers must not violate Canadian or international laws. Other considerations to be made when assessing emerging human enhancement technologies for the military are guided by biomedical research ethics principles. Studies conducted on soldiers in the Canadian military are judged against clear ethical guidelines that may further identify potential ethical problems during testing and development.²⁸ Even when legal and biomedical research principles are met, there are many remaining questions to consider. Could enhancements create inequalities between soldiers? Who is accountable if a flawed enhancement causes injury?



Does the enhancement increase security threats to soldiers? Are there long-term effects on the user or on society? It is also critical to assess the potential for enhancements to be used by adversaries, especially by those who may not adhere to the LOAC. Although there are questions included here that should also be considered when identifying ethical issues that could arise with the use of other technologies by the military, some other considerations listed are unique to human enhancement technologies.

Identifying Pervasive Military Ethical Issues Resulting from the Use of Human Enhancement Technologies

Early assessments of new technologies enables policymakers to develop policies that safeguard the ethical use of human enhancements by the CAF. Human enhancements are often classified into one of three categories: physiological, computational/cognitive, or autonomous/robotic.²⁹ Although there are ethical issues that persist across all three categories, enhancements can also have ethical issues unique to their classification.

Ethical Implications of Physiological Enhancements

At the core of human enhancement is human physiology. Enhancements that improve health, athletic performance, or the ability to detect and record physiological processes are of interest to the military because they can increase operational capabilities and soldier performance and survivability. For example, as blood loss is the leading cause of preventable death on the battlefield³⁰ synthetic or stem-cell derived blood for transfusion^{31,33} and devices that quickly stop bleeding³⁴⁻³⁷ could improve soldier survival. Enhancements such as wearable materials that prevent skin contact with contaminants³⁸ or mobile dialysis machines that filter bacteria and viruses out of circulation³⁹ could increase soldier protection and resilience against chemical and biological hazards. Soldier performance and resilience may also be improved by advances in implantable medical technology. Neuro-prosthetic devices that record brain activity from implanted electrodes and translate it into movements in paralyzed or robotic limbs represent a significant advance in brain-computer interfacing. These products may eventually be used to replace lost limbs in soldiers or to control external robotic devices.^{17,40-43} Finally, wearable non-invasive sensors that detect and record physiological information such as heart rate,⁴⁴⁻⁴⁶ blood pressure,⁴⁴ respiratory rate,^{44,46} skin temperature,^{47,48} and sweat concentrations of sodium,⁴⁸⁻⁵⁰ glucose,^{48,51} lactate,^{48,51-53} and cortisol⁵⁴ promise to enhance soldier performance by providing feedback about health and fitness levels.

Even with clear applications for soldier health, performance, and safety, these enhancements are not without potential ethical challenges. Any modification to human physiology is likely to raise ethical questions surrounding **health and safety** (see Figure 1). New medical products may have unexpected side effects. For example, first generation synthetic blood products led to sudden and unanticipated death during clinical trial testing.⁵⁵ Physiological or implanted technologies may also introduce issues with respect to **consent**. Soldiers ordered to use an enhancement may unwillingly surrender informed consent, which has been raised as a problem with mandatory vaccinations in the US military.⁵⁶ Challenges with the fair distribution and use of physiological enhancements may arise, leading to **equality** issues. This is especially likely if the enhancement provides improved performance or encourages competition among troops, which could create dissonance between soldiers. Equality and consent may also be compromised when soldiers leave the force if their enhancements cannot be removed upon return to civilian life. Any device that enables the collection and wireless transmission of health information, like



wearable physiological sensors, carries with it a **privacy and security** risk. These enhancements could be hacked by adversaries to target less fit units. Moreover, questions around data storage and data ownership remain unclear. Lastly, varying **reliability** of biological devices may introduce ethical problems. Using medical devices designed for civilian use in an operational environment where power sources and sterile conditions can be unreliable could reduce the practicality of certain enhancements for the military.

Ethical Implications of Cognitive/Computational Enhancements

Cognitive load is a significant military challenge. Soldiers often perform under high stress, with little sleep, and while managing copious information. Enhancements that augment cognition, improve memory, or simplify information gathering may help solve this problem. Cognitive pharmaceuticals including Dexedrine and Modafinil, typically prescribed for attention and sleep disorders,⁵⁷⁻⁶⁴ have been used by military personnel for years, and may reduce sleep, improve focus, and augment perception, particularly on long missions.^{63,64} Newer technologies to modify neural activity such as transcranial direct current stimulation (tDCS) may also enhance cognition, learning, and memory.⁶⁵⁻⁷¹ tDCS devices have recently been approved by Health Canada for treatment of pain disorders in adults.⁷² VR, characterized by immersive virtual displays that simulate environments, is currently used by the Canadian and American militaries for simulations and training purposes,^{13,73-75} and shows some promise for assessing, treating, and preventing post-traumatic stress disorder (PTSD).^{76,77} Augmented reality (AR) provides users with a real-world view that is augmented by a digital overlay.⁷⁸⁻⁸⁰ AR glasses are commercially available,⁸¹⁻⁸² have smartphone-like capabilities, and can track, analyze, store, and share data about the user and his/her surroundings. AR glasses can also provide a soldier with instant information, navigation, and identities of people and places, and can improve communication between unit members.

Despite widespread interest in cognitive enhancement, there are questions associated with its use by the military to avoid unethical outcomes. There are **health and safety** concerns for any emerging technologies, including cognitive enhancements, that are ingested or closely interact with the human body. As many cognitive drugs are prescription medicines, the potential side effects of their use in healthy people are unknown, raising questions about the safety of cognitive drugs for non-therapeutic or unregulated use.^{62,83-86} tDCS does not have significant side effects with controlled laboratory use; however, studies are still ongoing to determine whether there are negative effects of repeated, unregulated and/or long-term use.⁸⁷⁻⁹¹ Even after new drugs or technologies are approved in laboratory trials, there may still be new health and safety concerns to consider with their use on the battlefield. These concerns must be deliberated to develop effective policies and avoid unethical consequences. Cognitive enhancement could also raise questions about **accountability**. Who is responsible if a soldier under the influence of a cognitive enhancement is involved in an accident or casualty? There may also be accountability issues with AR and VR; who is accountable if AR incorrectly identifies a threat, or if VR results in misdiagnosis of PTSD? Clear accountability protocols in the case of error must be defined in policies and doctrine before such capabilities are implemented to avoid unethical outcomes. Ethical issues with **consent** and **equality** are also pertinent. Soldiers may feel coerced into using a cognitive enhancer in order to increase effectiveness and remain competitive; this could promote an unethical work environment (for example, the expectation of a 24-hour work day), and violates the concept of consent that is free from coercion. Unequal distribution of cognitive enhancement tools may create unfair advantages or disadvantages among soldiers, and raises questions surrounding soldier treatment during duty and after leaving the force. Cognitive or computational enhancements must also be **reliable** if



they are to be used ethically. The reliability of both cognitive drugs⁵⁷⁻⁶¹ and tDCS^{92,93} to provide cognitive benefits across many users and conditions has been questioned in the scientific literature. There are also questions about whether VR-based training can effectively mimic real-life experience. Sharing information over wireless devices introduces the threat of interference by adversaries, and could compromise **security, confidentiality, and privacy**. Prior to implementation, emerging technologies should be assessed for operational reliability challenges and for ways in which they could compromise privacy/security. This will help to predict and avoid unethical outcomes with their use on the battlefield. Similarly, personal data about soldier activity and health collected by AR or VR devices requires clear guidelines to safeguard privacy, and to ensure **consent** is not violated.

Ethical Implications of Automation/Robotics Enhancements

The rise of robotics and automation has made feasible many human enhancements once thought to be science fiction. One potential benefit of autonomous and remotely controlled systems such as unmanned aerial vehicles (UAVs) is increased safety, because they allow soldiers to carry out their duties while remaining further from dangerous zones.⁹⁴ Furthermore, some have hypothesized that fully autonomous military robots could reduce the risk of unethical behaviour by removing the emotional dimension (for example, anger and desire for revenge) from situations on the battlefield.^{95,96} However, the ethicality of unmanned military systems is still debatable.^{97,98} For instance, can we trust a UAV with face recognition capabilities to correctly discriminate combatants from civilians? If a civilian casualty occurs as a result of faulty technology, who is responsible? Does removing soldiers from the battlefield through the use of remotely controlled technology reduce their emotional involvement and encourage dispassionate and unethical behaviour? Does the use of robots contribute to disdain felt by adversaries toward our forces? These ethics questions do not have clear answers.

Not all autonomous systems and robotics are necessarily human enhancements; however, there are several examples in development for military use. A temporary electronic forearm tattoo that distinguishes hand gestures and translates them into commands to direct an UAV is currently under development, and could improve the ease of UAV control.⁹⁹ Robotic exoskeletons that can be worn by soldiers to enable them walk greater distances and carry heavier loads are of great military interest.¹⁰⁰ The most promising prototypes are lightweight and reduce the metabolic energy expended during walking.^{101,102} This has obvious utility for soldiers, who must often walk far distances carrying heavy loads, which can result in fatigue and lead to injury. Reliance on power in the form of batteries contributes to the heavy load that soldiers must carry. This year, the U.S. Army will be conducting field tests of PowerWalk®, an autonomous robotic leg brace that can harvest energy from walking motion.¹⁰³⁻¹⁰⁵ If successful, these leg braces could decrease the battery load carried by soldiers in the field without sacrificing power supply.

Despite the clear military benefits to autonomous/robotic enhancements, there are considerations to be made in order to avoid potential ethical issues with their use on the battlefield. The long-term **health and safety** effects of using these technologies is unknown; for instance, could a soldier accustomed to wearing an exoskeleton have gait, strength, or balance impairments when not using it? There are also potential **security** risks: soldiers may be more easily detected and targeted by adversaries if an enhancement is loud, easily hacked, and/or desirable. Malfunctions of an enhancement leading to civilian casualty or soldier injury raise **accountability and liability** concerns about where to place responsibility. Issues of **equality** may arise depending on how the enhancement is distributed in the CAF. The function of the enhancement itself could also contribute to **equality** concerns by creating an unethical work



environment. For example, relying on the PowerWalk® for power generation could require soldiers to walk further or run faster in order to generate electricity. There are **reliability and trust** concerns with any enhancement that has not been tested in an operational environment. There are also larger social issues associated with the use of autonomous/robotic human enhancement technologies. Any enhancement that reduces the risk incurred by soldiers by enabling them to fight safely from a distance could reduce the barriers to entering a conflict, which may violate the **Jus Ad Bellum** principles of Just War Theory.^{94,106} Finally, an enhancement might receive pushback from the public if it is viewed as unfair or evil, which challenges its **compliance with IHL** and emphasizes the importance of considering an enhancement's **effect on society**.

Summary

The science of human enhancement is developing rapidly, and offers exciting opportunities for improved military capabilities. The military advantages of enhancements like exoskeletons for improved endurance, pharmaceuticals for sharpened focus, and augmented reality goggles for instant and hands-free access to information are recognized and well documented. However, many questions raised by the use of specific enhancements remain unanswered, leading to policy gaps that hinder their assessment and subsequent implementation by the CAF. Several pervasive ethical issues of human performance enhancement technologies have been identified using our military ethics assessment framework. Identifying ethical issues early in the development phase of new potential enhancements will help policymakers develop informed policies that ensure the safe and ethical use of human enhancements by the CAF.

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