# Cyborg Soldiers: Military Use of Brain-Computer Interfaces and the Law of Armed Conflict

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## - Introduction

Recent years have seen a spotlight aimed at new technologies and how they might be used by the military. Scholars and policymakers have given much attention to autonomous weapons systems and artificial intelligence, as well as to cyber operations, but far less notice is paid to a host of other technologies which may also transform the way conflicts are conducted. One of these other areas of technological advancement is human enhancement. Enhancements can occur in a myriad of ways, from pharmaceutical to mechanical and even through gene modification. In this piece, we focus on one particular method of enhancing human capabilities: the use of brain-computer interfaces (BCI). These systems open a direct link for the transfer of data between the human brain and a machine,[3] and create possibilities for an extraordinary range of new abilities and actions. While it is still early days for this technology, BCI systems, including in many military-oriented projects, are currently in development.[4] The uses of BCIs range from one-way transfer of sensory data from the brain to a computer, to two-way data exchanges between the brain and artificial intelligence systems, providing the human with almost instantaneous access to the power of AI.

The advanced capabilities of BCI will create previously unimaginable opportunities, as well as risks, on the battlefield. They will also present new challenges to the application of the law of armed conflict (LOAC, also referred to as International Humanitarian Law or IHL). Consider the following hypothetical future scenario: Soldiers from State A are equipped with BCI systems designed to collect sensory data (sight & sound) from the soldiers, and they share this data directly with AI-based weapon platforms, including unmanned aerial vehicles. These systems also allow the soldiers to control the drones with commands issued directly from the brain to the weapon system. State B is aware of these functions and seeks to disrupt the data exchange between the soldiers and the drones, but corrupting the data communication could cause permanent brain damage to any BCI user in the vicinity, including persons other than the soldiers operating the drones. In a separate incident, State B detains a BCI-enhanced soldier from State A. However, the captors are uncertain if the BCI is still active and if the soldier should be considered *hors de combat* and entitled to protection, or whether the soldier's brain is still transmitting data back to headquarters; indeed, it is possible that the soldier may still be able to launch a strike through the BCI. These types of situations present complex challenges to the application of the rules on conduct of hostilities and protection of individuals during armed conflict.

As we will discuss in this Chapter, much of the technology in this area is still in its infancy. Our paper aims to identify the legal issues arising from future military uses based on potential technological development, rather than the current state of the science. As such, the scenarios we present are by and large hypothetical, and we cannot predict if and when they might become a reality. Nonetheless, we believe it is precisely at this early stage that an analysis based on the

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[3] See section on "BCI Definition".
[4] See section on "Military Uses".

possible direction of travel can be most useful. Too often, technologies are developed and deployed – including by militaries – only to face a host of legal and other challenges to their use. By understanding and foreseeing the legal obstacles that may arise in the future, we aim to identify ways in which such risks can be mitigated through appropriate design and development of the nascent technology.

The literature on the international legal questions surrounding human enhancement is relatively sparse. A very small number of publications have begun to explore the legal issues arising from military applications in this field. Their focus, in most cases, has been on human enhancement technologies more generally, and has provided an excellent start to the debates.[5] This chapter takes a different approach, by delving deeper into the issues surrounding one class of technologies. As we will show, BCI systems have the potential to fundamentally transform the battlefield. While military human enhancements generally raise questions about the dividing line between the weapon and the human operator,[6] it is hard to conceive of a greater blurring of the lines than that created by the human-machine symbiosis of brain-computer interfaces. Moreover, the use of brain-computer interfaces raises many of the challenging legal questions posed by AI and the growing use of data as well as complex new issues specific to the unique brain-computer connection. By providing one of the first in-depth examinations of this subject, this chapter aims to lay the foundation for applying international humanitarian law to the use of BCIs. Following an explanation of BCI technology and some of its potential uses by militaries in the future, the chapter provides an analysis of a wide range of legal issues from the regulation of weapon development to specific rules of targeting and protection. As we will show, solutions to certain challenges may require consideration in the actual development and configuration of BCI systems. We hope that, by tackling these issues here at this point in time, we may still be able to influence the development of the systems to ensure they can operate within the confines of international law.

## - What is a BCI

### *BCI definition*

A brain-computer interface (BCI) "is a system that measures [central nervous system] CNS activity and converts it into artificial output that replaces, restores, enhances, supplements, or improves natural CNS output and thereby changes the ongoing interactions between the CNS

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[5] *See*, for example: Heather A Harrison Dinniss & Jann K Kleffner, *Soldier 2.0: Military Human Enhancement and International Law*, 92 INT'L L.STUD. 432–482 (2016); Patrick Lin et al., *Enhanced Warfighters: Risk, Ethics, and Policy*, SSRN Electronic Journal 1–19 (2013); NEW TECHNOLOGIES AND THE LAW IN WAR AND PEACE (W. H. Boothby ed., Cambridge University Press) (2018); Rain Liivoja & Luke Chircop, *Are Enhanced Warfighters Weapons, Means, or Methods of Warfare? or Methods of Warfare?*, 94 INT'L L.STUD. 161–185 (2018); EMILY JONES, FEMINIST THEORY AND INTERNATIONAL LAW: POSTHUMAN PERSPECTIVES, (forthcoming 2022); Yahli Shereshevsky, *Are All Soldiers Created Equal? – On the Equal Application of the Law to Enhanced Soldiers*, VA. J. INT'L L., 271-324 (2020).

[6] Lin et al., *supra* note 5, at 29-30; Liivoja & Chircop, *supra* note 5, at 176–8.

and its external or internal environment."[7] Accordingly, there are five types of applications that a BCI output might control: (1) it might *replace* a natural output that has been lost due to injury/disease; (2) it might *restore* lost natural output; (3) it might *enhance* natural CNS output; (4) it might *supplement* natural CNS output; and (5) it might conceivably *improve* natural CNS output.[8] In *improving* the natural CNS output, which is the primary focus of this chapter, possible BCI applications might include enabling a wide range of super-human abilities such as extra-sensorial perception, superstrength, or super-precision.[9] Some applications aim to allow a device to send sensory data to the user or facilitate bilateral communication involving both sensory data and motor control.[10] A more advanced hypothetical application in the future might enable multilateral cognitive collaboration, where, for example, a soldier with a brain implant can stream live data from the battlefield to the Command Base and receive communication back from commanders directly to the brain. In certain circumstances, the implant might both be remotely controlled by commanders and control a prosthetic attachment with an offensive capacity.[11]

A subset of BCI systems, particularly with exogenously-driven operational modes, could potentially translate the user's intentions into actions through a correlation between brain and computer. For this correlation to happen, a device modulates the user's brain signals, and in turn the BCI identifies and interprets the neural signals. BCIs can be classified into those that use non-invasive, minimally invasive, partially invasive, and invasive BCIs.[12] EEG

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[7] JONATHAN R. WOLPAW & ELIZABETH WINTER WOLPAW, BRAIN-COMPUTER INTERFACES: PRINCIPLES AND PRACTICE 5 (J. R. Wolpaw & E. W. Wolpaw ed., 2012). *See also*, Stefan Reschke et al., *Neural and Biological Soldier Enhancement: From SciFi to Deployment*, NATO, RESEARCH AND TECHNOLOGY ORGANISATION RTO 33.1-33.11, 33.2 (2009); (BCIs are also synonymous with the concept of "technointegration" referring to the "symbiotic coupling of humans with technology to amplify human physical and cognitive capabilities.").

[8] A BCI output might *replace* a lost natural output; for example, a person who has lost limb control might use a BCI to operate an electric wheelchair. A BCI output might *restore* lost natural output; for example, a person with spinal cord injury (limbs paralysis) might use a BCI to stimulate the paralyzed muscles via implanted electrodes so that the muscles move the limbs. A BCI output might *enhance* natural CNS output; for example, a person performing a task that requires continuous attention over a prolonged period (e.g., flying a combat aircraft) might use a BCI that detects the brain activity preceding declines in attention and then provides an alerting output (e.g., a sound) to restore attention. A BCI output might *supplement* natural CNS output such as *supplementing* natural neuromuscular output with an additional artificial output; for example, a person might use a BCI to control third (i.e., robotic) arm and hand. Finally, a BCI output might conceivably *improve* natural CNS output; for example, a person whose arm movements have been impaired by a damage to the sensorimotor cortex might use a BCI that measures signals from the damaged cortical areas and then stimulates muscles so as to improve arm movements. A repeated use of such BCI may induce activity-dependent CNS plasticity that *improves* the natural CNS output and thereby helps the person to regain more normal arm control. This type of BCI changes the continuous interactions between the CNS and its external or internal environment. It reflects an ongoing hybrid mode of operation that may improve both sensory input from the environment and CNS output. WOLPAW & WOLPAW, *supra* note 7, at 4-5.

[9] *See* possible operational and applied capabilities in ANIKA BINNENDIJK ET AL., BRAIN-COMPUTER INTERFACES: U.S. MILITARY APPLICATIONS AND IMPLICATIONS, AN INITIAL ASSESSMENT 7 (RAND Corporation) (2020), https://www.rand.org/pubs/research_reports/RR2996.html (last visited Jan 24, 2022).

[10] Jeneva A. Cronin et al., *Task-Specific Somatosensory Feedback via Cortical Stimulation in Humans*, 9 IEEE TRANSACTIONS ON HAPTICS 515–522, 519 (2016).

[11] For more examples, *see* PETER EMANUEL ET AL., CYBORG SOLDIER 2050: HUMAN/MACHINE FUSION AND THE IMPLICATIONS FOR THE FUTURE OF THE DOD 7–10 (Oct. 2019), https://apps.dtic.mil/sti/pdfs/AD1083010.pdf .

[12] Otto et al, "Acquiring Brain Signals from within the Brain," *in* BRAIN-COMPUTER INTERFACES: PRINCIPLES AND PRACTICE 81 (J. R. Wolpaw & E. W. Wolpaw ed., 2012); Forian Heinrichs, *Introduction to Brain-Computer*

(electroencephalogram), for example, obtains electrical signals from the scalp and is considered the dominant and safest method for non-invasive BCIs.[13] Invasive BCIs, by contrast, retrieve electrical signals via microelectrodes surgically implanted in the cortical layers of the brain.[14] Partially invasive BCIs could use ECoG (Electrocorticography), which is a type of signal platform that enables electrodes to be placed on the attainable edge of the brain to detect electrical impulses originating from the cerebral cortex, without the need for brain surgery.[15] While most invasive and partially invasive BCIs require high risk neurosurgical implantation, minimally invasive BCIs[16] are low risk surgical procedures such as implants that could be inserted into the blood stream while they travel to a particular organ by themselves.[17]

Using an EEG-based system, humans have been able to control a computer cursor, and to command robots to manipulate objects and operate limb prosthetics.[18] The EEG devices, however, are fundamentally limited by their signal content, and recordings are prone to interference from the electromyographic activity.[19] Invasive and partially invasive BCIs, on some dimensions, enable higher performance limits.[20] For instance, patients with locked-in syndrome are able to move cursors and execute basic control over robotic devices, such as opening and closing a prosthetic hand.[21] Invasive and partially invasive BCIs hold greater potential for functionality than their non-invasive counterparts, but there are also risks and limitations associated with their implantation, some of which could affect the legal analysis conducted in this paper. A skullcap that is worn and removed like a hat will create far less

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*Interfaces: When Technology from Science Fiction Movies Becomes Reality*, TOWARDS DATA SCIENCE (Oct. 19, 2021), https://towardsdatascience.com/introduction-to-brain-computer-interfaces-d05d533e3543 .

[13] Otto et al., *supra* note 12.

[14] *Id.*

[15] *Id., see also* M F Mridha et al., Brain-Computer Interface: Advancement and Challenges, 21 SENSORS (BASEL, SWITZERLAND) 5746 (2021), https://pubmed.ncbi.nlm.nih.gov/34502636; Eric C. Leuthardt et al., *Defining Surgical Terminology and Risk for Brain Computer Interfaces Technologies*, 15 FRONTIERS IN NEUROSCIENCE 1–9, (Mar. 26, 2021) https://doi.org/10.3389/fnins.2021.599549.

[16] Such as the "stentrode"; Department of Defense - Congressionally Directed Medical Research Programs (CDMRP), *Stentrode: A SCIRP-Funded Device to Facilitate Independence After Paralysis* (Sept. 22, 2021), https://cdmrp.army.mil/scirp/research_highlights/21opie_highlight (last visited Apr. 4, 2022).

[17] Yuhao Zhou et al., *Implantable Thin Film Devices as Brain-Computer Interfaces: Recent Advances in Design and Fabrication Approaches*, 11 COATINGS 1–26 (2021); Jonathan R Wolpaw & Dennis J McFarland, *Control of a two-dimensional movement signal by a noninvasive brain-computer interface in humans*, 101 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA 17849–17854 (2004), https://pubmed.ncbi.nlm.nih.gov/15585584 .

[18] Paulette Campbell, *Quadriplegic Patient Uses Brain Signals to Feed Himself with Two Advanced Prosthetic Arms*, JOHNS HOPKINS U. HUB (Dec. 28, 2020), https://hub.jhu.edu/2020/12/28/quadriplegic-man-feeds-himself-with-brain-controlled-prosthetic-arms/ ; Sebastian Olsen et al., *An Artificial Intelligence that Increases Simulated Brain–Computer Interface Performance*, 18 J. OF NEURAL ENGINEERING 046053 1–16 (May 13, 2021), http://dx.doi.org/10.1088/1741-2552/abfaaa ; Sung Phil Kim et al., *Neural control of computer cursor velocity by decoding motor cortical spiking activity in humans with tetraplegia*, 5 J. OF NEURAL ENGINEERING 455–476 (2008); Michael Kryger et al., *Flight simulation using a Brain-Computer Interface: A pilot, pilot study*, 287 EXPERIMENTAL NEUROLOGY 473–478 (Jan. 2017), https://www.sciencedirect.com/science/article/pii/S0014488616301248 .

[19] Didar Dadebayev et al., *EEG-Based Emotion Recognition: Review of Commercial EEG Devices and Machine Learning Techniques*, J. OF KING SAUD U. - COMPUTER AND INFO. SCI. 1–17, 13 (2021).

[20] *Id.*

[21] Alberto J. Molina-Cantero et al., *Controlling a Mouse Pointer with a Single-Channel EEG Sensor*, 21 SENSORS, 4 (2021).

challenges than an implant surgically inserted into the brain. From the legal perspective, the latter type of BCI can most obviously affect matters such as the lawfulness of risk to the individual but also, as will be seen later, raises specific LOAC questions of targeting and protection. Accordingly, the attributes of any given BCI system must be considered when analysing the legal issues it may raise. There are a number of different ways to categorise and differentiate between the various BCI systems in this regard. As we will discuss in the legal analysis, factors to consider include: whether the BCI is attached in an invasive or non-invasive manner; where the BCI sits on the scale from wearable and easily removable to permanently implanted; whether the BCI's effects are temporary or ongoing; the direction of data flow to/from the device and whether it is bi-directional. These are not, as it may at first seem, overlapping categories; a removable device may, for example, nonetheless have caused changes in the brain which are not easily reversible even after the use of the BCI is ended.

### *AI, Data & BCI*

The introduction of artificial intelligence (AI) and machine learning in the data collection and communication of BCIs provides for further enhancement of the system and the potential for new capabilities for the human using it.[22] For example, in a future hypothetical capability, the integration of AI in the BCI would enable the analysis of large volumes of data to improve the soldier's efficiency when assessing a situation on the battlefield. The AI enhances the techniques for data acquisition, monitoring, and analysis. This can include a system capable of receiving sensory input data from the soldier's vision. The AI would then analyse this input to identify threats and relay findings and recommendations back to the soldier's brain as well as to the commanders. The sensory data could itself be augmented by systems capable, for example, of higher resolution perception or UV/IR spectrum readings. By combining the processing power of AI and the brain with direct flow of data between the two, such BCI systems are blurring the human-machine divide and raising questions across the spheres of law, ethics and social policy. Our focus here is on the legal aspects, in particular the international law of armed conflict. As we will demonstrate, there are significant complexities in categorising all such systems as weapons, with legal and practical concerns in relation to both the conduct of hostilities and protection of those *hors de combat*, as well as accountability for violations. In addition to the issues raised by potential physical integration of human and machine, there are unique challenges related to data in this context, and in particular to data reliability in targeting and to the possibility of attacks aimed at the data streams used by the BCI. The following sections will address these concerns. First, however, we must develop an initial understanding of how these systems might be deployed in a military context.

[22] Xiayin Zhang et al., *The Combination of Brain-Computer Interfaces and Artificial Intelligence: Applications and Challenges*, 8 ANNALS TRANSLATIONAL MED. 712 (Jun. 2020), https://pubmed.ncbi.nlm.nih.gov/32617332; Zehong Cao, *A review of artificial intelligence for EEG-based brain−computer interfaces and applications*, 6 Brain Science Advances (2020) https://journals.sagepub.com/doi/full/10.26599/BSA.2020.9050017.

## - Military Uses

BCIs have the potential to affect every aspect of military operations, from providing a wealth of previously inaccessible information to battlefield actors, to enhancing the performance of individual soldiers, to conferring superior abilities on commanders to influence the actions of their troops. While a significant amount of the research focuses upon medical advantages,[23] this section will detail other, operational uses of BCI systems.

### *Monitoring*

At the simpler (relatively) end of the scale, a BCI combined with other biotech could monitor brain and body functions of the soldier and transmit this information to the commander or a special monitoring unit.[24] Real-time soldier physiological monitoring is not a new concept. In 2004, US officials noted that

> monitoring is necessary to ensure that operational personnel are as physically fit as possible because success on the battlefield is to a great extent dependent on the ability of combat service members […] to endure a host of physical stresses and strains that could easily overwhelm unfit individuals. […] An alert or warning signal to the individual and to his or her squad leader could permit prompt intervention to alleviate the physiological danger and potentially save a mission.[25]

Detailed data could include hormonal readings of cortisol and adrenalin to indicate levels of stress and mental state in situations of danger, or other readings to provide information on fatigue and physical well-being.[26] This information would allow commanders to make better informed decisions on directing their troops, taking into account the exact state of the soldiers and possibly also determining which soldiers are in a better condition to carry out particular missions and tasks at any given moment. Moreover, the monitoring unit may also have the ability to trigger a function in the implant designed to affect the hormonal levels of the soldier and counteract undesirable readings or enhance particular functions. This could be achieved through brain stimulation mechanisms or in combination with other implants physically releasing chemicals. Commanders could, in theory, give their soldiers an 'energy' jolt, or heighten their situational awareness in particular circumstances.

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[23] *E.g.*, In 2013, DARPA launched the Restore Active Memory (RAM) program with the goal to develop a "fully implantable, closed-loop neural interface capable of re-storing normal memory function to military personnel suffering from the effects of brain injury or illness." DARPA, *Progress in Quest to Develop a Human Memory Prosthesis*, DARPA, 2018, https://www.darpa.mil/news-events/2018-03-28 (last visited Jan 19, 2022).

[24] For the purpose of this chapter, "BCIs" also include assistive devices that are subject to remote control, in a broader biotech landscape.

[25] INSTITUTE OF MEDICINE OF THE NATIONAL ACADEMIES, MONITORING METABOLIC STATUS: PREDICTING DECREMENTS IN PHYSIOLOGICAL AND COGNITIVE PERFORMANCE 15 (2004).

[26] M Gray et al., *Implantable Biosensors and Their Contribution to the Future of Precision Medicine*, 239 THE VETERINARY J. 21–29, 21 (Sept. 2018), https://www.sciencedirect.com/science/article/pii/S1090023318304180 .

### *Control*

Recently, in the field of precision medicine, there have been significant advances in the use of biosensors and biotelemetry. Biosensors are "analytical devices containing a biological sensing element that transforms a biological response into electrical signals."[27] They can sensitively and rapidly detect a wide range of biomarkers, including molecular signatures, phenotype, environment, and lifestyle. Biotelemetry is the remote measurement of an activity, function or condition, and it utilises the implantable technology of biosensors as a means of obtaining data such as electromyogram (EMG), electroencephalogram (EEG), electrocardiogram (ECG), heart rate, blood pressure, body temperature, activity and circadian rhythm.[28] Moreover, biosensors have been developed to have the ability to deliver drugs in response to biosensor readings.[29] Scientists at Johns Hopkins Electrical and Computer Engineering lab are currently developing "wireless biotelemetry using ultra-wideband communications."[30] These BCIs could be utilised in the future for significant control and monitoring of soldiers on the battlefield; not only to gage the level of stress or fatigue but to potentially allow commanders to issue orders to the brain and control implants that could release chemicals or stimulate brain activities - influencing behaviour and decisions of individual soldiers. As we will discuss below, such interventions raise several legal concerns.

### *Communications*

There are a number of ongoing and planned projects aimed at using BCI systems as an advanced means for communication. These include a system/algorithm that would translate the thoughts or intentions of a soldier into a signal suitable for operating devices. This would enable silent communication or "silent speech" through a process in which a user imagines speaking a word without actually vocalising any sound.[31] Using such technologies to enable silent speech among soldiers can provide a number of advantages on the battlefield. During hostilities when giving verbal commands is difficult due to the level of noise and chaotic

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[27] *Id.* at 22.
[28] *Id.* at 23.
[29] *Id.* at 23–4. *Also see*, Gemma Church, *How Hacking the Human Heart Could Replace Pill Popping*, BBC (Dec. 16, 2019), https://www.bbc.com/future/article/20191216-how-hacking-the-human-heart-could-replace-pill-popping.
[30] Ivana Čuljak et al., *Wireless Body Sensor Communication Systems Based on UWB and IBC Technologies: State-of-the-Art and Open Challenges*, 20 SENSORS 3587, 1 (Jun. 25, 2020), https://pubmed.ncbi.nlm.nih.gov/32630376.
[31] N Birbaumer et al., *The thought translation device (TTD) for completely paralyzed patients*, 8 IEEE TRANSACTIONS ON REHABILITATION ENGINEERING 190–193, 190 (2000); Benjamin Blankertz et al., *The Berlin Brain-Computer Interface: Progress Beyond Communication and Control*, 10 FRONTIERS IN NEUROSCIENCE 1–24, 1 (Nov. 21, 2016), https://www.frontiersin.org/article/10.3389/fnins.2016.00530 ; Francis R Willett et al., *High-performance brain-to-text communication via handwriting*, 593 NATURE 249–254, 249 (May 12, 2021), https://doi.org/10.1038/s41586-021-03506-2 ; Ian Sample, *Paralysed Man Uses 'Mindwriting' Brain Computer to Compose Sentences*, THE GUARDIAN (May 12, 2021), https://www.theguardian.com/science/2021/may/12/paralysed-man-mindwriting-brain-computer-compose-sentences ; Lauran Neergaard, *Device Taps Brain Waves to Help Paralyzed Man Communicate*, TECH EXPLORE (Jul. 15, 2021), https://techxplore.com/news/2021-07-device-brain-paralyzed.html .

surroundings, or during reconnaissance when silence is critical due to the stealth nature of a mission, silent communication will offer a significant benefit.

BCI designed for communication purposes could be a faster, more efficient, and safer method of communication not only among soldiers on the battlefield, but also between soldiers and their commanders.[32] The ability of commanders to receive information from soldiers and transmit orders directly to their brains could transform commanders' ability to direct operations from a distance. The communication from the soldiers could include data that goes far beyond what they might have been able to send verbally over the networks. Their 'words' could be accompanied by simultaneous real time sensory data, as well as other information described above.[33] With this technology, a soldier engaging in hostilities on the battlefield might, for example, be able to summon a drone and issue a firing command on a specific target with extreme precision through thought alone. With the aid of BCIs, soldiers may also be able to directly communicate with a drone in the air while it is surveying the surroundings, thereby avoiding - or preparing for - any perceived danger.

### *Enhanced Functions*

In addition to improved communications, BCI systems provide a myriad of possibilities to enhance soldiers' battle-related capabilities. For example, The Neurotechnology for Intelligence Analysts and Cognitive Technology Threat Warning System visual interface programs both "utilized non-invasively recorded 'target detection' brain signals to improve the efficiency of imagery analysis and real-time threat detection, respectively;"[34] where cognitive algorithms could highlight many events that would otherwise be considered irrelevant, but are actually indications of threats or targets. Moreover, DARPA's The Neural Engineering System Design also sought to develop "high-resolution neurotechnology capable of mitigating the effects of injury and disease on the visual and auditory systems of military personnel."[35] The aim of this programme was to develop neural implants that make it possible for the human brain to precisely communicate directly to computer interfaces.[36]

The military has also taken an interest in transcranial direct current stimulation (tDCS)[37] for enhancing/amplifying the soldier's core cognitive capabilities or baseline performance,

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[32] There will, however, be other safety and security concerns, for example over hacking and other interference.
[33] Cf sub-section on *Monitoring* under "Military uses".
[34] Robbin A Miranda et al., *DARPA-Funded Efforts in the Development of Novel Brain–Computer Interface Technologies*, 244 J. of Neuroscience Methods 52–67, 60 (Apr. 15, 2015), https://www.sciencedirect.com/science/article/pii/S0165027014002702
[35] Al Emondi, *Neural Engineering System Design (NESD)*, DARPA, 2018, https://www.darpa.mil/program/neural-engineering-system-design (last visited Jan 19, 2022).
[36] Today's Medical Developments, *High-resolution, Implantable Neural Interface* (August 3, 2017) https://www.todaysmedicaldevelopments.com/article/darpa-neural-system-design-manufacturing-device-8317/ (last visited Mar 26, 2022).
[37] Transcranial direct current stimulation (tDSCs), or transcranial electric stimulation (tES), is a form of non-invasive brain stimulation, usually through the application of a low-intensity electrical current via electrodes placed on the scalp.

independent of auxiliary conditions, such as fatigue or environmental factors (eg, noise exposure). In 2018, the Air Force Research Laboratory noted that tDCS "significantly improves the participants' information processing capability, which results in improved performance compared to sham tDCS."[38] Although several parameters were identified and studies suggested that this type of stimulation can also increase creativity and cognitive flexibility, perception, attention, accuracy, and boosts memory, further work is required before this type of technology can be recommended for operational use.[39]

Researchers are also studying systems affecting memory, including not only systems that encode and recall memories, but also those that rewrite memories with new data.[40] While these efforts to manipulate, decode, and re-write memory are publicly directed at treating combatants' post-traumatic stress disorder, their military utility goes far beyond treating and preserving the fighting force. For example, manipulation of memories can directly influence soldiers' behaviour and affect their decision making.[41] Moreover, while each BCI has its own application, it is important to note that it could be possible to combine the working of several BCIs and unlock potentials hitherto unconsidered. For example, the combination of biosensors and memory data manipulation has the potential to alter perception and affect a soldier's decision-making far more effectively than either of these systems could do alone.

## - LOAC Implications

The use of BCIs in military operations raises numerous questions under the law of armed conflict. Perhaps the most obvious one surrounds their categorisation as a means or method of warfare and how they are to be regulated under the weapon review process. But the issues to be addressed are far wider. The aforementioned blurring of the human-machine divide also creates challenges in relation to the rules on targeting and complex new problems in the protection of individuals *hors de combat*, as well as concerns over accountability for violations. Although intriguing philosophical questions can be asked about the metamorphosis of the

[38] MARK W VAHLE, OPPORTUNITIES AND IMPLICATIONS OF BRAIN-COMPUTER INTERFACE TECHNOLOGY 13, (Jul. 2020) https://www.airuniversity.af.edu/Portals/10/AUPress/Papers/WF_0075_VAHLE_OPPORTUNITIES_AND_IMPLICATIONS_OF_BRAIN_COMPUTER_INTERFACE_TECHNOLOGY.PDF .

[39] Kathryn A Feltman et al., *Viability of tDCS in Military Environments for Performance Enhancement: A Systematic Review*, 185 MIL. MED. e53–e60, e57-8 (Jan. – Feb. 2020), https://doi.org/10.1093/milmed/usz189; Steven E. Davis & Glen A. Smith, *Transcranial Direct Current Stimulation Use in Warfighting: Benefits, Risks, and Future Prospects*, 13 FRONTIERS IN HUMAN NEUROSCIENCE 1–18 (2019).

[40] Steve Ramirez, *Crystallizing a memory*, 360 SCIENCE 1182–1183 (2018); Pablo Uchoa, *Could Hackers "Brainjack" Your Memories in Future?*, BBC (Feb. 19, 2019), https://www.bbc.co.uk/news/business-47277340; Wake Forest Baptist Medical Center, *Prosthetic Memory System Successful in Humans*, SCI. DAILY (Mar. 27, 2018), https://www.sciencedaily.com/releases/2018/03/180327194350.htm ; Theo Austin Bruton, *Mind-Movies: Original Authorship as Applied to Works From "Mind-Reading" Neurotechnology*, 14 J. OF INTELL. PROP. CHICAGO-KENT J. OF INTELL. PROP. 263–286 (2014).

[41] Joshua J. Tremel et al., *Manipulating Memory Efficacy Affects the Behavioral and Neural Profiles of Deterministic Learning and Decision-Making*, 114 NEUROPSYCHOLOGIA 214-230 (2018), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5989004/.

human body and the human-machine divide in the age of BCI systems, the blurring of lines is not just a conceptual problem of theory, but fast becomes a practical matter with significant legal repercussions. When the machine in this case is a military human enhancement technology - possibly categorised as a means or method of warfare - differentiating between it and the human to which it is attached will be of critical importance for a number LOAC rules.[42] Moreover, the problem runs deeper when we turn to BCI systems with an AI component. In such cases, the brain-computer interaction may include AI-generated data affecting the thought process and decision-making of the soldier. The breaking down of divisions between human and machine will, therefore, involve more than concerns over the lack of physical separation between the two. The extent to which the individual's decisions are based on AI data, and the possibility that the BCI system may even affect the decision-making process itself, create new challenges to how we measure the control the individual has over their actions on the battlefield, including determining their intent and legal responsibility.[43]

### *BCI Reliance on Data from AI Systems*

As noted at the outset, by allowing for the bi-directional flow of data between the brain and a computer system, BCIs can effectively integrate AI and human capacities. For example, an AI system could be utilised to supplement and enhance individual perception and decision-making in a targeting situation. This could involve BCI systems designed to speed up the ability of soldiers to detect and respond to threats. Such a system may include a link to an AI mechanism that alerts the soldier to something their eyes have captured but they had not consciously noticed, by transmitting the images registered by the individual to the AI system for immediate analysis and determination of threat.[44] The system would essentially be the same as a comrade shouting a warning "enemy to your left", but in the form of an internal communication direct to the brain. The soldier could instinctively respond by quickly turning toward the enemy and firing.

While these combinations of the brain and AI may be designed to provide the best of both worlds, there is also the risk of them achieving the exact opposite. Ensuring that such systems do not cause violations of the principle of distinction will necessitate examination of the reliability of the AI threat detection mechanisms.[45] The extensive debates surrounding AI in recent years have examined in great detail the potential risks of delegating certain functions to machines, for example in relation to algorithmic biases.[46] There are many forms and causes of

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[42] Cf to section on "LOAC Implications".
[43] Cf to section on "Accountability and Responsibility".
[44] *See* earlier section on "Enhanced Functions".
[45] Cf to section on "Weapon Review".
[46] MICHAEL ROVATSOS ET AL., LANDSCAPE SUMMARY: BIAS IN ALGORITHMIC DECISION-MAKING 11–13 (2019); INTERNATIONAL LEGAL AND POLICY DIMENSIONS OF WAR ALGORITHMS: ENDURING AND EMERGING CONCERNS, https://pilac.law.harvard.edu/international-legal-and-policy-dimensions-of-war-algorithms (last visited Jan 19, 2022); Ashley Deeks, *Will Autonomy in U.S. Military Operations Centralize Legal Decision-Making?*, LIEBER INSTITUTE (Aug. 5, 2020), https://lieber.westpoint.edu/autonomy_military_operations_decision-making/ ; Wenlong Sun et al., *Evolution and impact of bias in human and machine learning algorithm interaction*, 15 PLOS ONE 1–39 (Aug. 13, 2020), https://doi.org/10.1371/journal.pone.0235502

bias in this context, including conscious or unconscious bias of the human programmers which finds itself built into the AI systems they design. Algorithmic bias can also occur when a machine learning AI system is trained on limited data sets.[47] For example, if the machine learning process for the AI system relied on data from previous conflicts that all took place in the same part of the world, it may associate certain ethnicities with enemy status.[48] These concerns are among the key reasons that many commentators (and states) advocate for maintaining human judgment in the targeting process, to ensure oversight and mitigate risk of flaws.[49]

If the BCI system utilises AI analysis, this opens up the all the familiar problems regarding use of AI data in targeting, since the human in this case could become a conduit for carrying out a targeting action on the basis of a determination made by - and data received from - the AI. Because the objective of using such systems would be to enhance and speed up the reaction time of the soldiers, it is unrealistic to expect them to question the calculations of the system before acting. Moreover, the integration of AI data with the BCI further compounds the existing AI concerns, given that it may become more difficult to differentiate the information sources and could lead to confusing human thought processes with AI calculations.[50] Accordingly, the debates over the risks of biased AI in the targeting cycle, and any measures adopted to reduce such risks,[51] will need to equally inform the development and use of AI-based BCI systems.

### *Weapons Review*

How we categorise BCI systems will affect their legal regulation. Notably, if these are weapons systems, then they must undergo the review process mandated by Article 36 of Additional Protocol I.[52] Not all of the envisaged systems and uses would require such a review, as their

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[47] ARTHUR HOLLAND MICHEL, THE BLACK BOX, UNLOCKED: PREDICTABILITY AND UNDERSTANDABILITY IN MILITARY AI 19 (2020)*; Will Knight, Forget Killer Robots—Bias Is the Real AI Danger*, MIT Technology Review (Oct. 3, 2017); Jonathan Vanian, *Unmasking A.I.'S Bias problem*, 178 Fortune (Jun. 25, 2018).
[48] Yasmin Afina, *International Humanitarian Law Considerations for the Development of AI-enabled Technologies for Military Targeting Operations*, PhD thesis in progress, on file with the authors.
[49] Dustin A. Lewis et al., *War-Algorithm Accountability*, SSRN ELECTRONIC JOURNAL 1–244 (2017); United Nation Institute for Disarmament Research UNIDIR, *Algorithmic Bias and the Weaponization of Increasingly Autonomous Technologies About the Project "The Weaponization of Increasingly Autonomous Technologies,"* 9 1–18 (Aug. 22, 2018), www.unidir.org.
[50] See discussion in section on accountability, *infra.*
[51] Neil Davison, *A legal perspective: Autonomous weapon systems under international humanitarian law*, in Perspectives on Lethal Autonomous Weapon Systems: UNODA Occasional Papers No. 30 5–17, 16–17, https://www.un.org/disarmament/publications/occasionalpapers/unoda-occasional-papers-no-30-november-2017/; Algorithmic Bias and the Weaponization of Increasingly Autonomous Technologies About the Project "The Weaponization of Increasingly Autonomous Technologies" 472–6 (2018), www.unidir.org; Dustin A. Lewis et al., *War-Algorithm Accountability*, SSRN Electronic Journal 1–244, 103–4 (2017); Klaudia Klonowska, *Shifting the Narrative: Not Weapons, but Technologies of Warfare*, ICRC HUMANITARIAN LAW AND POLICY BLOG (Jan. 20, 2022), https://bit.ly/3qLLBLC ; ICRC Position Paper: Artificial Intelligence and Machine Learning in Armed Conflict: A Human-Centred Approach, International Review of the Red Cross 463–479, 471–2 (Mar. 2021), https://international-review.icrc.org/articles/ai-and-machine-learning-in-armed-conflict-a-human-centred-approach-913 .
[52] Article 36 establishes an obligation to review new weapons, stating that "In the study, development, acquisition or adoption of a new weapon, means or method of warfare, a High Contracting Party is under an obligation to

function could, for example, constitute monitoring purely for medical care. There are also, undoubtedly, numerous bioethical concerns that must be considered in the development of these systems.[53] However, taking the monitoring function as an example, if the same system is also capable of affecting the soldier's performance (e.g. through brain stimulation, as discussed earlier) then it may also require a framework of analysis designed for weapon systems. This may also be the case for a BCI that provides a link between the soldier and an AI system for increased perception and faster decision-making in the targeting process.[54]

None of the terms "weapon, means or method of warfare" in Art. 36 are explicitly defined in established LOAC instruments. "Weapon" is generally understood as a device constituting a "means of warfare" or "means of combat" that inflicts injury, death of persons, or damage to or destruction of objects. "Means of warfare" can also appear in conjunction with the expression "methods of warfare"[55] and it is used in a broader sense than just referring to a weapon or combat "for it extends also to platforms and equipment which make possible an attack."[56] Whereas "means" are the tools used during military operations, "methods" refers to the operations themselves and how these means and weapons are used.[57]

Recent writings on human enhancement technologies in the context of weapons review obligations tend to focus on the physical integration of the human and the machine, and whether the fact that they cannot be easily separated might result in the soldier being considered part of the weapon system.[58] The challenge, in fact, goes much further and requires consideration of the fundamental distinction between weapons as tools, and humans as individuals with independent agency. "Weapon" has a relatively straightforward meaning as "an instrument through which an offensive capability that can be applied to a military object or enemy combatant."[59] But for BCI systems, this understanding of "weapon" presents new difficulties, since the use of "instrument" is rendered ambiguous by the organic relationship between the BCI and the soldier.[60] There is a general understanding that weapons are tools subject to human intention, but in the case of certain BCIs the roles may be reversed: the weapon itself can affect the intention. For example, in the case of a BCI system designed to scan for threats, there is a dynamic two-way flow of data influencing the soldier's thought-process even prior to action.

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determine whether its employment would, in some or all circumstances, be prohibited by this Protocol or by any other rule of international law applicable to the High Contracting Party": Protocol Additional to the Geneva Conventions of 12 August 1949, and relating to the Protection of Victims of International Armed Conflicts (Protocol I), art.36, 8 June 1977, [hereinafter API].

[53] These are outside the scope of this paper. For discussion in the context of human enhancement and BCI see, for example Thibault Moulin, Doctors Playing Gods? The Legal Challenges in Regulating the Experimental Stage of Cybernetic Human Enhancement, 54 ISRAEL LAW REVIEW (2021).

[54] *Also see* Klonowska, *Supra* note 51.

[55] Justin McClelland, *The Review of Weapons in Accordance with Article 36 of Additional Protocol I*, 85 REVUE INTERNATIONALE DE LA CROIX-ROUGE/INTERNATIONAL REVIEW OF THE RED CROSS 397–420, 405 (2003).

[56] PROGRAM ON HPCR AT HARVARD UNIVERSITY, HPCR MANUAL ON INTERNATIONAL LAW APPLICABLE TO AIR AND MISSILE WARFARE 50 (2013).

[57] *Id.* at xxiv.

[58] Liivoja & Chircop, *supra* note 5, at 180.

[59] Justin McClelland, 'The review of weapons in accordance with Article 36 of Additional Protocol I' (2003) 85(850) CIAC 397, 404; Some argue that it is unnecessary to include the wordings of "military object" and "combatant", Liivoja & Chircop, *supra* note 5, 175.

[60] *See also* Dinniss & Kleffner, *supra* note 5, at 438; Lin et al., *supra* note 5, at 31–2.

Accordingly, the reliability and accuracy of the BCI system for processing and alerting to threats may need to undergo a weapons review, especially when data input may influence offensive decisions on the battlefield. Moreover, the manner in which the BCI affects the soldier's actions will also require in-depth consideration.

### *Targeting the BCI*

While only certain types of BCIs could be categorised as weapon systems, even the ones that are not weapons might nevertheless be considered as military equipment, with implications for the rules of targeting and protection. Military communications systems, for example, would in most cases be considered a legitimate military objective,[61] and BCI communication devices would therefore likely fall into the same category. Firing a missile at a shipment of BCI crates on an army truck would not entail too many legal problems, but might this assessment change when the BCI is already connected to the individual soldier? At first glance, it would not appear to present a problem, given that the soldier could also be a lawful target; a classic case of two birds with one stone. But there are certain circumstances that may complicate this assessment. For example, let us assume a situation in which it is known that the enemy relies heavily on BCI systems for a combination of communications and enhanced capabilities. In this scenario, it may be possible to damage the BCIs and prevent their functioning by transmitting a strong electromagnetic pulse or by intercepting the data flow and inserting a malicious code into the software. Let us assume that doing so will take down hundreds of BCIs at once and provide a significant military advantage. However, given that these systems are directly connected to the brains of the enemy soldiers, there may be a risk that causing a BCI malfunction would lead to brain damage of the users. This raises two legal questions: first, one of the oldest rules of LOAC prohibits causing superfluous injury and unnecessary suffering.[62] Certain technologies, such as blinding lasers, have been prohibited in large part on this basis.[63] If targeting the BCI systems would lead to excruciating inter-cranial pain or to severe brain damage, this would need to be considered in light of this rule.[64] Second, BCI systems might be in use by soldiers who are not themselves legitimate targets of attack. This could include medical forces, or even combatants who are injured and incapacitated but still have implanted BCIs.[65] Operations to disrupt and damage BCI systems should, therefore, only take place after a review of all the possible

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[61] As a digital device purposely built to military specifications and used to organise and coordinate military operations, making effective contribution to military action. *See also* Heather A. Harrison Dinniss, *The Nature of Objects: Targeting Networks and the Challenge of Defining Cyber Military Objectives*, 48 Israel Law Review, 53 (2015) .

[62] API, art. 52(2), *supra* note 52.

[63] Louise Doswald-Beck, *New Protocol on Blinding Laser Weapons*, 36 INTERNATIONAL REVIEW OF THE RED CROSS 272–299, 273 (1996).

[64] It should be noted in this context that while the rule applies to all weapons, when there is relatively wide agreement on the need to prohibit or regulate a particular weapon, this often leads to attempts at drafting a new dedicated legal instrument on the matter.

[65] A divergence of views exists on whether the proportionality rule applies only to civilians or also to combatants hors de combat. *E.g.* Military Collaterals and Jus in Bello Proportionality, 48 in Israel Yearbook on Human Rights, Volume 48 (2018) 43–61; Geoffrey Corn & Andrew Culliver, *Articles Wounded Combatants, Military Medical Personnel, and the Dilemma of Collateral Risk*, 45 Ga, J. INT'L COMP. L. 445–473, 445 (2017).

foreseeable effects, and it may be that certain expected outcomes would limit the ability to conduct attacks of this kind.

### *Protection of Individuals Hors de Combat*

As noted above, an injured soldier may still be connected to an active BCI. In fact, BCI enhanced soldiers present significant challenges to the protections of individuals *hors de combat* for a number of reasons. Most apparent is the potential for abuse and ill-treatment of detainees.[66] For example, research into systems affecting memory – not only encoding and recalling memories, but also rewriting memories with new data – has been developing rapidly.[67] In the future, there might be a possibility for a military to try and use such systems on captured enemy soldiers to extract data or implant new information. Actions of this type may fall afoul of a number of prohibitions, including those that ban experimenting on detainees, as well as ill-treatment and torture.[68] Conversely, detaining powers aiming to abide by their obligations and provide appropriate medical care to detainees will face challenges of a different nature. BCI systems could be integrated in the individual's body in such a way that requires knowledge of their operation in order to provide medical treatment. If this arises in the case of seriously wounded or sick prisoners of war, then there is an obligation to repatriate them for treatment.[69] However, there may be prisoners who are not in a medically 'serious' condition and nevertheless require treatment that depends on understanding the workings of the BCI. Given that the BCI will not have a publicly available operating manual for obvious security and proprietary reasons, the detaining power may find it difficult to fulfil its obligation of medical care.[70] While this obligation is generally understood as one that takes into account reasonable expectations and available resources,[71] the question arises whether due diligence requires the detaining power to communicate with the enemy (possibly through the ICRC) in a request for information that may be necessary for treatment, or allow remote treatment. If

[66] Dinniss & Kleffner, *supra* note 5, at 446–7.
[67] *E.g.* Ramirez; Yasmin Anwar et al., *Scientists Use Brain Imaging To Reveal the Movies in Our Mind*, Berkeley News (2011); Robert E. Hampson et al., *Developing a hippocampal neural prosthetic to facilitate human memory encoding and recall*, 15 J. OF NEURAL ENGINEERING 1–15 (2018); *and* Wake Forest Baptist Medical Center; Vassilis Cutsuridis, Memory Prosthesis: *Is It Time for a Deep Neuromimetic Computing Approach?*, 13 FRONTIERS IN NEUROSCIENCE 1–9 (2019); Rockefeller University, *Scientists Discover a New Class of Memory Cells for Remembering Faces*, Sciences Daily (Jul. 1, 2021), https://www.sciencedaily.com/releases/2021/07/210701140929.htm (last visited Apr. 1, 2022); Massachusetts General Hospital, *Source of Remarkable Memory of 'Superagers' Revealed*, Science Daily (Jul. 6, 2021), https://www.sciencedaily.com/releases/2021/07/210706133136.htm .
[68] *E.g.,* Rome Statute of the International Criminal Court, art. 8(2)(a)(ii), July 17, 1998, 2187 U.N.T.S. 90 [hereinafter Rome Statute]; Geneva Convention (IV) relative to the Protection of Civilian Persons in Time of War, art. 32, Aug. 12, 1949, 6 U.S.T. 3516; 75 U.N.T.S. 287 [hereinafter GCIV]; API Article 11(5), *supra* note 52; Shereshevsky at 304-307, *Supra* note 5.
[69] Geneva Convention Relative to the Treatment of Prisoners of War, art. 109(1), Aug. 12, 1949, 6 U.S.T. 3316, 75 U.N.T.S. 135 [hereinafter GCIII].
[70] Geneva Convention (I) for the Amelioration of the Condition of the Wounded and Sick in Armed Forces in the Field. Geneva, art. (12), Aug. 12, 1949, 6 U.S.T. 3114, 75 U.N.T.S. 31[hereinafter GCI].
[71] INTERNATIONAL LAW COMMITTEE OF THE RED CROSS, COMMENTARY ON THE CONVENTION (I) FOR THE AMELIORATION OF THE CONDITION OF THE WOUNDED AND SICK IN ARMED FORCES IN THE FIELD OF 12 AUGUST 1949, art. 12, paras 1381-1385 (Jean Pictet ed., 1960).

such a communication is received, the duty of care of the soldier's own State will also need to be considered. These situations need to be taken into account in the development stages of BCI systems to ensure, to the maximum extent possible, that the design of the BCI allows for detained soldiers to receive medical care by providers who do not have operating knowledge of the system.[72]

Beyond the specific challenges surrounding medical care, the future use of BCI systems, along with other enhancement technologies, could have a more profound effect by potentially jeopardising the common understanding of who is entitled to protection - whether they are surrendering forces, wounded and sick, or detained. The protection status of individuals *hors de combat* rests on the fundamental principles of military necessity and humanity.[73] Persons clearly indicating that they no longer intend to engage in hostilities, or who are incapacitated and unable to engage, no longer represent a threat and there is no military necessity in targeting them.[74] However, a particular problem arising from the use of BCIs, especially if they involve embedded technology, is that soldiers may not be able to lay down their arms/devices, potentially leaving them unable to gain protected status and permanently open to targeting by the enemy. To avoid this result, it might be necessary to ensure that any such technology can be 'switched off' by the individual soldier. This solution notwithstanding, there will remain a difficulty when the soldier is wounded: consider a scenario in which the soldier has a surgically implanted BCI that is transmitting information back to headquarters. That information includes not just location data, but potentially also elements of whatever the soldier is seeing and hearing. The BCI continues to operate even after the soldier is incapacitated, continuously transmitting information of military value. How should the detaining power act in this context? Addressing this type of situation may require the development of a process (formally agreed or voluntary) between parties to a conflict, providing some sort of assurance that BCI systems can be de-activated when soldiers are otherwise *hors de combat*. Doing so without compromising security will be a particular challenge.

### *Risk of Perfidy and its Consequences*

The inability to be certain whether the BCI is in operation causes not only protection concerns, but might also facilitate certain war crimes. In particular, BCI-enhanced soldiers could be in a unique position of committing perfidious acts. Additional Protocol I Art. 37(1) defines perfidy as "acts inviting the confidence of an adversary to lead him to believe that he is entitled to, or obliged to accord, protection under the rules of international law applicable in armed conflict, with intent to betray that confidence" and prohibits doing so in order to "kill, injure or capture an adversary".[75] Perfidious acts include feigning surrender or an incapacitating injury, to invite protection. BCI-enhanced soldiers are in a unique position to invite the confidence of the enemy

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[72] *See also* below discussion of the possibility for an 'off switch', *infra*.
[73] David Luban, *Military Necessity and the Cultures of Military Law*, 26 LEIDEN J. OF INT'L L. 315–349, 343 (2013).
[74] Stefan Oeter, *Methods and Means of Combat*, *in* THE HANDBOOK OF INT'L HUMANITARIAN L. 170–245, 186–7 (Dieter Fleck ed.,2021).
[75] API art.37(1), *supra* note 52.

to believe they are *hors de combat* because the enhancement is not physically apparent. A soldier could lay down their visible weapons while silently using a BCI to send information and coordinate a strike. The risk is twofold: in addition to the concern over an enhanced soldier committing perfidy, if and when the use of BCIs becomes commonplace, the opposing side might assume that soldiers have active, hidden BCIs, and therefore be less ready to afford protection.

A perfidious act contains an element of intent to deceive;[76] likewise, the affordance of protection relies upon the trust that the opposing individual does not possess this malicious intent. For a BCI-enhanced soldier to surrender, it may be incumbent upon them to perform a "positive act," to demonstrate the absence of any foul intent.[77] Accordingly, the design and use of BCIs must take into account the need for the individual soldier to convey that their actions are not deceitful, whilst also providing their enemy the assurance that the trust is not misplaced. There are a number of ways in which this could be achieved, and a combination of measures might be necessary. First, BCI enhanced soldiers could, in such situations, explicitly declare the existence of their BCI. Second, they would need to demonstrate that the BCI is no longer usable as a weapon and does not present a threat. This would be analogous to a soldier demonstrably laying down their arms. Third, the opposing forces may need to have a way of verifying the non-active status of the BCI, for example by being able to check that the BCI is not transmitting data (which might be possible without having access to the content of the data stream). This last stage, for obvious security reasons, will be the most challenging one to implement.[78] Utilising an approach of this type would allow for BCI-enhanced soldiers to gain protection status where appropriate, and reduce the risk of them being accused of perfidy. The consequences of failing to do so may be that opponents cease to accept that enemy forces suspected of having BCIs can ever be *hors de combat*. This could subsequently result in extensive denial of protection for those who need it.

### *Accountability and Responsibility*

The use of BCIs also provides a unique twist to the debates taking place over autonomous weapons systems and military AI. A recurring theme in these debates has been the extent to which humans retain control when AI is deployed.[79] Indeed, while the concept of human control remains the subject of disagreement, most States and commentators appear to accept its centrality in the resolution of concerns over the use of AI.[80] Placing a human at the junction of critical decisions (such as engagement of targets) is, for many in these debates, a desirable – and even required – step to ensuring the legality of action.[81] In theory, BCI systems that make

[76] YORAM DINSTEIN, THE CONDUCT OF HOSTILITIES UNDER THE LAW OF INTERNATIONAL ARMED CONFLICT 264 (2004).
[77] HILAIRE MCCOUBREY & NIGEL D WHITE, INTERNATIONAL LAW AND ARMED CONFLICT 227 (1992).
[78] As discussed in the previous section.
[79] Lewis et al. at v–vi, *Surpa* note 47.
[80] United Nation Institute for Disarmament Research UNIDIR, *supra* note 49, at 8–9,.
[81] Convention on Prohibitions or Restrictions on the Use of Certain Conventional Weapons Which May Be Deemed to Be Excessively Injurious or to Have Indiscriminate Effects, Group of Governmental Experts on

use of AI and big data might be answering these demands by connecting the AI to the human and leaving the decision in the hands of the latter. The operation of BCI might therefore serve as a form of keeping a human 'in the loop', and be preferable to a system in which humans are 'on' or 'out of the loop'. The concern in these circumstances, however, is whether the direct flow of data from the AI to the human's brain ultimately renders the human decision as nothing more than the execution of AI commands. The phenomenon of humans trusting machine decisions has been well-documented and is particularly acute with systems designed to provide rapid reaction to incoming threats, such as missile defence systems.[82] BCIs exacerbate these concerns: although the BCI-enhanced human is now technically *in* the loop, the speed and format by which the individual receives the data is such that there may be less room and time to process and question it. Indeed, insofar as the data from the AI is transmitted directly to the brain, the individual may experience the AI input in a manner that is hard to differentiate from the data and brain processes generated from their own senses and thoughts. Further research is required in this area to determine the extent to which the individual is able – experientially and practically – to recognise data received from the AI and maintain control and agency over their own actions. The training in use of BCI systems must therefore include specific elements designed to guide individuals in this regard.

The use of BCIs may also affect the responsibility of commanders. Systems with a monitoring element could provide commanders with a continuous data stream direct from the brains of soldiers on the battlefield. Some of this data could be of use in early detection of soldiers' behaviour or impending action in violation of the law. Such systems could therefore provide a new mechanism for prevention of war crimes. While this application serves as an important and positive tool, increased capabilities will also lead to increased responsibilities. Access to such data could implicate commanders in accordance with the 'should have known' standard applicable to some war crimes.[83] The responsibility of commanders will be even greater if they also have the ability to intervene remotely and affect the soldiers' actions through the BCI (for example through brain stimulation, 'uploading data', or triggering hormone release).[84] In such cases, the responsibility of commanders may be equivalent to issuing direct orders, which would implicate them in violations committed by the soldiers. However, from the soldiers' perspective, BCI-enabled orders may be more consequential than those received in the 'old-fashioned' way.

The use of BCIs problematises individual criminal responsibility of the soldiers themselves in relation to notions of free will and, more specifically, to the mental element of criminal

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Emerging Technologies in the Area of Lethal Autonomous Weapons System 96 (Apr. 19, 2021), https://documents.unoda.org/wp-content/uploads/2020/07/CCW_GGE1_2020_WP_7-ADVANCE.pdf .

[82] United Nations Institute for Disarmament Research UNIDIR, *The Weaponization of Increasingly Autonomous Technologies: Considering how Meaningful Human Control might move the discussion forward*, 2 (Nov. 13, 2014), https://unidir.org/publication/weaponization-increasingly-autonomous-technologies-considering-how-meaningful-human .

[83] Command responsibility is contingent upon the ability to determine that the commander "either knew or, owing to the circumstances at the time, should have known that the forces were committing or about to commit such crimes"; Shereshevsky at 282, *Supra* note 5; *and* Rome Statute, *Supra* note 68.

[84] *See section on* "Monitoring," *supra*.

responsibility. The traditional paradigm in criminal law defines actions in binary terms, i.e. persons are expected to either be in control of their actions (liable) or not in control (not-liable). There must be a culpable state of mind for liability to hold.[85] Depending on how the BCI functions, interventions by commanders could affect the soldier's free will and control over their own actions, thus reducing the latter's criminal culpability. Multi-layered decisions are not new to LOAC; even without technology many decisions have different levels of military hierarchy.[86] In this scenario, however, there is an added complexity to the layering of such decisions. While the traditional understanding of the relationship between "intention","mind" and "responsibility" is already evolving through new findings in neuroscience,[87] BCIs expand the notion of legal personhood[88] and have the potential of altering the notion of criminal responsibility itself. These challenges to personhood and responsibility arise not only from the involvement of commanders and others in triggering or controlling an individual's brain functions, but also as a result of the above-mentioned combination of BCI and AI, which can equally destabilise our conception of what is a conscious and voluntary act, and have implications for individual liability.[89]

## - Conclusion

BCI systems will provide militaries – and individual soldiers – with a world of new possibilities. Everything from communications to targeting could be affected, and with these changes will come a host of new situations previously unenvisaged. The dividing lines between human and machine will not be merely mechanical questions relating to the individual's body and a weapon to which they are attached, but go to the core of our being, to a melding of human thoughts and sensations with machine-generated data.

The law of armed conflict has a long history of adjusting to new technologies and novel means and methods of combat. The fact that BCIs will raise new questions does not necessarily mean that the law cannot answer them. Finding these answers will, however, take some effort. The above sections have begun the work of identifying the legal conundrums that are likely to arise when BCIs are deployed on the battlefield. As we have demonstrated, these questions implicate a wide range of rules relating to everything from the regulation of weapon development, to

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[85] In other words, a person should intend to cause the harm; a principle notoriously coined by Edward Coke 'actus non facit reum nisi mens sit rea', (the act is not guilty unless the mind is also guilty).EDWARD COKE, INSTITUTES OF THE LAWS OF ENGLAND 45 (E. & R. Brooke) (1797).

[86] IAN. HENDERSON, THE CONTEMPORARY LAW OF TARGETING: (MILITARY OBJECTIVES, PROPORTIONALITY AND PRECAUTIONS IN ATTACK UNDER ADDITIONAL PROTOCOL I) 233–41 2009).

[87] Nick J. Davis, *Efficient Causation and Neuroscientific Explanations of Criminal Action*, in NEUROLAW AND RESPONSIBILITY FOR ACTION: CONCEPTS, CRIMES, AND COURTS 124–140, 125–6 (Bebhinn Donnelly Lazarov ed., 2018); Bebhinn Donnelly Lazarov, *Intention as Non-Observational Knowledge: Rescuing Responsibility from the Brain*, in NEUROLAW AND RESPONSIBILITY FOR ACTION: CONCEPTS, CRIMES, AND COURTS 104-123, 104 (Bebhinn Donnelly Lazarov ed., 2018).

[88] Susan W Brenner, *Humans and Humans+: Technological Enhancement and Criminal Responsibility*, 19 B. U. J. SCI. TECH. L. 1–73, 25–6 (2013).

[89] Stephen Rainey et al., *When Thinking is Doing: Responsibility for BCI-Mediated Action*, 11 AJOB NEUROSCIENCE 46–58, 47–8 (2020).

specific rules of targeting and protection. In addition to the need to consider these specific rules, there is a real risk that the use of BCIs would invite mistrust on the battlefield, leading to potential lower adherence to the rules on protection from attack for those *hors de combat*.

A number of the solutions proposed in this paper, such as the built-in ability for soldiers to self-disable their BCIs in order to safeguard their protected status when captured, would require implementation at the development and manufacture stage of the technology. While it is not within the authors' remit nor expertise to propose the precise technological implementation of such solutions, we hope that our analysis and suggestions will aid in the development of systems that can be used lawfully, and reduce the risk of those which are more likely to lead to violations.

There are, undoubtedly, further issues to be examined beyond the scope of this paper. International human rights law, as a separate legal framework, will present additional concerns to be addressed. The most obvious of these is the question of privacy in relation to data recorded from the brain of individual soldiers,[90] as well as matters of equality and non-discrimination which could arise among enhanced and unenhanced soldiers, as well as after their return to civilian life.[91] Attention is slowly turning to these issues, many of which arise in relation to human enhancement more generally, on and off the battlefield. Our focus was intentionally narrower, using the case of BCIs – one of the most transformative of these technologies – to delve deeper into an examination of the legal concerns under the law of armed conflict, and help progress the debate into the next stage of finding solutions so that the technology may contribute to adherence to the law rather than become a mechanism for violation.

[90] Dinniss & Kleffner, *supra* note 5, at 463–4.
[91] *Id.,* at 471–2.