

SOCIO-ETHICAL AND BEHAVIOURAL ASPECTS OF EXOSKELETON IMPLEMENTATION IN SPECIFIC MILITARY MISSIONS

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ABSTRACT

The article explores different socio-ethical and behavioural aspects on the implementation of exoskeleton systems, providing an overview of current debates in this rapidly developing field. It examines the benefits and risks of implementing exoskeleton systems in specific military missions by improving soldiers' physical performance and endurance, reducing the risk of injury, and increasing operational effectiveness. Alongside these positive aspects, the socio-ethical and behavioural implications of the use of these technologies are also considered, with concerns relating to morality and accountability. The research presents a literature-based assessment of the impact these technologies may have on the psychology and behaviour of military personnel, including their sense of autonomy and control. In order to achieve the proposed objectives, a careful analysis of these socio-ethical and behavioural issues will be conducted and measures will be developed to minimize the risks of integrating exoskeleton systems into military missions through deployment strategies and regulatory frameworks that maximize the benefits of exoskeleton systems while reducing the risks and negative impacts on individuals and society as a whole.

KEYWORDS: advanced technologies, exoskeleton system, military missions, socio-ethical and behavioural aspects

1. Introduction

In today's modern society, where creativity and advanced technology are streamlining human activities, the emergence of the exoskeleton system in the military

opens up new horizons and brings with it a number of significant benefits and challenges. Addressing these requires a balanced approach that takes into account the benefits and impacts of these technologies

on society and the individual. Overall, the exoskeleton is a promising technology for improving the physical and operational capabilities of soldiers in military operations. The implementation of this technology into the military arsenal can bring significant benefits to the efficiency and safety of the armed forces. However, it is also important to consider the socio-ethical and behavioural aspects associated with the use of these technologies in the military operational framework to ensure responsible and ethical use.

The augmentation of physical and technological capabilities by the exoskeleton system can be an advantage, but it can also be a vulnerability, which can lead to normal human limits being exceeded. This could lead to misuse and dangerous or destructive behaviour. Soldiers equipped with exoskeletons may be tempted to exceed their natural limits of endurance, putting their health and personal safety at risk, in order to achieve their objectives or gain a tactical advantage. Users may be tempted to act without considering the ethical implications of their actions, relying on the enhanced technological capabilities of their equipment to resolve difficult or conflicting situations. This can lead to escalating conflicts and violence, as the potential for destruction and injury increases when both sides in a conflict are equipped with advanced technologies.

To manage these risks and promote the ethical use of exoskeletons in military missions, education, training, development of regulations and guidelines, implementation of monitoring mechanisms, transparency and socio-ethical accountability should be considered. The socio-ethical and behavioural aspects to be considered in the deployment of these advanced technologies must promote the Kantian principle of “respect for humanity” (Lin, Abney & Jenkins, 2017).

Cognitive robotics is working on giving robots and advanced technologies the ability to motivate, desire, learn or perform tasks (NEURA Robotics, 2022).

To gather information about the outside world, the exoskeleton is designed to have human-like senses that allow it to perceive the world, helping it to make decisions. Movement is also important for this type of exoskeleton, so that it can respond to external stimuli; this requires a complex skeleton to work with the sensors (NEURA Robotics, 2022). This advanced technology must also be able to revise its thinking so that it can erase errors and misjudgments and replace them with new and correct information (Ciria, Schillaci, Pezzulo, Hafner & Lara, 2021). In addition to thinking, exoskeletons need motivation to act. This includes goals, aspirations and preferences. Without motivation, robots may be unwilling to collect new information, which will reduce how well these robots emulate humans. Motivation can be added in one of two ways. Cognitive robotics programmers can add it directly into the technology, or motivation can be manifested through the AI system (NEURA Robotics, 2022). To achieve this, the cognitive robotics branch is trying to create exoskeletons that can perceive the outside world and their environment. This is usually done through advanced sensors, and the system can receive the basic information about the main senses that the human factor normally perceives, i.e. touch/feel, smell, see or hear.

2. Description of Exoskeleton Technology and Capabilities in Military Missions

The exoskeleton is an external, wearable, mechanical device designed to support and enhance the physical performance of the user. This device is inspired by the human skeleton and is designed to support and augment human body movements. A fundamental aspect that distinguishes exoskeletons from other robotic technologies is the intrinsic and close physical interaction with humans, defined as the generation and exchange of a net force flow between both actors (Massardi et al., 2022, p. 3993).

In military missions, the exoskeleton has a number of capabilities and benefits; it can augment the user's physical strength, allowing them to lift and carry heavier loads without overloading the body (Proud et al., 2022). By distributing weight and supporting certain body movements, the exoskeleton can reduce fatigue and physical stress associated with intense and prolonged tasks in military missions. The exoskeleton can also facilitate rapid movement and movement of soldiers in difficult terrain or harsh conditions. And by stabilizing the joints and spine, the exoskeleton can reduce the risk of injury and muscle strain during military operations. Some exoskeletons are equipped with advanced sensors and technologies, such as GPS navigation or communication systems, which can improve situational awareness and coordination within the military team.

The exoskeleton brings many advantages and benefits to the military and military operations. The device allows the military to improve their physical performance by increasing strength and carrying capacity (Proud et al., 2022). It can help lift and carry heavy loads, reducing fatigue and physical stress associated with intensive tasks. It facilitates increased mobility and agility, reduces the risk of injury and physical overload, increases soldiers' resilience and endurance, and helps conserve their energy in the missions they undertake (Dominic et al., 2023, p. 61).

3. Social Impact Assessment of the Implementation of Exoskeleton Systems

The use of exoskeleton-type systems can help to increase solidarity and cooperation between members of the military organization. Soldiers using these technologies can feel more connected and share similar experiences, strengthening their relationships within the organization. The implementation of the exoskeleton can promote a sense of equality and inclusion. Military personnel who benefit from these

technologies can feel more included and have access to the same opportunities and benefits regardless of their physical differences or abilities. The exoskeleton helps to increase trust and a sense of security between members. They can feel more confident in their ability to perform tasks and protect their comrades, which strengthens their relationships within the unit and develops group cohesion. The exoskeleton also provides adaptability and flexibility; making users more confident in their ability to deal with different situations and challenges in the field, which can improve team dynamics and their ability to adapt to unexpected changes. It stimulates users' motivation to improve their performance and push their limits in a competitive atmosphere. It is very easy for people to ascribe mental properties to objects and empathize with them, especially when the external appearance of these objects is similar to that of living beings. This can be used to give the exoskeleton more intellectual or even emotional significance than it deserves (Vincent, 2022).

Overall, the impact on military morale and cohesion associated with the use of exoskeletons depends largely on how these technologies are implemented, communicated and integrated into the organizational culture of the military unit. Appropriate management of these issues can maximize the benefits and contribute to strengthening military morale and cohesion. The implementation of this equipment increases the efficiency and safety of the military by allowing them to move faster and sustain more intense physical effort. This leads to an increase in operational efficiency and can help reduce the risk of injury or exhaustion (Dominic et al., 2023, p. 61), which can boost military confidence and morale. Equalizing the physical capabilities of different members of the organization with different levels of physical fitness can benefit from increased

performance, reducing feelings of inequality and potential tensions within the group.

In conclusion, the use of the exoskeleton within the military organization has a significant impact on social relations and team dynamics, contributing to the strengthening of solidarity, mutual trust and overall performance. It is important that the implementation of these technologies is managed responsibly and ethically to ensure efficient and harmonious integration within military structures.

4. Ethical Aspects of Using Exoskeleton in Decision-Making Processes during Military Missions

Addressing the ethical issues associated with the use of exoskeletons in

military missions involves a delicate balance between autonomy and responsibility. Torrance (2011) suggests that “*artificial (or machine) ethics could be defined as designing machines that do things which, when done by humans, are criterial of the possession of 'ethical status' in those humans*”. The exoskeleton is an advanced technology that gives the military enhanced capabilities such as physical strength and endurance, but also the potential to influence decision-making in the field. In this regard, there are some key ethical issues that need to be considered, such as: human autonomy and control, moral responsibility, technological transparency and accessibility, and impact on conflict and international relations (Vincent, 2022):



Figure no. 1: *Essential ethical aspects*
(Source: Authors' contribution)

➤ **Human autonomy and control:** The exoskeleton offers increased autonomy to the user, allowing him to perform difficult and dangerous tasks more efficiently. However, there are concerns regarding the human control of this technology. The military must always have the ability to control and intervene in the exoskeleton's operation, so that there is no risk of the mechanism taking control during operations.

➤ **Moral accountability:** The use of these advanced technologies also raises

questions about who is responsible for their actions. Military personnel using exoskeletons may be perceived as less accountable for their actions during conflicts, as the technology may compel them to act in ways that would not have been possible without it. It is important to be clear about who is responsible for decisions and actions taken using exoskeletons.

➤ **Technological transparency and accessibility:** The exoskeleton technology must be transparent about its capabilities and limitations. All those involved in their

use, including the military, commanders and researchers, should fully understand how these technologies work and how they can influence decision-making.

➤ ***Impact on conflicts and international relations:*** The use of exoskeletons in military operations may have significant implications for the way conflicts and international relations are perceived. It is important to consider how these technologies can influence power dynamics and the balance of power between states.

➤ ***Privacy and security of personal data:*** The issue of privacy is raised as an aspect of the user's personality and control over information about oneself (Bennett & Raab, 2006). The result is that “*in this vast ocean of data, there is a frighteningly complete picture of us*” (Smolan, 2016, p.1). The exoskeleton is equipped with sensors and technologies that collect data about users, such as body movements or health status. This data is sensitive and could raise concerns about privacy and security of personal data.

The article “*Robotic Systems: Ethical Challenges, Military Utility, and the Autonomy of Weapons*” by Sparrow and Howard (2015) explores the ethical challenges associated with the use of robotic systems in the military field, considering both the military utility of these technologies and the issue of weapon autonomy. By analyzing the growing impact of robotic systems and autonomous weapons on military conflict and society in general, they bring to the fore some of the ethical dilemmas associated with delegating life and death decisions to robots, highlighting concerns about the responsibility and morality of the actions of these systems. There is a need to examine the pros and cons of using autonomous weapons in military conflict, highlighting the benefits and risks associated with these technologies (Sparrow & Howard, 2015).

The first argument is that autonomous weapons systems have the potential to be

more accurate and effective than human-controlled weapons because they are capable of carrying out missions with superior accuracy and consistency. The second argument supports the use of autonomous weapons, which could reduce civilian casualties in conflicts, as they could be programmed to avoid attacking civilians and only prioritize military targets. Another argument considers the protection of the military, as it would eliminate the need for human exposure to battlefield hazards (Sparrow & Howard, 2015). One of the biggest concerns with autonomous weapons is the lack of direct human control over life and death decisions. There is a risk that these weapons may act unpredictably or misinterpret information, leading to catastrophic consequences.

Another drawback is the increased risk of conflict escalation, as it could lower the barrier to entry into conflict and make it easier and quicker to start a war. There are concerns that the use of autonomous weapons could violate fundamental ethical principles, such as the distinction between combatants and non-combatants, and lead to violations of human rights and international humanitarian law.

Moreover, another counterargument is the risk that autonomous weapons could be used unethically and abusively by military or non-state actors, leading to serious and unpredictable consequences in military conflicts (Sparrow & Howard, 2015).

These pros and cons illustrate the complexities and challenges associated with the use of autonomous weapons in military conflict, and highlight the need for a responsible and ethical approach to the development and use of these technologies. It also highlights the need for international regulation and ethical norms for the use of robotic systems and autonomous weapons in military conflict. It is essential to develop control and oversight mechanisms to prevent the misuse and unethical use of these technologies in conflict.

5. Risks of Unethical Use of Exoskeleton Systems and Their Management

The unethical use of exoskeleton systems in military missions can pose numerous risks, and managing these risks is essential to ensure that these technologies are used in a responsible and accountable manner.

The augmentation of physical and technological capabilities by exoskeletons can be both an advantage and a vulnerability, which can lead to normal human limits being exceeded. This could lead to misuse and dangerous or destructive behaviour. Soldiers equipped with exoskeletons may be tempted to exceed their natural limits of endurance, putting their health and personal safety at risk, in order to achieve their objectives or gain a tactical advantage. Users may be tempted to act without considering the ethical implications of their actions, relying on the enhanced technological capabilities of their equipment to resolve difficult or conflicting situations. This can lead to escalating conflicts and violence, as the potential for destruction and injury increases when both sides in a conflict are equipped with advanced technologies. There is a risk that exoskeletons could be overused or misused by the military, leading to exhaustion or serious injury. To manage this risk, it is important to establish clear rules and guidelines for the appropriate use of exoskeleton systems, including rest periods and limitations on use (Vincent, 2022).

Another risk is vulnerability to hacking and tampering. Exoskeletons may be susceptible to these threats, which could allow adversaries to take control of these technologies or affect their operation in dangerous ways. In order to manage and prevent this threat, it is essential to adopt a number of cybersecurity measures and practices, as well as implement advanced encryption protocols for data transmitted between exoskeletons and control systems,

to protect against interception or manipulation by malicious third parties. The use of strong authentication mechanisms can help prevent unauthorised access to the exoskeleton and its control systems.

Ensuring that exoskeletons are regularly updated with the latest security patches can help fix known vulnerabilities and prevent attackers from exploiting them.

This technology requires proper awareness and training of users and military personnel on cybersecurity risks and best practices to prevent them and to reduce the likelihood of exoskeletons being compromised by human error or negligence. In addition to “responsible use”, there is also a need for “responsible design” in this area. Human-Robot Interaction (HRI) pays considerable attention to ethical issues, the dynamics of perception on both sides, and the different interests and complexities of the social context, including co-working (Vincent, 2022). Collaboration between military organizations, the technology industry and the cybersecurity community is needed to share information on cyber threats and security solutions to improve the ability to respond quickly to potential threats.

6. Behavioural Aspects of Exoskeleton System Use

The assessment of the long-term effects of exoskeleton system use on the physical and mental health of military personnel includes muscle overstrain (although this technology reduces some of the physical effort, it can still lead to muscle overstrain in certain areas of the body, such as the shoulders or back, joint problems (the force exerted by the exoskeleton on the joints can lead to wear and tear and even long-term injury), increased risk of injury (although the exoskeleton is designed to protect the user, its use can create new risks of injury, such as loss of natural mobility or dependence on the exoskeleton).

In terms of behavioural and mental health impacts, the military is under

psychological stress as it adapts to the use of exoskeletons, which can trigger stressful stimuli, especially in high-risk situations or hostile environments. Constant use of exoskeletons could lead to a psychological dependency on these devices, which could affect the military's confidence in their own physical abilities. Those who feel dependent on exoskeletons or have difficulty adapting to them could have a negative perception of their effectiveness in the armed forces.

There is a wholly separate issue of whether robots (or other AI systems) should be given the status of “legal entities” or “legal persons” – in the sense in which natural persons but also states, businesses, or organizations are “entities” and can have legal rights and duties. The European Parliament has considered allocating such status to robots in order to deal with civil liability (EU Parliament, 2016; Bertolini & Aiello, 2018) but not criminal liability, which is reserved for natural persons.

7. Risk Mitigation Measures for the Use of Exoskeleton Systems in Military Operations

In order to achieve the proposed objectives of implementing exoskeleton systems in military missions, a careful analysis of the socio-ethical and behavioural issues associated with their use is required. This analysis should cover a wide range of concerns such as: accountability of decisions, transparency of functionality, impact on individuals, individual rights and freedoms of military personnel and others involved in military operations, including the right to privacy and autonomy, and the development of policies and practices to ensure equitable use of these advanced technologies. Based on this analysis, regulatory frameworks and implementation strategies can be developed that maximize the benefits of exoskeleton systems in military operations while minimizing the risks and negative impacts on individuals and society as a whole. These frameworks should include clear standards for the operation and use of

exoskeletons, as well as monitoring and control mechanisms to ensure compliance with ethical and legal principles. At the same time, implementation strategies should focus on educating and training military personnel in the responsible and ethical use of these technologies, as well as promoting an organizational culture that emphasizes respect for individual rights and dignity.

To effectively manage these risks and promote the ethical use of the exoskeleton system in military missions, ways must be found to implement the formalization of socio-ethical issues, responsible training and the promotion of a culture of accountability and ethical compliance within the military. In formalizing the socio-ethical aspects of the use of these advanced technologies, clear and transparent regulations and guidelines for the use of exoskeletons need to be developed and implemented to help prevent misuse and unethical behaviour within the military. Military personnel or users need to be educated and trained in the ethical use of exoskeletons and how to recognise and manage situations where there is a risk of abuse or unethical behaviour.

8. Conclusions

In conclusion, this paper covers a wide range of issues related to the socio-ethical and behavioural use of exoskeleton systems in the military, including issues of autonomy, responsibility, human rights and societal impact. The ethical approach to exoskeletons involves careful assessment of their impact on the military, conflict and international relations, as well as respect for human autonomy and accountability in the use of these advanced technologies. The use of exoskeleton systems in military operations brings significant benefits in terms of soldier performance and safety, operational effectiveness and the maintenance of military superiority, making it a valuable investment for armed forces.

The article concludes by stressing the importance of an ethical and responsible approach to the development and use of

advanced technological systems and autonomous weapons for military purposes, arguing that appropriate regulation and ethical rules are essential to minimize risks and protect human rights in the context of technological developments in the military. The research shows that ethics and ethical challenges should be taken into account in

research dealing with robotics, AI and Human-Robot Interaction (HRI), robot development and the use of advanced technology in different fields of application (especially military). Robot morality and ethics are concepts that deserve interdisciplinary research in this dynamic of innovative technology development.

REFERENCES

- Bennett, C.J., & Raab, Ch. (2006). *The Governance of Privacy: Policy Instruments in Global Perspective*. 2nd Edition, Cambridge, MA: MIT Press.
- Bertolini, A., & Giuseppe, A. (2018). Robot Companions: A Legal and Ethical Analysis. *Information Society, Vol. 34, Issue 3*, 130-140.
- Ciria, A., Schillaci, G., Pezzulo, G., Hafner, V.V., & Lara, B. (2021). Predictive Processing in Cognitive Robotics: A Review. *Neural Comput. Vol. 13, Issue 33, Issue 5*, 1402-1432. Doi: 10.1162/neco_a_01383. PMID: 34496394.
- Farris, D.J., et al. (2023). A systematic literature review of evidence for the use of assistive exoskeletons in defence and security use cases. *Ergonomics, Vol. 66, Issue 1*, 61-87. DOI: 10.1080/00140139.2022.2059106.
- EU Parliament. (2016). *Draft Report with Recommendations to the Commission on Civil Law Rules on Robotics (2015/2103(INL))*. January 27, 2017. Available at: https://www.europarl.europa.eu/doceo/document/A-8-2017-0005_EN.html, accessed on March 06, 2024.
- Lin, P., Abney, K., & Jenkins, R. (2017). *Robot Ethics 2.0: From Autonomous Cars to Artificial Intelligence*. New York: Oxford University Press.
- Massardi, S., et al. (2022). Characterization and Evaluation of Human–Exoskeleton Interaction Dynamics: A Review. *Sensors, Vol. 22, Issue 11*, 3993. Available at: <https://doi.org/10.3390/s22113993>.
- NEURA Robotics. (2022). *Cognitive robots – the new era of true collaboration between human and machine*. Available at: <https://neura-robotics.com/cognitive-robots-the-new-era-of-true-collaboration>, accessed on March 06, 2024.
- Proud, J.K., et al. (2022). Exoskeleton Application to Military Manual Handling Tasks. *Hum Factors, May, Vol. 64, Issue 3*, 527-554. Doi: 10.1177/0018720820957467.
- Smolan, S. (2016). *The Human Face of Big Data*. PBS documentary. 56 mins.
- Sparrow, R., & Howard, M. (2015). *Robotic systems: Ethical challenges, military utility, and the autonomy of weapons*. Routledge.
- Torrance, S. (2011). *Machine Ethics and the Idea of a More-than-Human Moral World*. In Anderson, M. & Anderson, S.L. (Eds), *Machine Ethics* (115–137). Cambridge: Cambridge University Press.
- Vincent, C.M. (2022). *Ethics of Robotics*. In Cangelosi, A. & Asada, M. (Eds), *Cognitive Robotics*. CogNet.