PennState

CLEARINGHOUSE
FOR MILITARY FAMILY READINESS

Human-Machine Integration and Service Member Well-being

Rapid Literature Review

Clearinghouse Technical Assistance Team

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Executive Summary

This report was developed in response to a request from the Integrated Prevention Advisory Group at Ft. Moore, Georgia. The Technical Assistance Team at the Clearinghouse for Military Family Readiness at Penn State (Clearinghouse) was asked to conduct a rapid literature review on the impact of Human Machine Integration (HMI) on Service member well-being. This review sought to answer three questions:

- What are the potential negative impacts of HMI on Service member well-being?
- What should unit leaders consider or understand regarding the impact of HMI on Service member well-being?
- What implications do the above findings have for Army leadership in developing HMI policy and procedures?

HMI describes the interaction and interface between humans and machines, including robots, drones, and unmanned aerial systems for military operations (Galliott, 2018; Johnson, 2023). HMI can present significant challenges to Service member well-being and operational effectiveness. Researchers point out that, at a minimum, drone operators experience the same mental health challenges as those in more conventional roles, including post-traumatic stress disorder and trauma-related symptoms. For example, higher levels of psychological distress are observed in drone and intelligence operators, and these individuals have a notable risk of moral injury due to ethical concerns when engaging in remote warfare. The integration of autonomous systems may also erode unit cohesion and trust, which could, potentially, lead to feelings of social isolation and stigma consequences for robotics and drone operators. In addition, there is a risk of disrupting Service members' sense of autonomy and purpose, and this could diminish their perceived impact and prompt deskilling and overreliance on technology. Physical health concerns, particularly increased sedentary behavior and fatigue among operators, have also been identified.

These findings have important implications for military leadership. This review found that a human-centric approach in HMI design and implementation should be prioritized, and the risks of deskilling and loss of situational awareness should be addressed. Leaders must combat automation bias and complacency through targeted training and transparent system design. Facilitating seamless human-machine collaboration and embedding ethical considerations into HMI development are also essential. Continuous investment in training and education, and the promotion of open dialogue and feedback mechanisms, will be vital in navigating these challenges.

To address these issues effectively, several evidence-informed recommendations are proposed.

- Implement comprehensive mental health support programs, and develop strategies to maintain unit cohesion in technology-mediated environments.
- Create opportunities for leadership and moral development, and design training programs that balance technology use with critical-thinking skills.
- Establish clear policies on human control over mission-critical functions, and incorporate regular assessments of the physical health impacts on Service members who fill HMI roles.

By proactively addressing these challenges, military leaders can harness the benefits of HMI while safeguarding personnel well-being and maintaining operational effectiveness in an increasingly automated battlespace.

Note, this report provides a preliminary examination of the research. It is not intended to serve as a comprehensive review of the literature, and the Clearinghouse does not endorse the resources provided. The information about the resources is provided to help professionals make a data-driven decision about possible next steps in research, development, implementation, or evaluation.

Introduction

The Technical Assistance (TA) team at the Clearinghouse for Military Family Readiness at Penn State conducted a rapid literature review on the impact of Human Machine Integration (HMI) on Service member well-being. HMI describes the interaction and interface between humans and machines, including robots, drones, and unmanned aerial systems for military operations (Galliott, 2018; Johnson, 2023). This review examined research and recommendations that focused on the human component of HMI, and these were found exclusively in professional trade journals, academic publications, and government sources. Search queries included combinations of the following terms: Human Machine Integration, HMI, Robotics, Drones, Military, Service member, well-being, and readiness. Search platforms included Google Scholar, Elicit, Consensus, Perplexity AI, Semantic Scholar, and general Google web search.

Potential Negative Impacts of HMI on Service Member Well-Being

When researching and preparing this report, the TA team determined there is limited research that examines the psychological effects of HMI in military settings. While studies

have identified potential mental health risks for drone operators, such as emotional disengagement, post-traumatic stress disorder (PTSD), emotional exhaustion, and burnout, studies that assess risks for other individuals in similar positions (e.g., unmanned aerial systems operators) were not located, so this review focuses on drone operators and their experiences. One reason for the lack of research may be that access to military personnel and data are often restricted due to security concerns. As a result, research designs may be weaker and rely on self-reported data, which can lead to underreporting of mental health issues. Most available research originates from the U.S. Air Force, and little is known about the mental health and well-being of drone operators from other Service branches. Furthermore, existing research may not adequately capture the evolving nature of HMI in the military particularly as new technologies, such as autonomous systems, are rapidly integrated into defense operations. Therefore, these limitations should be considered when interpreting findings and determining how to advocate for more robust, transparent research on the impact of HMI on military personnel.

Mental Health

PTSD and Other Trauma-Related Issues

Despite the perceived benefits of remote warfare, such as reduced physical risk, drone pilots experience similar levels of PTSD and other trauma-related symptoms as fighter pilots. Pilots of traditional manned aircraft typically have little personal knowledge of their targets, quickly depart after launching their weapons, and do not stay to observe results. While drone operators may be geographically distant from their targets, they often develop a deeper psychological connection due to experiencing an extended surveillance and witnessing the consequences of their actions firsthand (Armour & Ross, 2017; Konigsburg, 2022).

Psychological Distress

Studies have revealed higher levels of psychological distress in drone and intelligence operators compared to control groups (Armour & Ross, 2017). This distress can stem from factors including the consistent exposure to high-resolution images of killing people, the pressure of making life-or-death decisions remotely, and the perceived disconnect between actions and consequences (e.g., drone operators viewing the battlefield through a screen often feel disconnected from the immediate consequences of a battle). In addition, an individual's limited ability to influence events once they have been authorized can contribute to operational stress. Boundaries between human operators and drone Artificial Intelligence technology are often blurred, and this situation can create a complex interplay of psychological, emotional, and spiritual challenges. The dissonance between

actions and consequences, especially compared to traditional risk profiles where the operator may feel more connected to the inherent risk of a mission, and the moral dilemmas of remote warfare may have a profound impact on an operator's well-being (Armour & Ross, 2017; Galliott, 2018; Johnson, 2023; Konigsburg, 2022).

Moral Injury

Using autonomous systems in warfare raises ethical concerns, which may lead to moral injury in Service members. The act of killing, even remotely, or taking human life from a distance can clash with an individual's moral values and cause feelings of guilt, shame, and a loss of faith in oneself or others. In addition, witnessing, perpetrating, or failing to prevent acts that violate deeply held moral beliefs can lead to spiritual or emotional distress, and this may further increase a Service member's the risk of developing PTSD (Galliott, 2018; Konigsburg, 2022).

Unit Cohesion and Social Well-being

Erosion of Trust and Camaraderie

Integrating autonomous systems into military units can affect unit cohesion, which relies heavily on trust, shared experience, and individuals' abilities to anticipate others' actions. For example, Soldiers might be hesitant to fully trust robots that could potentially report their mistakes or infractions. Additionally, the reliance on technology for communication, especially in remote operations, can hinder the development of the same level of trust and camaraderie built through shared experiences in the field (Galliott, 2018; Phillips et al., 2023).

Social Isolation and Stigma

Operating in remote environments, coupled with the potential stigma associated with the robotics operator's role, can contribute to social isolation and may negatively impact Service members' well-being. These factors, in addition to the increased mental workload associated with monitoring multiple autonomous systems, could create or worsen existing mental health issues like anxiety, depression, and burnout (Galliott, 2018; Konigsburg, 2022).

Autonomy and Sense of Purpose

Disruption of the Power Process

The increasing autonomy of machines could disrupt what Galliott (2018) refers to as the "power process," which involves setting goals and taking autonomous actions to achieve them. This disruption could arise from the perceived or actual loss of control over decision-making, especially in situations where Service members feel relegated to merely monitoring or supervising highly automated systems. This situation could lead to a diminished sense of agency and purpose, which may, ultimately, impact operational readiness and well-being (Galliott, 2018).

Potential for Deskilling and Overreliance on Technology

As machines take over more tasks, Service members may develop an overreliance on technology, and technological advancements often diminish the importance of specific Service member skills that were previously essential for completing a task. This reduction or loss of expertise is referred to in this report as deskilling (Galliott, 2018). Dependence on technology can make it challenging for Service members to function effectively when technology fails or is unavailable, which can lead to feelings of inadequacy and may compromise mission success. Service members who become overly reliant on autonomous systems may not be as capable of reacting effectively in critical situations. Moreover, the potential for automation bias, where operators overestimate the system's accuracy and fail to question its output, could have severe consequences. The USS Vincennes incident illustrates this situation in which a complex automated naval weapons system misidentified an Iranian airliner and fired on it, and 300 people were killed (Galliott, 2018; Johnson, 2023; Phillips et al., 2023).

Physical Health

Sedentary Behavior and Fatigue

The nature of operating robots or semi-autonomous systems often involves long hours of sedentary work, which can negatively impact physical health. When inadequate physical activity is combined with potential sleep disturbances, a range of health problems could arise, such as cardiovascular disease, diabetes, and lowered psychological resilience (Armour & Ross, 2017).

This list of potential health concerns is not exhaustive, and, as mentioned above, the sources primarily focus on the experiences of drone operators. The specific impacts of HMI on Service member well-being are likely to vary depending on factors such as the specific technologies involved, the nature of the tasks, and individual psychological characteristics. Engaging in continued research is crucial to fully understand and mitigate the potential negative consequences of HMI on Service member well-being.

Considerations For Unit Leaders Regarding the Impact of HMI On Service Member Well-Being

Unit leaders may want to consider multiple factors when addressing the impact of HMI on Service member well-being. By taking a proactive, multifaceted approach to the challenges mentioned in this review, unit leaders can create a work environment that supports the well-being, morale, and operational effectiveness of Service members in an increasingly technology-driven military landscape. To do so, they should consider the following evidence-informed strategies.

Acknowledge and Address Operational Stressors

Unit leaders should aggressively implement strategies to mitigate the impact of operational stressors on the Service members under their command. This includes carefully managing work hours, ensuring a healthy work-life balance, and providing adequate staffing levels to prevent burnout and promote a sustainable operational tempo (Armour & Ross, 2017; Konigsburg, 2022).

Cultivate a Supportive Environment for Mental Health

Units should foster a culture of openness and support where Service members feel comfortable discussing mental health concerns without fear of negative repercussions. This involves actively promoting mental health resources, ensuring confidentiality, and challenging any stigma associated with seeking help for mental health issues (Armour & Ross, 2017; Konigsburg, 2022).

Provide Comprehensive Health and Well-being Support

Leaders should prioritize a holistic approach to Service member well-being and address the mental and physical health challenges that can arise from prolonged exposure to HMI and autonomous systems. A holistic approach may include offering programs to promote physical activity, providing ergonomic workstations to mitigate the risks of sedentary work, and ensuring access to a range of healthcare professionals who are equipped to address the unique needs of this population (Armour & Ross, 2017; Konigsburg, 2022).

Prioritize Moral and Leadership Development

To counterbalance the potential impact of autonomous systems on moral and leadership development, unit leaders could actively create opportunities for Service members to exercise and strengthen skills, such as decision-making and communication. In addition, incorporating ethical dilemmas into training scenarios, providing chances for leadership

in training and non-combat settings, and encouraging mentorship opportunities can help fill potential gaps in experience (Galliott, 2018).

Promote Unit Cohesion in the Age of HMI

Units should implement strategies to foster unit cohesion in an increasingly technology-mediated environment. This could involve organizing team-building activities that promote trust and understanding for Service members regarding the autonomous systems they operate. Additionally, striking a balance between technology-driven communication and face-to-face interactions can help maintain the strength of interpersonal connections within the unit (Galliott, 2018).

Recognize Individual Differences in Technology Adaptation

Leaders should acknowledge that Service members will adapt to new technologies at different paces and comfort levels. Providing individualized training programs and taking into account factors such as age, prior experience with technology, and personal preferences can help ease the transition to HMI systems and reduce potential anxiety for the Service member (Armour & Ross, 2017; Galliott, 2018; Johnson, 2023).

Promote Realistic Expectations of HMI and Autonomous Systems

While building trust and confidence in HMI and autonomous technologies are important, unit leaders should also emphasize that these systems are not infallible and require human oversight. Educating Service members on the potential limitations and inherent biases of these systems encourages critical thinking and prevents overreliance (Armour & Ross, 2017; Galliott, 2018; Johnson, 2023).

Recognize the Potential Role of Religious and Spiritual Support

Units should be mindful of the important role that religious or spiritual practices can play in supporting the well-being of their Service members, particularly in those who work in high-stress environments. Providing access to chaplains, accommodating religious practices, and creating space for spiritual expression can offer solace, guidance, and a sense of community (Konigsburg, 2022).

Advocate for Continuous Research and Development

Unit leaders are well positioned to advocate for continued research into the impact of HMI on the well-being of military personnel. By staying informed about the latest research findings and advocating for the implementation of evidence-based strategies and HMI system designs that prioritize human well-being, unit leaders can contribute to a more

supportive and resilient military force (Armour & Ross, 2017; Johnson, 2023; Phillips et al., 2023).

By taking a proactive and multifaceted approach to understanding and addressing the challenges of HMI and autonomous systems, unit leaders can create a work environment that supports the well-being, morale, and operational effectiveness of their Service members in an increasingly technology-driven military landscape.

Implications For Army Leadership in Developing HMI Policy and Procedures

The research findings have significant implications for Army leadership in developing HMI policies and procedures. By implementing the following strategies based on this review's interpretation of the best available literature, Army leaders can develop HMI policies and procedures that balance operational effectiveness with ethical considerations in an increasingly automated battlespace.

Prioritize a Human-Centric Approach

The research consistently emphasizes that HMI design and implementation should prioritize the human element. Army leaders should not view Soldiers as mere components within a technological system; instead, they should ensure humans remain central to decision-making and retain control over mission-critical functions. Policies and procedures should reflect this human-centric approach and emphasize the importance of human judgment, ethical reasoning, and leadership in an automated battlespace (Robelski & Wischniewski, 2016).

Address the Risk of Deskilling and Situational Awareness Loss

Researchers highlight the potential for automation to erode critical skills and diminish situational awareness among Soldiers. Army leadership should develop HMI policies and procedures that mitigate this risk by emphasizing continuous training in manual skills, promoting adaptive expertise, and encouraging Soldiers to maintain vigilance and actively question automated systems. For example, policies could mandate regular exercises that require Soldiers to perform tasks manually, even when automated options are available (Galliott, 2018).

Combat Automation Bias and Complacency

The sources caution against automation bias, which is a situation in which humans overestimate the capabilities of automated systems. Army leaders need to address this

issue through training and system design. Training should include educating Soldiers on the limitations of automation and providing strategies for recognizing and responding to potential errors. HMI systems should be designed to present information transparently, so system limitations are clearly indicated and will prompt human verification of critical decisions (Johnson, 2023).

Facilitate Seamless Human-Machine Collaboration

Effective HMI relies on seamless collaboration between humans and machines. Army leadership should prioritize policies and procedures that foster effective communication and trust within hybrid teams. This includes developing intuitive interfaces, standardizing procedures for human-machine handovers, and addressing potential challenges posed by information overload or alarm fatigue (Johnson, 2023).

Embed Ethical Considerations into HMI Development

Researchers raise ethical concerns related to the use of autonomous systems, particularly regarding moral agency, accountability, and unintended consequences. Army leadership must ensure that HMI policies and procedures explicitly address these concerns. This includes integrating ethical guidelines into algorithm development, establishing clear chains of responsibility for human-machine decisions, and fostering a culture that prioritizes ethical reflection and decision-making at all levels (Johnson, 2023; Konigsburg, 2022).

Invest in Continuous Training and Education

The rapid pace of technological change necessitates continuous training and education for Soldiers who operate within HMI environments. Army leadership should invest in training programs that impart technical skills and foster critical thinking, ethical reasoning, and adaptability. Training should evolve alongside advancements in HMI to ensure Soldiers are equipped to operate effectively and ethically in an increasingly complex and automated battlespace (Phillips et al., 2023; Robelski & Wischniewski, 2016; Tam et al., 2021; Welfare et al., 2019).

Promote Open Dialogue and Feedback Mechanisms

Army leaders should foster a culture of open dialogue and feedback regarding HMI systems and procedures. Soldiers on the ground often have valuable insights into the practical challenges and ethical dilemmas posed by these technologies. By establishing channels for feedback, leaders can identify potential issues early, develop policies and procedures as needed, and ensure HMI implementation aligns with operational

effectiveness and ethical considerations (Armour & Ross, 2017; Robelski & Wischniewski, 2016).

By carefully considering these implications and adopting a proactive and human-centered approach to HMI policy and procedure development, Army leadership can harness the potential benefits of using advanced technologies while mitigating risks for the individuals who utilize these technologies and safeguarding the core values of the military profession.

Conclusion

HMI in military operations presents opportunities and challenges for Service member well-being. This review has highlighted several key areas of concern, including mental health risks, potential erosion of unit cohesion, disruption of autonomy and sense of purpose, and physical health impacts. To address these challenges, military leadership must take a proactive and multifaceted approach:

- implement comprehensive mental health support programs,
- develop strategies to maintain unit cohesion in technology-mediated environments,
- create opportunities for leadership and moral development, and
- design training programs that balance technology use with critical-thinking skills.

As the military continues to advance its technological capabilities, establishing and maintaining a human-centric approach in HMI design and implementation are critical. This involves addressing risks of deskilling, combating automation bias, facilitating seamless human-machine collaboration, and embedding ethical considerations into HMI development. Continuous research, open dialogue, and adaptive policies are strategies that can help leadership and Soldiers navigate the complex landscape of HMI in military settings. By prioritizing Service member well-being alongside technological advancements, the military can harness the benefits of HMI while safeguarding the health, cohesion, and effectiveness of its personnel.

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