DOI: https://doi.org/10.52651/ntpp.b.2024.9788080406486.11-28

THE USE OF DIGITAL LEARNING AND NEUROSCIENCE IN THE HUMAN-AI-EXPERIENCES (HAX) TRAINING OF MILITARY PERSONNEL

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Abstract:
The aim of the article is to present the possibilities of using digital learning and knowledge regarding the influence of selected neurotransmitters on the learning process in the education and training of soldiers. The analysis concerns training focused on cooperation between soldiers and artificial intelligence. The research process used the literature review method and a diagnostic survey. It was found that in areas such as: Reconnaissance, Military means of destruction, supporting operations and Cryptology, digital learning tools should be developed as complementary training to physical tactical training. At the same time, knowledge about the influence of neurotransmitters such as dopamine, acetylcholine, cortisol, etc. on the course of cognitive processes, memory and learning effectiveness should be transferred to the military training environment.

Keywords: *Human-AI-Experiences, Digital learning, Neuroscience, Military training*

INTRODUCTION

Digital transformation is a strategic initiative that incorporates digital technology across all areas of an organization (processes, products, operations, etc.) to improve operational efficiency. The strategic nature of this change involves a holistic transformation of the organization: Business Models, Operational Processes and Customer Experiences (Morakanyane et al., 2017). Digital transformation is not only a change in the way an organization operates through the use of digital technologies and data, but above all, a change in the mentality of people (owners, managers and employees, customers, etc.). Meeting the expectations of all stakeholders is a core component of digital transformation. According to McKinsey research (2023), several drivers can be identified that are necessary to build a robust digital transformation framework effectively: strategy, data (no digital transformation will work unless the organization can identify, manage, and analyze the data they have produced), talent (organizations that incorporate new tools like generative AI, machine learning, Internet of Things and advanced data platforms also need to train their employees to use them) and operating model (new technology and agile processes will matter little if the organization's culture and hierarchy remain the same).

However, the concept of digital transformation does not apply only to economic organizations. It also finds an important place in the military sector. Modern battlefield strategies are evolving from the Multi Domain Operations (MDO) to the Joint All-Domain Operations (JADO) approach (Terino, 2020). In both cases, the key role is played by the continuous availability and exchange of information between devices from the ground, water and air segment during hostilities. Therefore, the key task of the military systems is not only to keep up with the technical aspect of JADO, but also to prepare soldiers (at various levels of command) to act within this system (Voltz et al., 2021). JADO enables commanders to make better decisions by collecting data from different sensors, processing the data using AI algorithms to identify targets, then recommending the optimal weapon to engage the target. So, more attention should be paid to cadet's education and soldiers development as an emerging activity of military systems.

Personnel development, understood as an organized and formalized system of professional development for officers and non-commissioned officers, is of key importance in the system of managing the competences and qualifications of soldiers (Sylwestrzak, 2023). Therefore, the development of methods and techniques of military andragogy becomes particularly important. Assuming that in the field of professional skills training, the training environment should be as consistent with the real environment as possible (i.e. with the environment of task implementation/work), the challenges of the battlefield should be confronted with the challenges in the field of military training (Czainska et al., 2023). This article focuses on the issue of soldiers' cooperation with devices equipped with artificial intelligence. Therefore, the following research questions were formulated:

1/ in what areas of military operations will the use of AI develop?
2/ whether the use of digital learning can be a basic form of military training?
3/ what neurotransmitters play a key role in the cognitive and learning process?
4/ can knowledge about the influence of selected neurotransmitters (identified on the basis of question no. 3) be used in digital learning?

Searching for the answer to the first question, a pilot survey was conducted on a group of officers with various professional experience in the army. In order to identify new trends in the development of competences, selected solutions in the field of neuroscience and digital learning were analyzed.

1 HUMAN – AI – EXPERIENCES (HAX) – A NEW TREND IN THINKING ABOUT COOPERATION OF HUMAN AND TECHNOLOGY

The technological component is an important element of the modern battlefield. Therefore, in addition to general analyses of the relationship between the macro-environment and the military sector, key entities analysing the military situation in the world have developed a set of technological trends that may have an impact on maintaining an appropriate level of security. For example, NATO has indicated the following directions of changes that will have the most significant impact on the operational environment in the

perspective of: a) short-term (up to 6 years) - Additive Manufacturing, Everywhere Computing, Predictive Analytics, Social Media, Unmanned Air Vehicles); b) medium-term (up to 20 years) - Advanced Materials, Augmented Reality, Mixed Reality, Sensors Are Everywhere; c) long-term (over 20 years) - Artificial Intelligence, Electromagnetic Dominance, Hypersonic Vehicles, Soldier Systems (NATO, 2017). The above challenges are also reflected in scientific works, which emphasize the importance of the new e-environment associated with highly powerful web technology and mobile communication, i.e. mobile applications (Cristofaro, 2020), Machine Learning, Neural Networks, Artificial Intelligence (Kemp, 2021), development of ERP systems and the entire sphere related to the use of Big Data (Wang et al., 2019).

The direction of change in military education should be towards developing a new mental model of cadets and soldiers regarding cooperation with devices equipped with artificial intelligence; This change concerns the expansion of the perception of the usefulness of AI from a purely computational function to a multi-tasking support object. So, it is worth pointing out that the concept of AI does not refer to one specific solution. The following types of AI can be distinguished:

- artificial narrow intelligence (ANI) - refers to intelligent systems that do specific tasks (i.e. games playing);
- artificial general intelligence (AGI) – refers to agents whose intelligence is equivalent to human agents (AGI can be equivalent to HLI);
- human-level-intelligence (HLI), which defines an agent that is equivalent to a human agent in terms of thinking and acting capabilities;
- artificial super intelligence (ASI) – comes in three varieties: Speed ASI, collective ASI, and quality ASI. Speed ASI refers to an agent faster than a human, collective ASI refers to decision-making capabilities similar to a group of humans, and quality ASI refers to an agent that can do work that humans cannot (Saghiri et al., 2022).

Due to the definitional complexity of the concept of AI, it was assumed that further considerations would be carried out without distinguishing a specific type of AI.

Focusing on the issues of AI, in the context of this article, it is worth citing the work of Rania Afiouni (2021), in which the author conducted a bibliometric analysis of the business and management literature on AI and identified four emerging topics: 1/ AI and Industry 4.0 technologies; 2/ AI and Robotics; 3/ AI in Marketing and Commerce; 4/ AI Adoption and Acceptance. The fourth group of publications covers motivational and behavioral issues. These aspects have been discussed so far in works in the field of "Human-Robot Interaction" (HRI) and "Human-Computer Interaction" (HCI).

Currently, research is being developed in the field of “Human – AI – Experiences” (HAX). The concept comes from the name of the team initiated by Microsoft Corporation, which brings together specialists in the field of HCI, AI, and software engineering "to advance the state-of-the-art in human-AI collaboration with a focus on leveraging the capabilities of people and AI-based agents and systems” (Microsoft, 2024). The team's work covers, among others: Human interaction and complementarity with AI and large language models (LLMs);

AI agents, multi-agent systems, and human-AI teaming; Foundation model, agent, and multi-agent system evaluation and understanding; AI and agent development tools; Responsible and human-centered AI; Information retrieval and retrieval augmentation; Personalization and adaptation; Interactive machine learning and machine teaching; Applications including AI-assisted programming, information visualization, search and recommendations.

Behavioral research related to HAX, conducted by scientists around the world, concerns such issues as: building trust, team decision-making, team imagination, mental modeling, and communication. The following thematic groups of research works are also indicated:

- Virtual assistants: AI-powered assistants can understand and respond to human voice commands, perform tasks, provide information, and assist with various daily activities;
- Natural language processing: enables AI to interpret and respond to text or speech inputs, facilitating communication between humans and machines;
- Autonomous vehicles: AI systems analyze sensor data, make real-time decisions, and assist human drivers in navigation, collision avoidance, and traffic management;
- Healthcare: AI can assist with diagnosis, treatment planning, and patient monitoring;
- Education: AI can enhance the learning experience by providing personalized tutoring, adaptive learning platforms, and intelligent feedback (IDF, 2024).

Knowledge of the fields indicated above is important for people responsible for military training and education, because in this way they learn about competence gaps that should be eliminated in the process of educating soldiers of a modern army. The competence gap of soldiers in cooperation with AI has been noticed by most armies.

2 NEUROSCIENCE OF LEARNING TO DIGITAL EDUCATION ENVIRONMENT

Assuming that the training environment and system should be consistent (or even identical) with the task execution environment, solutions called digital learning are recommended for training in the "soldier - AI" system. The basic meaning of "digital learning" comes from "e-learning" and means a set of technology-mediated methods that can be applied to support student learning and can include elements of assessment, tutoring, and instruction (Wheeler, 2012). The author of the definition also indicates an important difference between "learning using technology" and "learning through technology"; in the first case the technology is being used as one method amongst many others; in the second case, the technology is the sole conduit through which the student receives instruction and communicates with his instructor. The symptom of a change in the approach to modern education is therefore not only semantic. The use of the word "learning" instead of "teaching" in the names of individual forms of education (i.e. digital learning, immersive learning, long-life learning, e-learning, virtual learning, etc.) indicates primarily the support of self-education by digital systems equipped with AI. The student is the active entity in the learning process. Taking into account the above features, concepts have been developed in the literature that expand the meaning of "digital learning" to include the following components:

a) personalized digital learning (PDL) - systems enable teachers/creators to tailor their instruction to individual students' needs and learner characteristics (Maier, Klotz, 2022);
b) next generation digital learning environment (NGDLE) - which characterizes the learning environment as an ecosystem - a dynamic, interconnected, ever-evolving community of learners, instructors, tools, and content (Brown et al., 2015).

Effective use of digital learning, especially in the context of training on human cooperation with artificial intelligence, requires mental support for all involved entities, i.e. student, teacher, system creator, tutor, etc. Solutions in this area are offered by, among others: neuroscience. At least two aspects of the application of neuroscience knowledge in training can be distinguished (Collins, 2019):

a) neurobiological basis of memory and learning mechanisms,
b) stimulation of neurotransmitters and brain hormones.

The above assumption shows that, first of all, digital learning solutions should be created by interdisciplinary teams to combine the following sources of knowledge: content (e.g. regarding the construction of combat vehicles), pedagogical (indicating effective training methods), technology (indicating technological solutions supporting the training process) and merged *Mind, Brain and Education* learning (MBE) sciences (explaining biological mechanisms of learning) (Tokuhama-Esponosa, 2021). The basic principles resulting from the MBE concept for digital learning include:

1) uniqueness – while the basic structure of most humans' brains is the same (sililar parts in similar regions), no two brains are identical; the genetic makeup unique to each person combines with life experiences and free will to shape neural pathways;
2) different potentials – each individual's brain is differently prepared to learn different task; learning capacities are shaped by the context of the learning, prior learning experiences, personal choice, an individual's biology and genetic make up, pre-and peri-natal events and environmental exposures;
3) prior experiences – all new learning passes through the filter of prior experience; the efficiency of the brain economizes effort and energy by ensuring that external stimuli are first decoded, compared, both passively and actively, with existing memories;
4) constant changes – the brain is a complex, dynamic, integrated system thai is constantly changed by individual experiences; these changes occure at a molecular level either simultaneously, in parallel, or even before they are visible in behaviour;
5) neuroplasticity - is the brain's ability to adapt and change; it is a term that refers to the ability of the nervous system to respond to internal or external stimuli by restructuring and reorganizing the structure and function of the brain and expanding neural networks; structural and functional changes come from brain damage, environmental changes, new experiences, or structural changes attributed to learning; neuroplasticity helps humans adapt to physiological changes, new experiences and environmental pressures; this happens by creating new connections between neurons;

6) memory and attention systems – both systems are vital for learning; “memory” is not the same as offering “memoristic” activities in which mindless repetition replaces meaning, but rather that memory involves deeper learning, ehich can be retrived and transferred to new contexts with ease.

Communication between nerve cells that create memory networks takes place using chemical signals generated by neurotransmitters. From the point of view of learning processes, but also other aspects of shaping soldiers' behavior, it is important to know the impact of neurotransmitters on basic behavioral activities, such as: learning, risk-taking, decision-making, socialization, empathy, etc. The attention of management, command and leadership practitioners should be paying particular attention to the following neurotransmitters: dopamine, oxytocin, serotonin, endorphins, acetylcholine, testosterone, cortisol, GABA. Neurotransmitters can have an impact on our work because they influence our behavior, our state of mind, our energy, and consequently our fatigue (Aboiron, 2022).

Dopamine is a critical modulator of both learning and motivation (Berke, 2018). Oxytocin induces a general sense of well-being including calm, improved social interactions, increased trust, and reduced fear as well as endocrine and physiological changes (IsHak et al., 2011). Serotonin, also known as 5-hydroxytryptamine (5-HT), is an important neurotransmitter, growth factor and hormone that mediates a range of physiological functions; 5-HT is centrally in the control of mood, sleep and anxiety and peripherally in the modulation of gastrointestinal motility; additionaly appreciated role for 5-HT has emerged, however, as an important metabolic hormone contributing to glucose homeostasis and adiposity (Jones et al., 2020). β-Endorphins, and the system of opioid receptor agonists more generally, have a part to play in a wide variety of biological systems; while they are most well-known for their antinociceptive properties and stress-relieving nature, they also have their hand in homeostatic function and behavior; natural methods of modulating β-endorphin levels, such as exercise, have proven to be helpful in a variety of disorders (Pilozzi et al., 2020). Extensive evidence supports the view that cholinergic mechanisms modulate learning and memory formation; release of acetylcholine is important in engaging these systems during learning, and that the extent to which the systems are engaged is associated with individual differences in learning and memory (Gold, 2003). Basal testosterone could play a role in acquiring leadership positions through agressive, dominant and authoritarian behaviour (van der Meij et al., 2016). Cortisol is released in times of stress, which causes the production of large amounts of glucose; glucose, on the other hand, gives energy to deal with a given situation; in addition, cortisol balances the activity of the immune system during inflammation. Gamma-aminobutyric acid (GABA) is generally recognized as a substance that can have anxiolytic, sleep-facilitating, and calming effects. (Philips, 2024).

Knowledge about neurotransmitters allows you to understand and stimulate the learning process, eliminate undesirable behaviors, strengthen positive ones, and, above all, correctly select training methods and techniques. Learning and memory being highly specialized process of human brain involves complex interaction between neurotransmitters

and cellular events. Over the years, the understandings of these processes have been evolving from psychological, neurophysiological, and pharmacological perspectives. The most widely appraised model of learning and memory involves attention, acquisition, storage and retrieval. Each of these events involve interplay of neurotransmitters such as dopamine, acetylcholine, etc. Further, dopamine is documented to play crucial role in the process of forgetting (Bairy, Kumar, 2019).

3 PREDICTION OF AREAS OF AI USE IN MILITARY ACTIVITIES – COMPETENCE GAPS

The main goal of the study was to identify areas of military operations in which modern solutions should be implemented in the field of acquiring and developing soldiers' competences regarding cooperation with AI. In the first stage of the research, an attempt was made to determine in which military areas the use of artificial intelligence would be developed. The pilot study was conducted in December 2022 among a group of 26 officers with various years of military service (fig. 1), of which 73% of respondents had more than 21 years of military service.

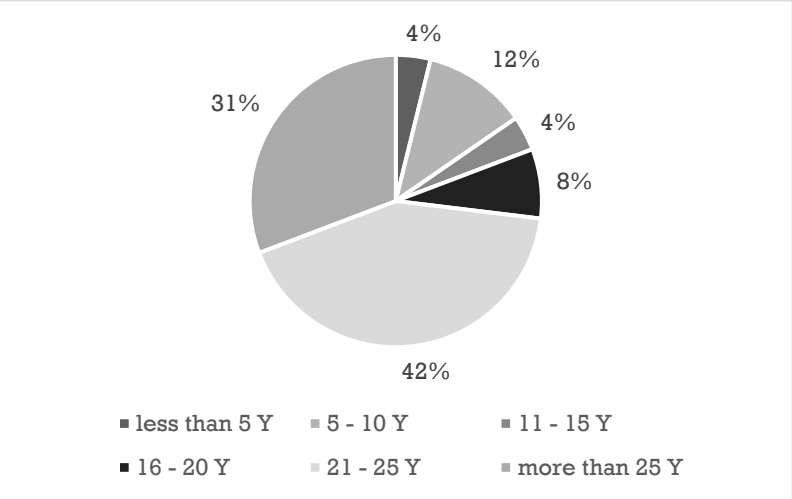

Figure 1 Period of military service of respondents
Source: own

The method of diagnostic survey and in-depth interview was used. As part of the survey, respondents were asked to rate the indicated issues on a scale from 1 (not important) to 10 (essential). During the in-depth interview, the interlocutors explained the validity of their views, indicated additional solutions not included in the survey questionnaire and shared their experience in educational activities. The results of the study are to be used to: 1/ indicate areas of training soldiers in the field of cooperation with artificial intelligence; 2/ selection of training methods and techniques; 3/ checking the possibility of using digital learning solutions; 4/ checking the possibility of using neuroscience solutions.

The first stage of the study was to determine the current state, so respondents were asked a question about their perception of the use of artificial intelligence in modern armed

forces. Unfortunately, there was no agreement among the respondents (tab. 1). However, in all groups (differing in professional experience in the army), the key areas that ranked first were (fig. 2): Reconnaissance, Military means of destruction, Planning, Command, Supporting operations, Cryptology. Additionally, in the comments, as a supplement to the assessment, respondents indicated the importance of AI in the following areas: simulations / simulators, cyberspace, operations of surface and underwater units. A set of areas was also indicated which, according to the US military doctrine, were referred to as Information Operations (IO OPS), which included: computer network operations (CNO) (which include computer network attack, computer network defense, and computer network exploitation), psychological operations (PSYOP), electronic warfare (EW), operations security (OPSEC), and military deception (MILDEC). From 2022, the above sections have been replaced by Information in Joint Operations (OIE), defined as "the aggregate of social, cultural, linguistic, psychological, technical, and physical factors that affect how humans and automated systems derive meaning from, act upon, and are impacted by information, including the individuals, organizations, and systems that collect, process, disseminate, or use information" (Theohary, 2023). It is also interesting to note the importance of AI in the analysis of morale in the army (of the fighting forces and the enemy), or the psycho-physical condition of soldiers.

Table 1 Perception of the importance of artificial intelligence in military operations - current status

Field of application	WAR*	Period of military service					
		less than 5 Y	5-10	11-15	16-20	21-25	More than 25 Y
Reconnaissance	5,8	6	6,3	3	6,5	5,5	6,1
Military means of destruction	5,5	7	4,0	1	6,5	5,6	6,1
Command	5,2	4	3,3	2	6,5	5,5	5,9
Supporting operations	5,2	6	4,7	3	6,5	5,1	5,3
Communication	4,9	3	4,3	1	5	5,3	5,3
Coordination of operations	4,8	5	4,0	2	6	5,5	4,3
Weapons and ammunition	4,7	6	4,7	1	6	5,5	3,6
Planning	4,7	1	5,7	3	6	3,9	5,6
Combat vehicles	4,5	6	5,0	1	5	4,4	4,5
Connectivity	4,2	3	4,0	1	5	4,9	3,8
Cryptology	4,0	7	7,0	3	3,5	3,2	4,0
Contamination monitoring	3,8	6	5,0	1	2,5	4,6	2,8
Training	3,5	5	3,3	2	5	3,6	3,1
Civil protection	3,4	4	4,0	1	1,5	4,2	2,8
Survival and protection of troops	3,3	5	4,3	1	2,5	3,2	3,3
Non-military system support in non-military threat situations	3,3	2	5,0	2	2	3,3	3,3
Medical rescue	3,2	4	4,3	1	2	3,5	2,9
Logistical security of operations	3,2	6	4,7	1	2	2,6	3,5
Transfer and mobility	3,2	6	4,7	1	2	2,8	3,3
Protection of cultural assets	2,7	2	4,0	1	1	2,9	2,5
Control	2,4	5	4,3	3	1,5	1,8	2,4

*/ weighted average rating factor *Source: own*

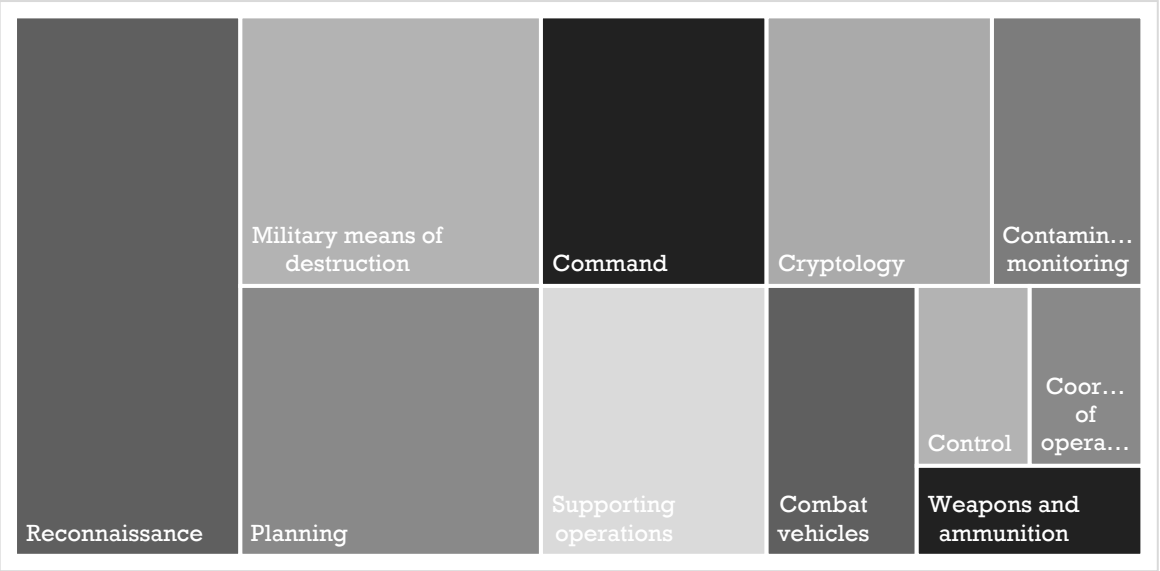

Figure 2 The most frequently indicated areas of use of AI in military operations - current status
Source: own

Then, respondents were asked about their predictions regarding the use of artificial intelligence in specific areas of military operations in the future (tab. 2). Respondents indicated that the most important application areas include: Reconnaissance, Military means of destruction and Planning. According to respondents, Cryptology will become more important (fig. 3).

Table 2 Perception of the importance of artificial intelligence in military operations - prediction

Field of application	WAR	Period of military service					
		less than 5 Y	5-10	11-15	16-20	21-25	More than 25 Y
Reconnaissance	6,2	6	7,0	2	7	5,9	6,5
Military means of destruction	5,7	7	4,3	2	6,5	5,8	6,1
Command	5,4	4	5,7	2	7	5,5	5,4
Supporting operations	5,2	6	5,3	3	6	5,0	5,5
Communication	5,2	6	5,0	2	6,5	4,8	5,8
Coordination of operations	4,7	6	5,7	2	4	4,8	4,5
Weapons and ammunition	5,2	7	5,3	2	6,5	5,0	5,1
Planning	5,1	6	7,0	3	7	3,9	5,6
Combat vehicles	5,0	6	5,3	2	6	4,7	5,1
Connectivity	5,2	6	5,0	2	6,5	4,8	5,8
Cryptology	4,2	7	7,0	3	4	3,3	4,4
Contamination monitoring	4,1	7	6,3	1	3	4,3	3,4
Training	4,1	4	5,3	2	6	3,5	4,3
Civil protection	3,8	5	5,7	2	2	3,8	3,5
Survival and protection of troops	4,1	6	5,3	2	2,5	4,7	3,3
Non-military system support in non-military threat situations	3,5	4	5,7	2	2	3,8	2,9
Medical rescue	3,8	6	5,0	1	2	3,8	4,0
Logistical security of operations	3,5	6	6,3	1	2,5	3,0	3,4
Transfer and mobility	3,9	6	5,7	1	2,5	4,0	3,5
Protection of cultural assets	3,2	5	5,7	2	1	2,7	3,3
Control	2,9	3	5,7	3	2,5	2,2	2,9

Source: own

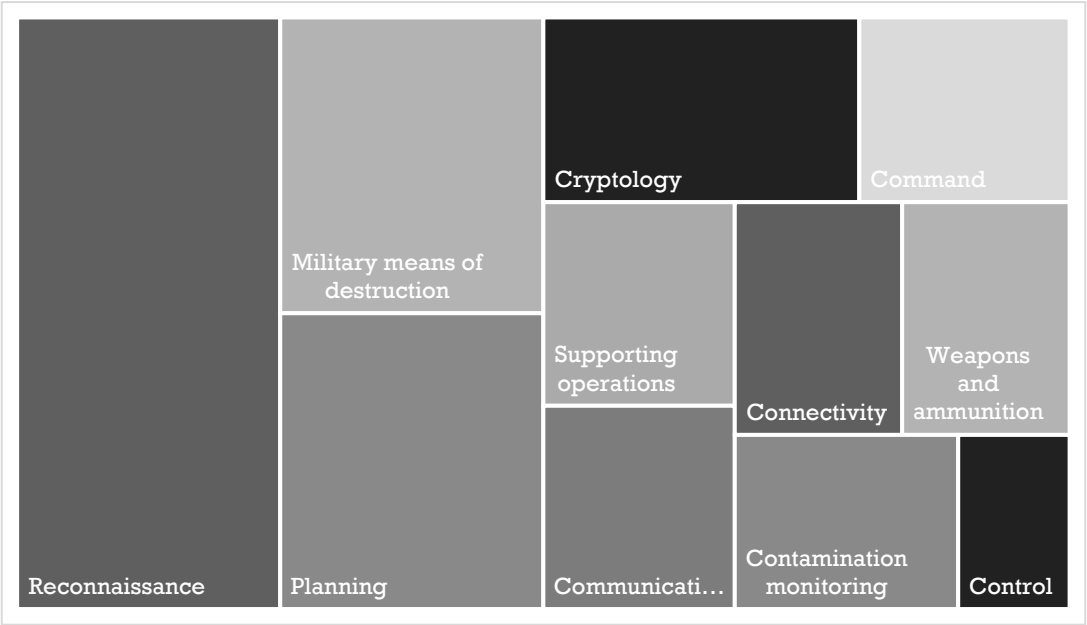

Figure 3 The most frequently indicated areas of use of AI in military operations - prediction
Source: own

Respondents were also asked in which elements of a military operation the use of AI should be developed (tab. 3). In this respect, the opinion of experienced officers with more than 20 years of military service was particularly important. According to this group, AI should be implemented for: Reconnaissance, Military means of destruction and Supporting operations. The group of officers with less than 20 years of experience is dominated by: Cryptology; the next places (with the same number of indications) were: Reconnaissance, Military means of destruction, Weapons and ammunition, Command, Planning, Communication and Connectivity.

Table 3 Elements of military operations in which solutions using AI should be developed

Field of application	WAR	Period of military service					
		less than 5 Y	5-10	11-15	16-20	21-25	More than 25 Y
Reconnaissance	6,3	6	7,0	4	7	6,2	6,4
Military means of destruction	6,0	7	4,7	3	6,5	6,5	6,0
Command	5,5	4	5,0	6	6,5	5,7	5,3
Supporting operations	5,6	6	5,7	3	6	5,6	5,8
Communication	5,6	6	6,0	5	5,5	5,6	5,4
Coordination of operations	5,4	6	5,3	5	6,5	5,4	5,1
Weapons and ammunition	5,4	7	5,0	2	6,5	5,5	5,5
Planning	5,3	6	7,0	6	6	4,5	5,4
Combat vehicles	5,3	6	5,7	2	5,5	5,0	5,9
Connectivity	5,2	6	6,0	5	6	5,4	4,5
Cryptology	4,5	7	7,0	6	3,5	4,0	4,0
Contamination monitoring	4,6	7	5,7	4	3,5	4,9	3,8
Training	4,6	4	5,3	5	6	4,2	4,5
Civil protection	4,0	7	5,7	1	2	4,3	3,6
Survival and protection of troops	4,3	6	5,0	4	3	4,6	3,8

Non-military system support in non-military threat situations	3,8	4	5,3	2	2	3,9	3,6
Medical rescue	4,1	6	5,0	4	2	4,3	3,8
Logistical security of operations	3,8	6	6,0	2	2,5	3,6	3,5
Transfer and mobility	4,1	6	5,7	3	2,5	4,1	3,8
Protection of cultural assets	3,2	4	5,7	1	1	3,1	3,3
Control	3,1	4	5,3	5	2	2,5	3,0

Source: own

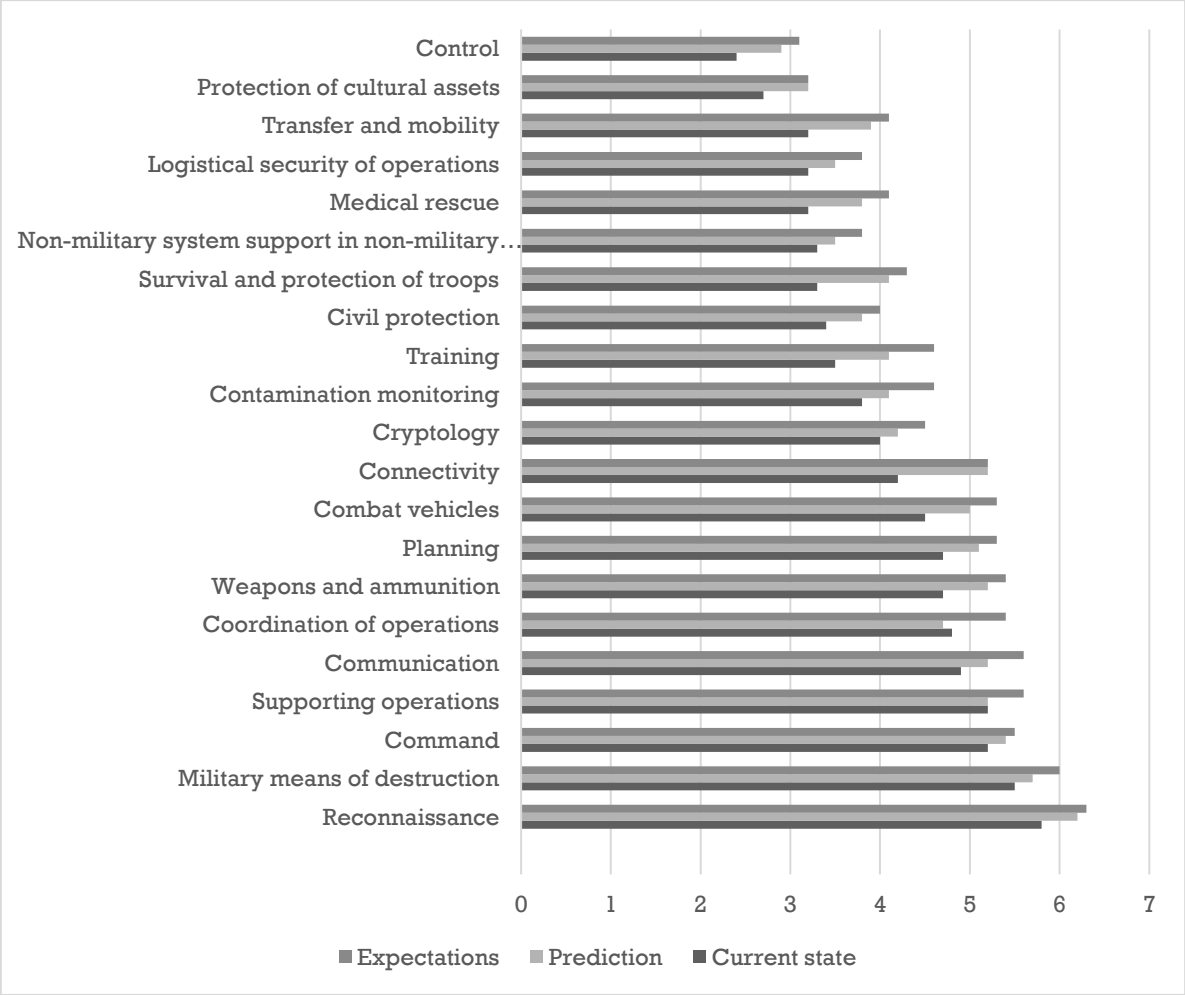

Figure 2 Directions of development of the use of AI in military operations
Source: own

In order to diagnose the needs of soldiers in terms of AI support, respondents were asked to assess in which areas of a soldier's professional work the use of artificial intelligence should be developed. Support for decision-making, organizational and communication processes turned out to be crucial (tab. 4).

Table 4 Areas of soldier's professional work, the use of AI should be developed

Method / tool	WAR	Period of military service					
		less than 5 Y	5-10	11-15	16-20	21-25	More than 25 Y
Support for the decision-making process	6,1	6	5,7	5	6,5	6,3	6,0
Support for the organizational process	5,8	6	5,7	6	6,5	5,7	5,6
Support for the communication process	5,4	6	4,0	4	5	5,5	6,0
Support for intellectual development	5,2	7	4,0	4	5	5,5	5,1
Psychological support	4,1	4	3,3	2	4	4,4	4,3
Support for physical development	2,9	2	3,3	1	3	2,8	3,1

Source: own

Knowing the predictions and needs of soldiers regarding the use of AI in military activities, respondents were asked a question about the recommended methods and techniques of educating/training cadets and soldiers in the field of cooperation in the "soldier-AI" system (tab. 5). The research results do not allow for a clear formulation of preferred solutions. It can be noted, however, that methods and techniques belonging to the "digital learning" group (i.e. training using AI, simulators, computer games) were rated highly.

Table 5 Methods and techniques recommended for training cadets in the field of the "soldier-AI" system

Method / tool	Total	Period of military service					
		less than 5 Y	5-10	11-15	16-20	21-25	More than 25 Y
Field training using devices equipped with artificial intelligence	6,4	7	4,7	7	7	6,0	6,5
Simulators	6,2	3	3,7	1	4,5	5,6	5,5
Online information review	5,2	7	5,0	6	7	6,6	6,5
Projects	5,2	3	3,0	1	4	3,5	3,8
Participation in conferences and seminars	5,2	7	3,7	1	6	5,2	4,6
Analyzing operational documentation	5,1	5	3,0	3	5	4,4	4,6
Computer games	5,0	7	4,0	4	5	5,3	4,3
Participation in military equipment fairs	5,0	7	3,7	1	6,5	5,6	5,0
Visits to technical universities, scientific institutes, etc.	4,9	3	2,7	1	4	3,7	4,6
Case studies	4,8	6	4,3	1	5,5	5,4	5,4
Brainstorm	4,8	6	3,3	3	5	4,0	4,1
Discussion	4,3	5	3,7	4	4,5	5,7	5,5
Review of literature and articles	4,1	5	4,0	3	6	4,8	5,4
Watching movies	3,8	6	4,0	5	6	5,0	5,0
Lectures	3,4	6	4,0	5	3,5	5,6	5,3

Source: own

4 DIGITAL LEARNING AS A DIRECTION OF DEVELOPMENT OF MILITARY TRAINING - EXAMPLES OF SOLUTIONS

Modern digital learning solutions are widely used in practical professional competence training. This is made possible by solutions related to immersive learning (virtual reality - VR, augmented reality - AR), thanks to which it is possible to reproduce specific processes and activities, and thus "immerse" in the reality of the training subject (Garzón, 2021). This applies in particular to the use of trainers, simulators and computer games that very realistically reproduce the conditions of the modern battlefield. Simulation consists in recreating the properties of given objects or phenomena using a specific model.

With regard to IT tools, computer simulation are distinguished, which, properly programmed, allows soldiers to study the behaviour of real objects based on observation of the operation of a computer program that simulates this behavior, an example can be both a computer game and a professional simulator, e.g. flight.

An example of the use of simulators for specialized training are parachute simulators used by cadets of the Land Forces Academy (AWL), such as a wind tunnel and an open canopy flight simulator. These simulators are an effective and safe training tool that can be used in the field of parachute landing of soldiers. By training each individual soldier in flight simulators, we increase their professional competences, which then translates into the combat usefulness of the subunit. Regardless of whether it is a wind tunnel or an open-canopy flight simulator, research and observations of instructors allow us to conclude that it is an effective training infrastructure that allows us to significantly shorten the time needed to achieve the goals of learning how to perform parachute jumps. Both simulators are tailored to the individual needs of training participants and their level of advancement, which allows for obtaining the best results, where ensuring safety is one of the main elements. Additionally, training simulators allow for repetition of exercises and simulations, which can help consolidate skills and accelerate the learning process. There is therefore an important cost aspect, which is definitely more advantageous in the case of simulator training. AWL cadets also train on the PACAST and VBS System (virtual battlespace) tactical simulation systems, trainers (e.g. motorized infantry platoon - Aster), laser shooting simulator (LSS) and the KTO Rosomak "JASKIER" driver training simulator.

Progress resulting from the growing needs and challenges generated by the modern battlefield requires training of both individual soldiers and entire vehicle crews. The interactive intervention of the above-mentioned entities is created thanks to properly coordinated simulation tools, the so-called "distributed simulation", which allows you to connect and exchange relevant information using a computer network in a war game. An example of such a solution is Mission Training via Distributed Simulation (MTDS), which uses modern simulation technology to provide a new concept for collective training of aircrew in flight operations. The system is developed by a group of NATO experts (Tomlinson et al., 2003).

According to M. Salamon, an important element of such a simulation is the need to use computer simulation models that describe the behavior of individual objects on the virtual battlefield. A computer generator of the behavior of objects involved in the battlefield simulation increases the realism of the exercises. It enables a realistic simulation of combat operations without the need to connect many expensive real military simulators, intended for training crews of military vehicles and individual soldiers. New types of simulators developed in the last few years make it possible to combine constructive and visual simulation (Salamon, 2001). Visualization and programming of processes that take place during military operations faithfully reproduce, for example, the Virtual Battle Space (VBS) program. It is a platform that allows you to transfer military exercises to the monitor screen. The VBS includes IT tools used at all stages of the exercise (i.e. data preparation, scenario development, exercise implementation and analysis of the exercise course and evaluation of the results obtained) supported by a battlefield simulator (trainer). The trainer can design any scenario describing the simulation on the battlefield. A very important and useful component of VBS is a library of ready-made objects (a man in various configurations, a group of people, vehicles of various categories, buildings, roads, vegetation and other objects) along with their properties. The use of this type of IT tools is able to satisfy a certain part of the diagnostic and training deficit.

Most of the world's leading armies, based on current experience and future actions resulting from them, strive to develop simulation and training systems in the direction that should lead to: a) combining them into a single-level and multi-level simulation network (with the possibility of using constructive, virtual and real at the same time); b) "supervising" the simulation network, e.g. through the "communication and integration bus", the task of which is to create an environment that enables the exchange of data between heterogeneous components of the simulation system, ensuring the transfer of data between the systems connected to it and enabling further development of the simulation system by modernizing or switching it on newer simulators or trainers for the training process (Stopniak, Chmieliński, 2015).

As part of the technological solutions used in AC/DC, it should be noted that the online, computer-administered test of the required competencies for junior non-commissioned officers throughout the army, tested since 2002 by the US Army. The use of the above tool to diagnose the competence profile of soldiers in the following categories was analyzed: a) Basic Soldiering (Common Tasks - e.g., weapons, navigation, first aid); b) NCO and Army History, Customs, and the Seven Army Values; c) Leadership; d) Training (Campbell et al., 2004). The pilot test was configured to be administered via the Army's Digital Training Facilities (DTF) to serve as a portal to the military distance learning programme; despite limitations in availability, DTFs are still the most promising place for an operational assessment test.

CONCLUSION

The conducted pilot research allowed to initially formulate answers to the research questions. It was indicated that technological trends related to the introduction of artificial intelligence will primarily concern such areas of military operations as: Reconnaissance, Military means of destruction, Supporting operations and Cryptology. Therefore, the requirement to change the content, methods and techniques of education and training of soldiers towards digital learning solutions becomes necessary. However, taking into account the limitations that still exist when using computer software lead to the conclusion that digital learning is only an "additional" element, because trainees can achieve effective and correct learning outcomes only through practice in physical tactical training. The development of digital learning in the military sector should, on the one hand, concern narrowly practical competences (e.g. simulation of parachute jumps); on the other hand, digital training programs using solutions from modern neurosciences can be used to develop complex competencies, e.g. command skills. Additionally, it is recommended to create the so-called comprehensive modules implemented as Assessment/Development centers (AC/DC). An important research gap for further work includes: analysis of the level of neurotransmitters in the process of implementing individual tasks with the support of AI or the possibility of AI stimulating the secretion of neurotransmitters in the trainee in order to improve the ability to learn, make decisions, remember, etc.

REFERENCES

BOIRON, J. (2022). Leadership Seen by Neuroscience. Contemporary Applied Business Research in Light of Standard Academic Literature, 3(1), s. 8-18. https://doi.org/10.51137/ijarbm.2022.3.1.2

AFIOUNI, R. 2021. Emerging Topics in AI Business Research: A Bibliometric Study. In Academy of Management Annual Meeting Proceedings 2021(1):16387. https://doi.org/10.5465/AMBPP.2021.16387abstract

BAIRY, L. K., KUMAR, S. (2019). Neurotransmitters and neuromodulators involved in learning and memory. International Journal of Basic & Clinical Pharmacology, 8(12), s. 2777-2783. https://doi.org/10.18203/2319-2003.ijbcp20195296

BERKE, J.D. 2018. What does dopamine mean? Nature Neuroscience 21, 787-793 https://doi.org/10.1038/s41593-018-0152-y

BROWN, M., DEHONEY, J., MILLICHAP, N. (2015). The next generation digital learning environment. A Report on Research. ELI Paper. Louisville, CO: Educause April, 5(1), s. 1-13.

CAMPBELL R., KEENAN P., MORIARTY K., KNAPP D. AND HEFFNER T. 2004. Army Enlisted Personnel Competency Assessment Program Phase I (Volume II): Demonstration Competency Assessment Program Development Report. United States Army Research Institute for the Behavioral and Social Sciences.

COLLINS, S. 2019. Neuroscience for Learning and Development: How to Apply Neuroscience and Psychology for Improved Learning and Training. Kogan Page Publishers

CRISTOFARO, M. 2020. E-business evolution: an analysis of mobile applications' business models, In Technology Analysis & Strategic Management, 32 (1), s. 88-103. https://doi.org/10.1080/09537325.2019.1634804

CZAINSKA, K., BALCERZYK, D., BALCERZYK, R. (2023). Evolution of Development Centres in the Military Sector - from Beginnings to Game Changers. In Game Changers in Management, Hajdas, M. (Ed.). Publishing House of Wroclaw University of Economics and Business https://doi.org/10.15611/2023.10.9.07

GARZÓN, J. (2021). An overview of twenty-five years of augmented reality in education. In Multimodal Technologies and Interaction, 5(7), 37. https://doi.org/10.3390/mti5070037

GOLD, P. E. (2003). Acetylcholine modulation of neural systems involved in learning and memory. Neurobiology of learning and memory, 80(3), 194-210. https://doi.org/10.1016/j.nlm.2003.07.003

IDF. 2024. What is Human-AI Interaction (HAX). INTERACTION DESIGH FOUNDATION. Available online: https://www.interaction-design.org/literature/topics/human-ai-interaction

ISHAK, W. W., KAHLOON, M., & FAKHRY, H. (2011). Oxytocin role in enhancing well-being: a literature review. Journal of affective disorders, 130(1-2), 1-9.

https://doi.org/10.1016/j.jad.2010.06.001

JOHANNESSEN J.A. 2020. Brain Science and Evidence-based Leadership. In Knowledge Management for Leadership and Communication. Emerald Publishing Limited, 49-96. DOI: 10.1108/978-1-83982-042-720201004

https://doi.org/10.1108/978-1-83982-042-720201004

JONES, L. A., SUN, E. W., MARTIN, A. M., & KEATING, D. J. (2020). The ever-changing roles of serotonin. The international journal of biochemistry & cell biology, 125, 105776.

https://doi.org/10.1016/j.biocel.2020.105776

KEMP, A. 2021. Artificial Advantages: Toward a Theory of Situated AI. In Academy of Management Annual Meeting Proceedings 2021(1):16279. https://doi.org/10.5465/AMBPP.2021.16279abstract

MAIER, U., KLOTZ, C. (2022). Personalized feedback in digital learning environments: Classification framework and literature review. In Computers and Education: Artificial Intelligence, 3, 100080. https://doi.org/10.1016/j.caeai.2022.100080

McKINSEY AND COMPANY. 2023. What is digital transformation? Available online: https://www.mckinsey.com/featured-insights/mckinsey-explainers/what-is-digital-transformation

MICROSOFT. 2024. HAX Teams. Available online: https://www.microsoft.com/en-us/research/group/hax-team/.

MORAKANYANE, R; GRACE, A. A., O'REILLY, P. 2017. Conceptualizing Digital Transformation in Business Organizations: A Systematic Review of Literature. In BLED 2017 Proceedings. 21. Available online: http://aisel.aisnet.org/bled2017/21.

https://doi.org/10.18690/978-961-286-043-1.30

NATO. 2017. Tech Trends Report 2017. Empowering the Alliance's Technological Edge. NATO Science & Technology Board, Public Release Version of AC/323-D(2017)0006 (INV).

PHILIPS, D.J.P. 2024. Hormonalna rewolucja. Wydawnictwo Filia.

PILOZZI, A., CARRO, C., & HUANG, X. (2020). Roles of β-endorphin in stress, behavior, neuroinflammation, and brain energy metabolism. International journal of molecular sciences, 22(1), 338.
https://doi.org/10.3390/ijms22010338

SAGHIRI, A.M.; VAHIDIPOUR, S.M.; JABBARPOUR, M.R.; SOOKHAK, M.; FORESTIERO, A. 2022. A Survey of Artificial Intelligence Challenges: Analyzing the Definitions, Relationships, and Evolutions. In Applied Sciences, 2022, 12, 4054.
https://doi.org/10.3390/app12084054

SALAMON, M. 2001. Koncepcja łączenia symulacji konstruktywnej i wizualnej pola walki. In Biuletyn Instytutu Automatyki i Robotyki, 16, s. 97-115.

STOPNIAK, M., CHMIELIŃSKI M. 2015. Środowisko symulacyjne VBS jako przykład możliwości symulatorów wirtualnych dla sił zbrojnych. In TTS Technika Transportu Szynowego, 12, s.2336-2340.

SYLWESTRZAK, B. 2023. Managing selected areas of preparation military personnel for their assigned roles in the state. In Scientific Papers of Silesian University of Technology. Organization & Management, 2023, 170, s. 531-549.
https://doi.org/10.29119/1641-3466.2023.170.33

TERINO, H. 2020. Joint All Domain Operations for 2030. Air Univ Maxwell AFB AL MAXWELL AFB United States.

THEOHARY, C. A. 2023. Defence Primer: Operations in the Information Environment. IF10771 · VERSION 10. Available online: <https://crsreports.congress.gov.

TOMLINSON, B., VAN GEEST, J., FYSISCH EN ELEKTRONISCH LAB TNO THE HAGUE. 2003. Aircrew Mission Training via Distributed Simulation-Progress in NATO. In NATO HFM-101 conference on "Advanced Technologies for Collective Training", Genoa.

TOKUHAMA-ESPINOSA T. 2021. Bringing the Neuroscience of Learning to Online Teaching. An Educator's Handbook. Teachers College Press. Columbia University.

VAN DER MEIJ, L., SCHAVELING, J., & VAN VUGT, M. (2016). Basal testosterone, leadership and dominance: A field study and meta-analysis. Psychoneuroendocrinology, 72, 72-79.
https://doi.org/10.1016/j.psyneuen.2016.06.005

VOLTZ, C., REITH, M., LONG, D., DILL, R. 2021. Improving Joint All Domain Operations (JADO) Education. In ICCWS 2021 16th International Conference on Cyber Warfare and Security. Academic Conferences Limited, s. 401-408.

WANG, F., DING, L., YU, H. et al. 2019. Big data analytics on enterprise credit risk evaluation of e-Business platform. In Information Systems and e-Business Management, 18, s. 311-350.
https://doi.org/10.1007/s10257-019-00414-x

WHEELER, S. 2012. e-Learning and Digital Learning. In: Seel, N.M. (eds) Encyclopedia of the Sciences of Learning. Springer, Boston, MA.
https://doi.org/10.1007/978-1-4419-1428-6_431.

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