# Briefing Memo

## Military Functions and Artificial Intelligence (AI): Substitution of Intellectual Labor and Coexistence

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Artificial intelligence (AI) has permeated all sectors of society and has the momentum to substitute intellectual labor–the very characteristic that makes humans the lord of creation. The military is not an exception to this trend. Nevertheless, discussions on AI related to the military have so far been focused on robot weapons that incorporate AI (Lethal Autonomous Weapons Systems [LAWS]). Looking ahead to the future, this article discusses AI's substitution of the intellectual labor functions of the military, together with coexistence between AI and military personnel in the case of substitution.

1. From complementing to substituting intellectual labor (first AI boom)

Attempts to complement human intellectual labor using tools are said to date back to the invention and use of the abacus in Mesopotamia in 3,000–4,000 B.C. Substituting intellectual labor, on the other hand, is a much more recent development, with full-fledged attempts being made after the emergence of all-purpose computers (1945). The world's first all-purpose computer is ENIAC developed in the United States. Its original purpose was to create a firing table for indirect fire (a correlation table listing information such as type of shell, elevation angle, propellant amount, wind, temperature, and humidity). Creating a single firing table for artillery required 2,000 to 4,000 trajectory calculations and took three to six months with 50 people using desktop mechanical calculators. ENIAC was able to complete the same work with five people in a day. This computer was, though, anything but a practical product. It required approximately 18,800 vacuum tubes, had 6,000 switches, was 12m in length and 4m in height, and weighed 30t. The vacuum tubes broke down frequently (one tube per day; replacement took one hour), and its rate of operation was 69%.

In 1956, an international conference on the mechanization of intellectual activities ("Dartmouth conference") was held. The term "artificial intelligence (AI)" was used for the first time at this conference. This period is known as the "first boom" of AI. The functions of AI were primarily inference (Ex: If A leads to B and B leads to C, then A leads to C) and search (Ex: Loads with different weights and prices are combined to find the maximum price under a given weight limit). Since there is a finite number of possible outcomes however large the number, computers were able to find an answer through a "round-robin" process. In this phase, computers were only able to perform high-speed processing based on a given set of rules and conditions.

2. Tackling tacit knowledge (second and third AI boom)

The "second boom" of AI, which began in the 1970s, is represented by the development of the "expert system" that sought to substitute the advice and decisions of experts. This is a system in which users input logical conditions into a database of a specific discipline in order to narrow down the data and arrive at a conclusion (deductive inference). MYCIN developed at Standard University in the early 1970s succeeded in accurately determining the diagnosis of infectious diseases at 69% probability (close to the 80% probability of medical specialists). As the number of conditions increases, it becomes possible to diagnose complex symptoms, while at the same time, the errors become larger. The same data sometimes led to different decisions, even among medical specialists, and the conclusions reached by AI were subject to this restriction.

Above all, it was basically impossible to systematize the "tacit knowledge" (≒instinct or intuition) of humans, including both experts and non-experts. Based on tacit knowledge, humans can make diagnoses even if they only have ambiguous information (Ex: "The patient's stomach hurts"). AI, on the other hand, stops working if the details are not known, such as which area of the stomach hurts or which organs hurt, what the symptoms, are and what the patient's condition is. To overcome this obstacle, it was necessary for humans to anticipate physician-patient Q&As in advance and input them into AI that required extraordinary labor and effort. If there was a slightest difference between the patient's response and the anticipated answer, the AI stopped responding.

Later, in the 2010s, the "third boom" began and has continued to the present. Unlike the "second boom" that integrated the correct answers based on logical conditions, the third boom searches for the correct answer by statistical processing (inductive inference). The more sample data (Big Data) there are, the better it is for increasing the accuracy of the statistics. Such sample data must be broken down (deep learning) into relatively few mutually uncorrelated feature values (components and factors). After the data is broken down into feature values, the coefficients of the feature values are revised by checking against the original sample data. The sample data is then abstracted and generalized. By having AI perform these series of tasks (machine learning), the accuracy of the decision-making increases. Furthermore, in this process AI seemingly acquires tacit knowledge through the "experience" of using vast data.

The problem: even if there is improvement in the accuracy of AI's decision-making, including tacit knowledge acquired in this manner, AI cannot in essence logically explain why it arrived at its decision. For example, the type of AI that wins against top-notch professional shogi players is one that has studied records of 60,000 shogi games since the Edo period (1603–1868) and has broken down players' moves into over 10,000 feature values. Even if the coefficients attached to the more than 10,000 feature values can be shown inductively as a result of statistical processing, it is impossible to explain deductively why a particular value was attained. AI merely offers a highly accurate result. The "why" may be the "tacit knowledge" of humans.

3. The military and the substitution of intellectual labor by AI

Labor substitution by computers had traditionally been limited to routine operations that have had clear rules. With the recent advances in AI, however, computers have begun to substitute non-routine operations. The abstraction and generalization of non-routine operations have been made possible by Big Data. This requires, of course, advancements in hardware that instantly conducts deep learning of Big Data and enable the breakdown of data into uncorrelated feature values (abstraction and generalization).

Many studies have been conducted on the probability of AI's substitution of human labor. A leading example is "The Future of Employment" by Carl B. Frey and Michael Osborne of the University of Oxford published in 2013. This study estimates the probability of substitution by AI (including robots) from the mid-2010s to the mid-2020s for 702 occupations, utilizing the categories used by the U.S. Department of Labor. The 702 occupations do not include the military. I have thus compiled probabilities of AI substitution for duties that resemble military functions (see Table).

Table: Comparison between military functions and the probability of job substitution by AI (including robots)

| Military functions | | Resembling occupation | Probability of substitution by AI |
|---|---|---|---|
| HQ (staff ) | General Affairs | First-Line Supervisors of Office & Administrative Support Workers | 1.4% |
| | | Administrative Services Managers | 73 % |
| | Intelligence | Social Scientists & Related Workers | 4 % |
| | | Market Research Analyst & Marketing Specialists | 61 % |
| | Operations | Training & Development Specialists | 1.4% |
| | | Business Operations Specialists | 23 % |
| | Logistics | Medical & Health Services Managers | 0.73% |
| | | Logisticians | 1.2% |
| | Planning | Urban & Regional Planners | 13 % |
| | Communi -cations | Computer &Information Systems Managers | 3.5% |
| | | Information Security Analysts, Web Developers & Computer Network Architects | 21% |
| | Legal | Lawyers | 3.5% |
| | | Paralegals & Legal Assistants | 94 % |
| | Adjutant | Executive Secretaries & Executive Administrative Assistants | 86 % |
| Combat Unit | | First-Line Supervisors of Fire Fighting & Prevention Workers | 0.36% |
| | | First-Line Supervisors of Police & Detectives | 0.44% |
| | | Police & Sheriff's Patrol Officers | 9.8% |
| | | Firefighters | 17 % |
| | | Airline Pilots, Copilots & Flight Engineers | 18 % |
| | | Captains, Mates, and Pilots of Water Vessels | 27 % |
| | | Police, Fire & Ambulance Dispatchers | 49 % |
| | | Transit and Railroad Police | 57 % |
| | | Sailors & Marine Oilers | 83 % |
| | | Security Guards | 84 % |
| Support Unit | | First-Line Supervisors of Mechanics, Installers & Repairers | 0.3% |
| | | First-Line Supervisors of Transportation & Material-Moving | 2.9% |
| | | Chefs and Head Cooks | 10 % |
| | | Air Traffic Controllers | 11 % |
| | | Commercial Pilots | 55 % |
| | | Transportation, Storage & Distribution Managers | 59 % |
| | | Aircraft Mechanics & Service Technicians | 71 % |
| | | Heavy and Tractor-Trailer Truck Drivers | 79 % |
| | | Cooks, Institution and Cafeteria | 83 % |
| | | Laborers & Freight, Stock & Material Movers, Hand | 85 % |

Source: This table was prepared based on Carl Benedikt Frey and Michael A. Osborne, "The Future of Employment: How Susceptible Are Jobs to Computerisation?" *Oxford Martin School Working Paper, University of Oxford* (September 2013), pp. 61-77.
Note: Colored rows indicate substitution probability of 50% or higher.

The values shown are no more than estimates of the probability of substitution by AI for occupations considered to resemble military functions. Nevertheless, they provide indications of some trends. For example, while the probability of AI substituting command and management duties in the near term is low, the probability of AI substituting their supporting duties is high. Furthermore, human decision-making will be essential for the management and supervision of duties, including routine duties. For the most general managerial duties, the substitution of supervisors by AI is within the field of view.

Commanders of future military units will be making decisions based on their own experience and intuition (i.e., tacit knowledge), while referring to materials prepared by AI. Even if AI (robots) substitutes humans for physical tasks on the field, humans will still be conducting the management and supervision of the tasks. Military units operate in battlefields and natural disaster sites that require adapting to frequent occurrences of never experienced circumstances. AI is unable to make decisions in such situations. This can easily be inferred from AI’s nature to analyze feature values through statistical processing of past sample data.

## 4. Coexistence of AI and future military units

According to Frey and Osborne, it will be difficult in the near future for AI to substitute occupations requiring: 1) non-routine perception and manipulation; 2) creative intelligence; and 3) social intelligence. The difficulty of 1) is due to the technical limitations of hardware and software. The unlikeliness of 2) is unavoidable so long as AI’s decision-making depends on statistical processing of past sample data. 3) is the ability to have human interaction in human society and is an area that is most difficult (and unsuitable) for AI to substitute. Conversely, while it is expected that the obstacles of 1) will be reduced with advances in technology, it remains a major challenge for AI to adapt to never experienced circumstances of 2). In addition, although examples of AI’s creation of artworks have been introduced, these works are no more than works that imitate (i.e., statistically approximate) the style of past artists and are not creations of art (style). 3) is unlikely to be resolved as AI is different from humans and it cannot become members of human society.

Expert analysis provided by AI will likely have greater accuracy in the coming years. Such analysis, however, assumes that the prerequisites will not change from the current state. For example, an AI that wins against the best shogi players has learned tens of thousands of shogi games from the past 400 years. All the games have the same assumptions (e.g., 9-by-9 square shogi board, 40 pieces, the allowed movements of the pieces). In contrast, the assumptions are not uniform in settings where the military operates (e.g., battlefield, natural disaster site) and change from time to time. If we utilize the metaphor of shogi, it is as if, in the middle of the game, the shogi board suddenly expanded to 12-by-15 squares, the number of pieces increased to 60, and the allowed movements of the pieces changed abruptly (for example, it becomes possible to retreat fu [pawn] and kyosha [lance] pieces). For this reason, it has become normal to “adapt to never experienced circumstances.”

How will AI and humans (military personnel) coexist in future military units where much of the intellectual labor has been substituted by AI (robots)? This question has been broadly discussed not only in the context of military units but also as an issue facing human society itself. In addition, the issue of “fallacy of composition” is unavoidable. This is to say, synthesizing local optimal solutions produced by AI does not necessarily produce the optimal solution for the whole society. Ryoichi Tobe compares military leaders of the Meiji period (1868–1912) and pre-war Showa period (1926–1945), and describes that the latter were military specialists while the former had wide-ranging knowledge and *samurai* (chivalry) ideals. In other words, whereas the military leaders of the pre-war Showa period pursued local and specialized optimal solutions, the military personnel of the Meiji period were able to pursue optimal solutions for a large scope and society. “Large scope” is thought to include “never experienced circumstances.” Herein may lie hints for revealing the ideal military unit and military personnel that should coexist with AI that is exceptionally accurate and reasonable.

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