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Human Enhancement – biological-neurological aspects from a military perspective

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1. Introduction

The bodies of chronically ill or handicapped patients were originally improved through the use of prosthetics, physiotherapy and dietetics. Later on, findings from the fields of sports medicine, rehabilitation and plastic surgery as well as soft skills such as special training, were used to improve performance and, above all, to optimise quality of life.

Human enhancement (HE), on the other hand, is defined as the use of similar technologies or treatments to improve or increase the human capabilities of **healthy people** beyond their natural limits. Unlike transhumanism, human enhancement does not involve the further advancement or evolution of Homo sapiens, but rather the expansion of the abilities of specific individuals or distinct groups.

Armed forces have always had an interest in using artificial aids to improve the performance of their soldiers The range of these optimizations began in the late Palaeolithic period with the spear thrower as an extension of the arm lever. This was further developed in the Middle Ages, in the golden age of blacksmithing, when sophisticated armour reduced the risk of injury from sword strikes or projectiles. Later on, this led to the widespread use of Pervitin® (methamphetamine) mixed into "tanker's chocolate" in the German Wehrmacht to temporarily increase the endurance, cognitive performance and concentration of soldiers of all armed forces.

It goes without saying that HE is still being researched worldwide today. The challenges and opportunities that can arise from the use of originally medical-neurological methods of HE (i.e. **neuroenhancements**) are the focus of our work on this subject.

Efforts to enhance the mental performance of healthy people through the consumption of psychotropic substances are referred to as "pharmacological neuroenhancement" or "cognitive enhancement". Pharmacological neuroenhancement essentially aims to reduce fatigue and to increase attention, concentration, memory and motivation.[1]

The term "brain doping" refers, in a disapproving tone, to the use of psychotropic substances which, according to the Austrian Prescription Requirement Act, are prescription only and the use of which by healthy persons constitutes abuse or falls under the Single Convention on Narcotic Drugs of 1961 in its current version. They can cause long-term damage to consumers and their social environment.

The use of over-the-counter (OTC) medication is sometimes referred to as "soft enhancement", irrespective of whether a positive or negative effect can be clinically proven.

As well as "pharmacological neuroenhancement", there are non-pharmacological methods, such as vagus nerve stimulation, transcranial magnetic stimulation, deep brain stimulation or various neural implants, which will be discussed in another chapter. The range of methods is complemented by a vision of sentient and thought-controlled prosthetic limbs with extraordinary power or precision. However, there are few advantages that are not also linked to sometimes considerable disadvantages or negative consequences.

In keeping with the editor's intention, the focus of interest is primarily on the use of neuroenhancement by potential opponents of the Austrian Armed Forces and the associated effects on their own actions.[2] The Austrian Armed Forces could also encounter HE in the context of an international deployment in the medical care of "optimised" soldiers. Relevant ethical and legal aspects will not be explicitly considered in this chapter. Instead, references

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1 See Bayerisches Landesamt für Gesundheit und Lebensmittelsicherheit (Bavarian Health and Food Safety Authority – LGL): Neuroenhancement: Doping für das Gehirn – Zusammenfassung (Doping for the brain – Summary), 2019, https://www.lgl.bayern.de/gesundheit/arzneimittel/warnungen_verbraucherinformationen/verbraucherinformationen/neuroenhancement.htm.

2 See Planungsamt der Bundeswehr (Bundeswehr Office for Defence Planning): Human Enhancement: Eine neue Herausforderung für Streitkräfte (A New Challenge for the Armed Forces)? 2013. https://www.bundeswehr.de/resource/blob/140504/d757cfdc2b1a467fb7d88544075da1d9/ft-he-data.pdf.

will be made to the corresponding chapters of this book. The term "medical" is replaced by "biological" in this chapter, because the former has been clearly proven to imply a medical measure for the benefit of patients, and corresponding national and international standards are not applicable for present purposes.

Ultimately, the question that arises for the military stakeholders is whether performance-enhancing drugs are actually necessary or appropriate for modern soldiers. With this in mind, this article, as part of the overall project, will address the following three-part question:

- Which future biological-neurological HE developments are currently being researched, are they foreseeable for armed forces in the future and are they useful in terms of their objectives or, from the authors' point of view, pure aberrations?
- What could be the impact on security forces, the Austrian Armed Forces, society and the resilience of the EU, Austria and non-European countries?
- Are they generally superior to military-technical solutions to problems?

This article therefore aims to provide a brief inventory of relevant developments in biological-neurological human enhancements, and a basis for decision-making in strategic military planning.

2. State of research

Whereas the medical technology and pharmaceutical industries already have a number of standard means and methods for the treatment or rehabilitation of sick or injured patients, neuroenhancement, i.e. the use of these in healthy people, is still largely within the framework of application-oriented basic research or, as with addictive substances, illegal. This is mainly due to the fact that, despite the results of the corresponding treatments for affected patients bringing considerable improvements, the partial performance improvements in the overall result have not yet achieved superiority over healthy patients.

Taking medicines without medical necessity is regarded as drug abuse. This is often accompanied by numerous negative effects, both physical and psychological.[3] As psychotropic substances, these medicines almost always have the potential to become addictive. This means that there is a tendency to increase the dosage, with even more pronounced negative consequences, as well as a psychological or physical need for continued use.

Because there are no known clinical studies with positive overall results that are equivalent to contemporary drug research, long-term use by healthy people is strongly discouraged from a medical perspective!

It is therefore necessary to start by taking a look at the contemporary development of medication by the pharmaceutical industry:

Drug development is a very risky undertaking. On average, out of 5,000 to 10,000 substances which were originally considered promising, only one is actually approved of as medication after **about 14 years of development**. Studies have shown that the average cost of developing a new, innovative medication is up to **2.6 billion US dollars**.[4] This sum includes the direct costs of developing the substance, the associated failures and the opportunity costs, i.e. the indirect costs of financing these lengthy and costly development projects. These high costs arise from the considerable volume of documentation and safety requirements in clinical trials, as well as the large number of study participants that would be required. For many substances, it is only through extremely complex multinational studies on their therapeutic effectiveness ("Phase 3" studies) that it becomes clear that they are not sufficiently potent or have too many side effects.

Accordingly, it is highly likely that a show-stopping application will not be discovered until about ten years after the start of the research – if at all.

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3 See Bayerisches Landesamt für Gesundheit und Lebensmittelsicherheit (Bavarian Health and Food Safety Authority – LGL): Neuroenhancement: Doping für das Gehirn – Zusammenfassung (Doping for the brain – Summary), 2019, https://www.lgl.bayern.de/gesundheit/arzneimittel/warnungen_verbraucherinformationen/verbraucherinformationen/neuroenhancement.htm.

4 See PHARMIG Verband der pharmazeutischen Industrie Österreichs (Association of the Austrian Pharmaceutical Industry): Daten und Fakten 2024, Arzneimittel und Gesundheitswesen in Österreich (Data and Facts 2024, Drugs and Health in Austria), 2024, 2024-pharmig_daten-fakten_de.pdf.

Simply falling back on drugs that were previously used in clinical practice is not permissible, because, as previously described, clinical trials relating to drug development are carried out exclusively with patients suffering from precisely determined disease, for which pharmaceutical approval and licencing is being sought. The effectiveness and side effect profile in healthy individuals is not taken into account. The use of prescription drugs approved for a specific disease on healthy people without modern clinical research is therefore outdated, unscientific and not justifiable. As with any medication, the desired effect is only seen in some of the test subjects.

3. Examples

The selected areas of neuroenhancement can be briefly outlined here, and are limited to invasive methods or at least methods that interfere with physical integrity:

3.1 Pharmacological neuroenhancement

The consumption of psychotropic substances is not a modern invention. Some wild mammals often enthusiastically gnaw at fermenting fallen fruit. It is thought that even in ancient times, shamans harvested and produced various intoxicants. It is well documented that the Ancient Sumerians enjoyed beer, and that the Ancient Greeks drank wine to excess, especially at festivals in honour of Dionysus, the god of viticulture. The stimulating effect of coffee became known and popular in Central Europe after the second Turkish siege of Vienna in 1683. To this day, no office is complete without a supply of coffee, tea and energy drinks.

It is also generally known that the misuse of various prescription drugs is not uncommon in countries that are member to the Organisation for Economic Co-operation and Development (OECD). There are also known scientific studies involving the intake of naturally occurring catecholamines such as dopamine, serotonin, noradrenaline and others. The consumers – many of them students – want to improve their mood, increase their motivation and concentration, and reduce fatigue and anxiety.[5]

[5] Maierhofer, Veronika: Human Enhancement – Entwicklung zum Übermenschen (Development into a Super-Human)? Master's dissertation to obtain the academic degree of Master of Science in Business Administration at the Karl-Franzens University of Graz, Austria. 2020. 4908970, p. 21.

3.1.1 Modafinil®

Modafinil® is an approved medicinal product and used therapeutically for a single application – specifically narcolepsy, a relatively rare sleeping disorder. If it is used improperly, it is expected that performance will be improved even with little sleep, for example before academic exams or other stressful situations.[6]

In addition to possible addiction to Modafinil®, the side effects can range from minor ones such as digestive disorders, headaches, colds and movement disorders to more serious ones, such as changes in blood values, aggression, sleep disorders, anxiety, tremors, muscle weakness and hyper excitability. The current medical instructions for use list no less than around 70 different side effects plus a large number of possible reactions with other medicines, which of course do not occur very frequently, but are unforeseeable for the individual consumer.

3.1.2 Methylphenidate (MPH)

Ritalin® for example, is a stimulant prescription drug intended for the treatment of attention deficit/hyperactivity disorder (ADHD). The exact mechanism of action of methylphenidate is not yet completely understood.[7]

In any case, methylphenidate improves attention and concentration and therefore has a positive effect on the deficits caused by ADHD. It is possible to increase cognitive performance.

3.1.3 Taurine

Taurine is an amino acid that plays a key role in several important biological processes in the metabolism of many mammals – and therefore also in humans – as a breakdown product of the amino acid cysteine.

A high concentration of taurine is found in tissues exposed to oxidative stress.

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6 See Walliczek-Dworschak, Ute.: Modafinil. In: Gelbe Liste Online (Yellow List Online), 2019. https://www.gelbe-liste.de/wirkstoffe/Modafinil_27434.

7 See Maucher, Isabelle Viktoria: Methylphenidate. In: Gelbe Liste Online (Yellow List Online), 2024. https://www.gelbe-liste.de/wirkstoffe/Methylphenidat_1306.

Drinks containing taurine are particularly popular in Japan, and the substance is said to have a positive effect on athletic performance. That is why taurine is an ingredient in several energy drinks.

However, meaningful scientific evidence of these effects in humans have yet to be corroborated.

Illegal substances used as neuroenhancers:

In certain circles, illegal substances such as **cocaine**, **hallucinogens** (magic mushrooms, LSD, etc.), **speed** or **ecstasy** are also regarded as popular performance-enhancing drugs.

Microdosing is becoming increasingly popular. It involves consuming a small dose with the aim of improving performance and creativity. This is how it is perceived subjectively, yet studies on long-term effects or successes are not yet known, which is why supra-individual use would be questionable.

Crystal or **crystal meth** deserves a special mention: These scene names designate methamphetamine, a fully synthetic stimulant produced in back-street laboratories, which was synthesised as early as 1893 by the Japanese chemist Nagayoshi Nagai. It was patented in 1920; and, until the 1980s, it was sold in pure form as a drug under the trade name Pervitin®. Methamphetamine is closely chemically related to amphetamine (speed), but the addiction potential of methamphetamine is considerably higher. Methamphetamine affects the metabolism of serotonin and dopamine neurotransmitters.

Figure 1: Tin of Pervitin. Source: Wikipedia.

"The physical agitation goes hand-in-hand with an increase in physical performance. Particularly monotonous and quickly tiring tasks can be performed for considerably longer, without signs of exhaustion, under the influence of methamphetamine. An increase in mental capacity and creativity is subjectively perceived; but objectively, this is usually not present."[8]

From a contemporary perspective, the long-lasting and diverse side effects alone prohibit the widespread use of methamphetamine in the armed forces, even after the poor military-historical experiences related to "tanker's chocolate (high dependency potential with a tendency to uncontrolled dose increase).

3.2 Non-pharmacological methods of neuroenhancement

3.2.1 Deep brain stimulation

Deep brain stimulation has become a promising treatment method for many people with various forms of movement disorders. Its best known application is in patients with Parkinson's disease. To date, electrodes have been installed in well-defined intracerebral regions in around 100,000 patients. The battery and the operating system are installed into the torso below the collarbone. The electrodes are placed under the skin of the neck and skull and finally placed in the target region of the brain.

A side effect is that neural implants can affect emotions. As a result, patients usually react in the form of conspicuous cheerfulness but occasionally respond the opposite way. Neural implants appear to change a patient's personality.

Depressive disorders disrupt the functioning of certain nerve fibre bundles. Accordingly, stimulating the intracerebral brain areas can also locally increase neuronal activity and lead to improvement in certain forms of therapy-resistant depressive disorders. PET scans of the brain can provide clues as to

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[8] Bundeszentrale für gesundheitliche Aufklärung – eine Fachbehörde im Geschäftsbereich des Bundesministeriums für Gesundheit (Deutschland) / Federal Centre for Health Education – a specialist authority within the portfolio of the Federal Ministry of Health (Germany) Drugcom: Methamphetamine https://www.drugcom.de/drogenlexikon/buchstabe-m/methamphetamin/, accessed 21.08.2024. Translation by the editors.

whether behavioural therapy or drug treatment is appropriate. Deep brain stimulation is recommended when nerve cell networks are no longer capable of self-correction.[9]

The patient then becomes noticeably calmer and more relaxed, their interest in their surroundings increases and their cheerlessness decreases. If the pulse generator is deactivated, the patient's condition will deteriorate again.

The only side effects are infections in the area of the implanted pulse generator in the skin under the right or left collarbone. In some cases, patients also commit suicide, albeit much less frequently than with the untreated underlying disease.

There have also been promising initial treatment successes with deep brain stimulation for obsessive-compulsive disorders.

Although many people now live or work with therapeutic electrodes in their brains, the exact mechanism of action is still largely unclear.

As far as we know, relevant research was financially supported by the US armed forces.[10]

In summary, however, it seems questionable as to whether healthy people can ever benefit from deep brain stimulation without paying the price of a significant personality change.

3.2.2 Vagus nerve stimulation

For the best part of three decades, a method of stimulating the tenth cranial nerve (vagus nerve) has been used to treat certain forms of epilepsy, which does not require electrodes in the brain itself but on the side of the neck.

This treatment also has mood-enhancing effects, which is why such implants are approved in the USA as complementary treatment for severe depression when other therapies are insufficient or not tolerated by the patient.

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9 See Lozano, Andres M. / Mayberg, Helen S.: Depression an der Wurzel packen (Tackling the Roots of Depression). In: SPEKTRUM der Wissenschaft KOMPAKT. Issue from 25.03.2019, p. 4 et seq.

10 See Krämer, Tanja: Neuroenhancement – Kommt die gesteuerte Persönlichkeit (Here Comes the Controlled Personality). In: SPEKTRUM der Wissenschaft Spezial Physik-Mathematik-Technik. 2/2015, p. 40 et seq.

The medical risk of the operation is lower than with deep brain stimulation, so that the inhibition threshold is probably lower.[11]

As a method of neuroenhancement, there is currently no recognizable advantage over pharmacological methods - on the contrary: the mood-enhancing effect is very unspecific and comes at a relatively high technical and financial cost.

3.2.3 Transcranial magnetic stimulation

Transcranial magnetic stimulation (TMS) is a neurological treatment method in which areas of the brain can be both stimulated and inhibited with the help of strong magnetic fields that are applied externally, i.e. without damaging the skull bone. Transcranial magnetic stimulation is being investigated to a limited extent for the treatment of neurological conditions such as tinnitus, strokes, epilepsy or Parkinson's disease, and is also used in psychiatry for the treatment of affective disorders, especially depression and schizophrenia. Studies conducted thus far have demonstrated the antidepressant effectiveness of repetitive TMS (rTMS). A magnetic coil applied tangentially to the skull generates a short magnetic field of 200 to 600 μ, with a magnetic flux density of up to 3 Tesla. The resulting change in electrical potential in the cerebral cortex near the skull causes the depolarisation of nerve cells, triggering action potentials that propagate into the depths of the brain with exponential attenuation. The antidepressant effect is said to last for at least several months after several weeks of treatment. A fundamental problem with stimulation by TMS is the spatial resolution. It is uncertain to what extent connected regions are stimulated by the stimulation of a targeted region. It is therefore difficult to make statements about the exclusive role of a stimulated brain area. Despite intensive research since the introduction of the method in 1985, the exact mechanism is still not fully understood.[12]

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11 Ibid.

12 See Wikipedia, "Transcranial magnetic stimulation". In the "Adverse effects" section. 2004. https://de.wikipedia.org/wiki/Transkranielle_Magnetstimulation, accessed 04.08.2024.

An additional problem arises from the fact that TMS stimulations cannot currently be standardised in terms of their intensity. An individual, patient-specific calibration is required.[13]

Since magnetic stimulation was introduced in 1985, hardly any side effects have been noticed. The most frequent side effect is temporary headaches, which mainly occurs when muscles are stimulated.

As a method of neuroenhancement, this treatment is much more user- and patient-friendly than deep brain stimulation or vagus nerve stimulation. However, no advantages compared to pharmacological methods have been identified thus far.

3.2.4 Brain-computer interfaces (BCI)

A brain-computer interface (BCI) interprets the specific electrical signals of the cerebral cortex that are triggered when someone has certain and also regularly trained thoughts, and uses a computer to specifically control prosthetic limbs or other technical devices. Prototypes of these BCIs are intended to help people with disabilities to carry out everyday tasks and use a wide range of communication methods.

Invasive BCIs – neuro implants

The implantation of electrodes and electronic components in and on the brain requires a neurosurgical operation. This is not a routine task. It is lengthy and highly complex, and the follow-up medical care is complicated.

So far, the results have not yet been objectively satisfactory.

Typically, Elon Musk's medical technology company, Neuralink, announced in a widely circulated press release that it had completed its first human brain implant in January 2024: "The patient is recovering well after the procedure on Sunday,' the tech billionaire wrote on his online platform X (formerly

[13] See Wikipedia, "Transcranial magnetic stimulation". In the "Medical uses" section. https://de.wikipedia.org/wiki/Transkranielle_Magnetstimulation, accessed 04.08.2024.

Twitter). 'Neuralink implants are intended to make it possible to operate a smartphone – and other technology – using thoughts."[14]

Apart from newspaper reports, there is a lack of objective information on the case. The implant allegedly had a comparatively large number of 1024 electrodes, which were connected to nerve cells in the patient's brain. However, just a few months later, in September 2024, newspaper reports appeared in which it was claimed that 85% of the 1024 electrodes were no longer functional. This 'result' is consistent with observations from other research groups, namely that the number of activatable neurons decreases over time. This problem can be understood biologically, yet it is unlikely that it will be overcome in the foreseeable future. There are no known scientific publications about this, and what can be read publicly in Europe ought to more plausibly be interpreted as "marketing".

Another of Neuralink's spectacular research projects is 'Blindsight'. This is an attempt to convey optical stimuli to blind people whose optic nerve and/or eyes are non-functional by means of direct electronic stimulation of the cerebral cortex responsible for visual acuity. The triggered image does not have to be limited to the spectrum of electromagnetic waves that is visible to the human eye.

Although the success of the venture will still require several years of observation, it appears that at least one promising funded study programme is already in progress.

Non-invasive BCIs

Unlike the invasive method, these appear to be easily reversible. They essentially involve an EEG device and a computer that analyses the EEG and uses it to generate control commands for another computer or a smart home.[15]

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14 See: Musk-Start-up Implantiert Ersten Chip in Menschlichem Gehirn (Musk Start-up Implants First Chip in the Human Brain). In: Tiroler Tageszeitung Online. 30 January 2024. https://www.tt.com/artikel/30874844/musk-start-up-implantiert-ersten-chip-in-menschlichem-gehirn.

15 See Lenzen, Manuela: Mit der Kraft der Gedanken (With the Power of Thought). In: Spektrum der Wissenschaft Kompakt. 03/2019.

A highly sophisticated system of this type has been developed by DARPA, the research department of the US Army. Patients are able to use such controlled prosthetic limbs to grasp a glass and drink from it, clench a fist and shake someone's hand. The artificial hands can even be equipped with sensors that give the wearer a feel for their new limb. This is sometimes so precise that they can tell which finger of their artificial hand is being touched.[16]

The main factor for further progress in this technology is the so-called brain plasticity, which makes targeted training of control methodologies possible. However, it can be expected that useful applications for healthy people will be possible in five to ten years. For this reason, and to avoid the difficulties with the invasive BCIs described above, the current research focus is on non-invasive BCIs.[17]

Enhancement objectives of BCIs

In recent years, research into BCIs has also intensified outside of medicine.

Using the power of thought to quickly communicate by e-mail or to even control aircraft are said to be the goals.

The fundamental problem with BCIs

Around 70 years ago, the neurosurgeon Wilder Graves Penfield (* 1891 † 1976), who was born in the USA, completed his education there and in Oxford and later worked in Canada, recognized that complex sensory impressions could be simulated and movements of peripheral muscles provoked with point-shaped, weak, electrical stimulation on the open brain of his patients without pain sensation. Back then, he mapped the corresponding areas of the cerebral cortex at the so-called sulcus centralis: this image became world-famous as the "Penfield's homunculus" in the standard works of anatomy.

16 See Lenzen, Manuela: Mit der Kraft der Gedanken (With the Power of Thought). In: Spektrum der Wissenschaft Kompakt. 03/2019.

17 See UK's Ministry of Defence (MOD) and Bundeswehr Office for Defence Planning: Human Augmentation – The Dawn of a New Paradigm A strategic implications project. 2020. https://www.bundeswehr.de/resource/blob/5016368/fdc7f1c529ddfb014d4e321e8b666a2d/210111-sip-ha-data.pdf, accessed 20.11.2023.

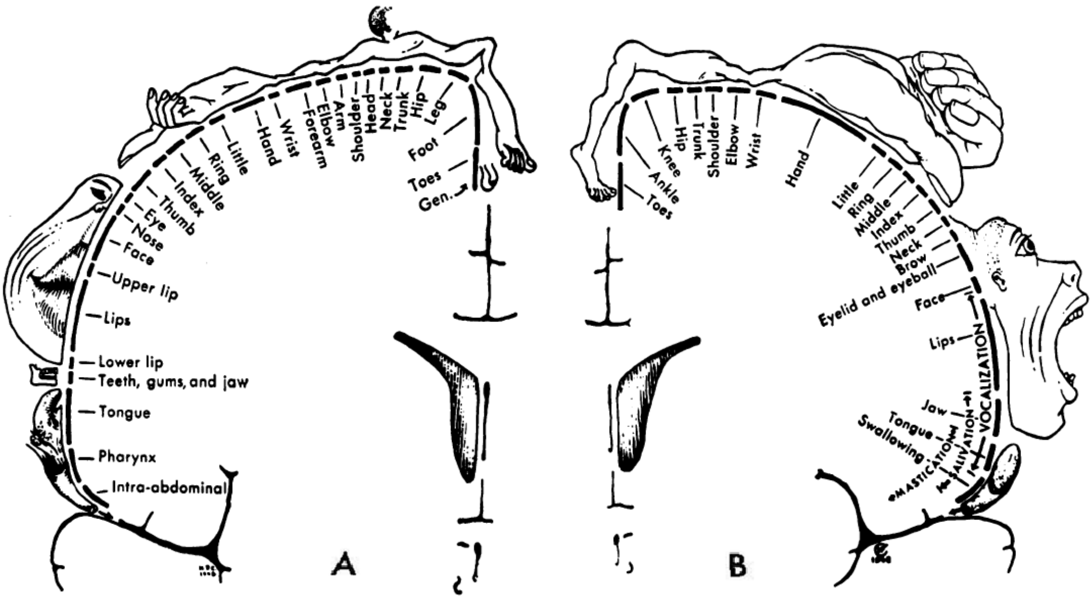

Figure 2: This illustration explains the widely held vision that neuroenhancement could be developed with smart electronics. 1954 Penfield Homunculi: (A) Sensory homunculus. (B) Motor homunculus. Image from the Penfield Archives, Osler Library of the History of Medicine.

Although it is now possible to enable patients with nerve failures caused by illness or injury to have some form of spectacular motor or sensory function, this remains far behind the capabilities of healthy people.

This is due to the fundamental differences between biological and electronic components, which make it difficult to create a common bio-electronic system. A Homo sapien's brain contains about 86 billion (= 8.6×10^{10}) nerve cells, of which around 16 billion (= 1.6×10^{10}) are in the cerebral cortex. The length of all the nerve pathways in the brain of an adult human totals to about 5.8 million kilometres, which is equivalent to 145 times the Earth's circumference. The nerve cells in a human brain are connected to each other via synapses, of which there are about 100 trillion (= 10^{14}). These large numbers alone defy comprehension; they can only be calculated statistically. In comparison, the 1024 electrodes of the neural link experiment and perhaps soon a multiple of that number will look downright minuscule.

Regardless, there are at least two further phenomena that stand in the way of a standardised BCI: electronic components can be manufactured identically, but no two human brains are exactly the same. There is even a difference between the biological genders in the internal organization of the brain with regard to language and spatial perception. But even within these gender groups, brains diverge according to different lifestyles and living conditions. Examples include different nutritional habits, exposure to harmful substances (including alcohol consumption and the like), exposure to radiation (high risk: flight personnel and astronauts) and, above all, major or minor, often unnoticed injuries. The fact that brains are usually capable of comparable performance, despite these individual differences, is demonstrated by their enormous plasticity, which also distinguishes them from technical components.

One aspect that should not be underestimated is the energy supply. A human brain has an output of about 20 W and is optimised for a working temperature of 37°C. Even a slight deviation in energy supply and temperature can have a very negative impact on function. Technical components have completely different tolerances here but also play in a completely different league in terms of process speed.

In summary, it is unlikely that the aforementioned differences between biological and technical systems will be able to be combined into a militarily useful instrument in the coming decades.

<u>Biological consciousness versus artificial intelligence (AI)</u>

It is still largely unknown how consciousness came to be as a sum of sensation, perception and experience. There is no recognised definition of consciousness, due to the variety of aspects that it involves. The primary focus of natural science is on the definable properties of cognitive and emotional reactions.

With its ability to automate complex tasks and process large amounts of data, AI can boost productivity, improve efficiency and create new opportunities for innovations.

However, there are serious differences between AI and biological or human consciousness:

Emotions such as love, loyalty, trust and the sense of security, joy or sadness, which – pars pro toto – arose in the evolution of placental mammals, are expressed at least partially unconsciously and have contributed decisively to the survival of the relevant species. The same applies to the human need to give our own existence some kind of meaning. Nowadays, it is no longer possible to define a small region of the brain as the seat of consciousness. This is a function of the entire brain, with its highly complex network of nerve cells. This means that targeted control of human consciousness cannot be stimulated by electrodes, however fine they may be.

On the other hand, AI is based on neural networks and thus ultimately on mathematical functions with the aim of optimising the results of an individual process specified by its programmers. Unlike the human brain, however, a decentrally organized AI is neither limited in size nor in its energy supply.

But it lacks the essential characteristics that constitute a personality and confer human dignity.

This gives AI the character of a powerful tool that can be used for both problem solving and criminal activities.

4. Ethical challenges and military significance

Whereas the advantages of neuroenhancement in terms of medical rehabilitation are largely undisputed, there are several ethical and legal-philosophical reservations regarding its justifiability outside of medical treatment or medical-technical support for rehabilitation.

The increasing pressure to perform in today's liberal, secular and capitalist Western society is a strong incentive to strive for the optimisation of the human workforce in general competition. Doping in sports is a widely known phenomenon. However, doping is internationally viewed as a form of fraud against non-doped athletes and against sports enthusiasts.

With regard to the ethical issue of the use of neuroenhancement by the armed forces, reference should be made to the wide range of relevant research and discussions activity. These numerous aspects – including legal ones – are discussed in detail in another chapter of this book.

<u>Here are just a few brief points for discussion:</u>

- The main questions that arise are the extent to which soldiers must 'dutifully' endure neuroenhancement methods, and the advantages that they may enjoy as a result. It is also unclear as to whether they will even be considered as combatants under international humanitarian law and whether doped soldiers will be allowed to take part in competitions with non-doped members of civil society, etc.
- What impact might the widespread use of neuroenhancement have on the organisational culture of the armed forces? What impact will this have on the self-perception of a person who is affected by this? Does this affect the cohesion within the team? New employer branding is therefore also important when recruiting professional soldiers.
- Due to the difficulties described and the high cost of the necessary intervention for an individual soldier, any relevant use of BCIs by armed forces can be ruled out at least until the middle of the 21st century. This leaves pharmacological NE, with which contradictory experiences were already made historically in the world wars. A possible short-term increase in performance due to Pervitin® was countered by drug dependency, alternating withdrawal and overdoses, the associated unreliability and long-term physical and mental deterioration and, in some cases, fatal overestimation of one's own abilities.
- However, it cannot be ruled out that pharmacological NE will be used in a targeted manner by various armed forces, especially if new substances with a safe effect and low side-effect rate are developed. However, a decisive influence on war is not to be expected because, despite 'doping', the increase in human performance remains limited for biological reasons in contrast to technical progress.

The following fundamental ethical objections can be raised against neuroenhancement in general:[18]

- There may be problems regarding the health and safety of the affected individual when 'enhancing' brain interventions, especially in terms of unwanted side effects and personality changes. This also includes questions about the limits of the risk that the addressee of such an intervention can legitimise for a third party by giving consent.
- Problems regarding autonomy, 'authenticity', and perhaps even personal identity: Could these qualities be impaired, or even nullified by mental enhancement?
- Disavowal, in the long term possibly a social devaluation of the desired goals, i.e. of the artificially enhanced characteristics themselves?
- Could there be corruption of human nature or even of human dignity?
- Could the frequency of medical corrections of variants of mental characteristics that were previously within the normal spectrum be increased?
- Misuse for external control of people?
- Social justice issues.

5. Conclusion

Everything that can be developed will be developed. It is just a matter of time. It should be kept in mind that European ethical and cultural viewpoints are of minor interests in today's world. What was and is unthinkable for European armed forces can often be realized outside of Europe without 'old-fashioned' reservations. The observation of the Asian and Islamic cultural area in particular is all the more important as a technical catch-up to Western science is foreseeable in the coming decades.

18 See Merkel, Reinhard: Neuroenhancement aus normativ-rechtlicher Sicht (Neuroenhancement from a normative-legal perspective). In: SPEKTRUM der Wissenschaft. May 2015, p. 74. www.spektrum.de/artikel/1133992.

The fact is that relevant research is currently being carried out in both East and West, with the aim of exploring the extent to which healthy soldiers can be optimised in such a way that leaders, and particularly specialists such as military pilots, can carry out their duties longer and better thanks to increased intellectual abilities, particularly faster comprehension.[19] Physically-challenged soldiers should be able to fight even faster and with less fatigue, and military personnel should be able to devote themselves even more intensively and creatively to their specific tasks.

From today's perspective (2024), the authors expect pharmacological and non-pharmacological methods in medically indicated neurorehabilitation to continue to achieve impressive successes in the future. In our opinion, however, there are fundamentally insurmountable biological disadvantages and limitations to performance that stand in the way of widespread use in healthy soldiers. This is primarily due to the fact that the reproducibility of desired effects can be predicted with sufficient accuracy as a statistical average, but not for specific individuals. The same applies to undesirable effects and the reversibility of the measures taken. However, it cannot be ruled out that the pharmacological performance enhancement of soldiers from various armed forces will be sought – as has already been the case in the past – regardless of the aforementioned disadvantages.

Especially in the case of invasive BCI (neural implants), the surgical effort seems extremely unprofitable, due to the uncertainty of the resulting operation The mechanistic view of man held by Frederick the Great's personal physician Julien Offray de La Mettrie in his pamphlet 'L'Homme-Machine' (1748) has long been a concept of the past. Overall, humans cannot be understood as technically measurable machines. The human being in toto cannot be understood as a machine that can be technically grasped; the high number of nerve cells in the brain alone - around 86 billion - and, above all, the variety of rapidly changing connections between them prohibit this.

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[19] European Parliament: Science and Technology Options Assessment – Human Enhancement Study, May 2019, https://www.itas.kit.edu/downloads/etag_coua09a.pdf.

In view of the advantages of increasing automation in weapons and air force technology and the support of tactical and operational decisions by networked information systems with artificial intelligence, the efforts of human enhancement with neurobiological methods and their limited results appear to be outdated.

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