MONITORING AND ENHANCEMENT OF NEURO-VISUAL PERFORMANCE FOR AIRPORT SECURITY SCREENING PERSONNEL

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Abstract

The aim of the study is to develop a proof of concept experiment dedicated to the monitorization and augmentation of neuro-visual performances in airport security screening personnel. The main specific parameters of the visual tasks involved are visual stereotypy, detection of complex visual patterns, visual-spatial perspective, low-frequency anomaly detection, limited time exposure and psychological pressure. The final result of the research is the development and validation of a neuro-augmentation program.

The rapid development of this branch in the United States (military and civilian spin-offs), the previous interest of some NATO states and similar Romanian civilian initiatives determin~~ed~~ us to propose the foundation of a Human Performance Optimization (or Enhancement) Centre for National Security Personnel. We consider that are at least three main areas of research and development – physical fitness, neuro-augmentation and human-computer interaction.

Keywords: *airport pre-flight security screening personnel, visual task, neuro-visual performances, neuro-augmentation program, low-frequency anomaly detection.*

Introduction

The development of neuroscience and the research aimed at investigating the nervous system and the human mind had a number of outcomes, including military applications. One application is cognitive enhancement or neuro-augmentation, whose goal is to provide to the soldier

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cognitive performance, endurance and higher adaptive capacity, while minimizing unwanted effects.

Although there are a significant number of researches and studies on neuro-augmentation and the concern for improving cognitive abilities started since ancient times, this domain is not yet regulated, the terminology is ambiguous and does not enjoy full consensus. The media focus on this subject, in most cases positive and highly optimistic, further contribute to the trivialization and confusion, ignoring the fact that the methods used to improve cognitive performance are largely experimental, and sometimes are risky or invasive.

Terminology and ethical issues

The most important aspect is that, at least for the time being, neuro-augmentation is not a medical procedure in itself. Notwithstanding, it often employs methods that are used for therapeutic purposes within several medical specialties, it is sometimes carried out under guidance by medical personnel and it makes use of data that have been obtained during medical studies or research. The concept appeals to neurological and psychiatric healthy persons and it aims to enable the reaching of an individual's full potential. In doing so, it elevates (cognitive and emotional) individual neuro-psychological performances, on both the quantitative and qualitative levels (the latter implying self-control and personal skills). The approach is similar to the one encountered in sports medicine in the case of high performance athletes.

Other examples are the military (Special Forces, para-troopers, supersonic pilots, astronauts, drivers) and extreme sportsmen (mountain climbers, arctic explorers, deep divers, speleologists etc.). What all these examples have in common is the employment of medical knowledge in order to reach the maximum biological threshold while observing safety precautions and with the full consent and cooperation of the individual, thus making it possible to set personal or collective records.

Neuro-augmentation comprises a soft and non-invasive optimization phase, on the one hand, which is fulfilled through personalized trainings and manipulation of environmental factors as well as an augmentation phase, on the other hand, which may involve invasive and potentially risky methods that might be referred to as doping.

A controversial aspect of the neuro-augmentation concept is dealing with ethical issues that arise from the potential high-scale or highly effective application of the procedure. The idea of neuro-augmentation itself leads to controversy when questioning the reasons of its potential developers and users, the public opinion and perception, as well as its methods and consequences. Debates on the subject have covered various topics which highlighted a series of challenges following rapid development of research into improving human performance and convergence of strategic and top technologies (such as bio, nano and artificial intelligence).

A first point of interest deals with the types of national or international institutions which will regulate and influence the technologies that are aimed at improving human performance. Equally important are concerns regarding the legal approaches and the political control that will be responsible for the design of such evolutions (Sauter and Gerlinger, 2013, p. 265).

By contrast to other similar practices (e.g. doping in sport), neuro-augmentation is not recognized and regulated by an international treaty. As a result, some voices in the research field are claiming that all courses of action in relation to neuro-augmentation (which range from a *laissez-faire* approach to having it encouraged, enforced as obligatory, allowed or banned altogether) are potentially relevant.

As such, publishing of articles on the subject in top scientific journals is correspondingly challenging, due to the ambivalent status and a lack of a general consensus on the research topic as well as to the absence of specialized institutional authorities in the field. At present, the majority of authors believe that regulations should be issued by state authorities but also incorporated into international guidelines due to their potential social, medical and security implications.

A third point of interest is the context in which neuro-augmentation technologies are used. On the one hand, some authors are advocating for cognitive augmentation as a necessary and mandatory process in connection to claims that there is a direct correlation between an increased IQ and a step-up in productivity. Moral augmentation that might be targeting lawyers, priests or decision-makers at large has its share of staunch supporters as well. On the other hand, some authors urge that all these forms of amplification be categorized as doping and banned altogether. Nevertheless, it is obvious that contextualization of neuro-augmentation practices can produce various interpretations which are not in the smallest degree also influenced by judicial practices or cultural traditions at national level (Dubljević, 2015).

A last point of interest is that lawmakers cannot overlook the fact that the attitude of public opinion is quickly shifting between a highly enthusiastic embrace of the concept, especially in techno-progressive environments (such as communities of youngsters in cities, Silicon Valley, university town, corporations etc.) (Goertzel, 2015) residing at the forefront of the knowledge-based liberal society and a clear-cut rejection by traditionalists and conservatives.

Further arguments for developing and employing neuro-augmentation techniques are appealing to concepts such as virtue, liberty, cognitive autonomy, utilitarianism, and gaining of new and superior capabilities, which are fundamental topics to consider if neuro-augmentation is to be used ethically (Hughes, 2014).

Within this context the use of neuro-augmentation is justifiable from both the point of view of the utilitarian moral theory, according to which any given action is moral as long as its outcome is positive for as many people as possible and no other damage has been produced, and the point of view of the autonomy principle, which although may be viewed as a personal right stemming from individual liberty, may also be condemned for reasons having to do with social injustice, hedonism, security concerns, and unforeseen consequences.

Risks

In the context of a lack of regulation, the risks ensued by research in the neuro-augmentation field are far from being well defined and mapped. To this purpose, a prospective endeavour in this sense is absolutely necessary.

A primary aspect is constituted by the risk of proliferation of double-use technologies, since neuro-augmentation already employs or will make use of a series of top technologies that have the potential to be exploited for both military and civil purposes. Examples of such technologies are some components of artificial intelligence, neuro-biometrics, brain-computer interfaces, advanced robotics, nanotechnologies, and genetic engineering. Even though these technologies by themselves are strictly controlled and regulated, their convergence can result in products with potential military applications.

The approach is quite similar to the one pertaining to autonomous artificial intelligence. It too is believed to be a double-use technology that may generate major security risks that are difficult to foresee. The pre-emptive argument, which is so abundantly invoked in relation to the emergent technologies in the last half of the century, claims that although the current development state of neuro-augmentation is not posing a serious threat, the next generations stemming from this type of technology will generate major security risks which are difficult to anticipate and counteract. In light of this argument, super-regulation or banning of military research would have to become a priority.

By invoking similarities with artificial intelligence, another concern becomes apparent. That is the fact that neuroaugmented individuals will become increasingly interested in perfecting the very methods that they have benefited from, as well as dispose of the necessary cognitive resources and other means to learn by themselves at a much faster pace than the rest of the non-augmented individuals. At least in theory, the fusion between human and artificial intelligence by means of neurotechnologies is possible. However, the result would not guarantee predictability in terms of its final utilization and adherence to morality, especially within the military field.

A characteristic of future conflicts will be the employment of Enhanced Human Operations, which are based on the use of man-machine dyads, such as advanced robotics, exoskeletons, directed-energy weapons (neuro) augmented soldiers. Some are fearful that certain countries, which benefit from a lack of legal regulation, the support of the authoritarian political factor, and testing ground in proxy conflicts, are already involved in the development of military augmenting means that can yield an asymmetric advantage.

Research

One of the most important superior cognitive function essential for civilian and military professions relevant for national security is the neuro-visual performance. This was one of the main reasons that motivated our research, alongside the fact that the neuro-visual cortex is well studied and understood. Our research targeted the neuro-visual performances specific to tasks meet in several security related professions: airport pre-flight security screening officers, port facility screening officers, radar operators, image analyst, cyber security officer, UAV pilots, etc. Our research targeted he visual tasks in the case of the airport pre-flight security screening officers. The main specific parameters of the visual tasks involved are visual stereotypy, detection of complex visual patterns, visual-spatial perspective, low-frequency anomaly detection, limited time exposure, psychological pressure.

Our research was aimed at identifying a non-invasive, easy-to-use and safe-to-use method that improves the neuro-visual performance in a short amount of time (3-6 months). Our study was designed as a proof of concept experiment dedicated to the monitorization and augmentation of neuro-visual performances in airport security screening officers. The final result is the development and validation of a neuro-augmentation program.

The study was carried out on the course of three months, after several preliminary trials dedicated to the improvement of the research methods. We used two groups (study and control, 10 subjects in each group), males and females, smokers and non-smokers, ages between 25-38 years old. The subjects from the first group were informed about the nature of the procedure and signed a consent form. On the course of the three months they were subjected to three different interventions: EEG-neurofeedback, mild pharmacological stimulation and visual training. The EEG-neurofeedback was performed by a specialized neurologist for three months (1 session/week) and the evaluation was made via LORETA analysis[1], using the Neuroguide[2] protocol (functional connectivity analysis).

This is a process that requires experience and successive error attenuation over multiple sessions in order to eliminate the background noise, biases, and insignificant electrical signals. The pharmacological stimulation targeted the cholinergic and GABA-ergic central systems and was also administered for three months. A non-specific neuro-stimulant was also added for 10 days/month. The candidates were monitored weeks and had been instructed regarding safety issues. The tolerance was good, but even if none of the candidates experienced side effects, the subjective experience ("feelings of enhancement") was different. The efficiency evaluation was realised using visual-spatial intelligence tests monitored with eye tracking and EEG recording devices.

Visual training was administered via a commercial app that is available in smartphones and computers (laptop, tablet), for 15-30 minutes/ day (3 days/we). The evaluation in this case was realised using visual intelligence and discrimination task monitored with eye tracking.

The final evaluation consisted in the visualization of specific and standardized Rx images for 8 seconds each (100 images), was administered at the beginning and at the end of the study. We tried to replicate most of the real-life conditions (noise, illumination, irregular distractions, random blank images interposed). The neuro-visual performance was evaluated using

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1 LORETA is the acronym for standardized low resolution brain electromagnetic tomography, method used for localizing the electrical activity in the brain based on scalp potentials from multiple-channel EEG recording

2 https://bio-medical.com/neuroguide-deluxe-qeeg-255.html

electroencephalography (EmotivEpoch – 14 channels EEG and MindWawe Mobile - single channel), visual interaction (Tobi eye-tracking device and CoolTool platform) and galvanic skin response (a channel). The raw data obtained was processed using several specific software and the results interpreted and compared with similar studies.

Results

The fusion and interpretation of the information obtained from different channels was a complex task, with some of the issues still necessitating further optimization. For example, we persistently observed a high variability in the electroencephalographic recording that attenuated in most of the cases after 10 or more minutes after the beginning of the work sessions (near-real occupational exposure). Major differences were also observed in the electric activation patterns between males and females and smokers and non-smokers (nicotinic receptor activation?).

Using LORETA analysis (EEG, 14 channels, minimum of 20 minutes of evaluation) we observed a stable and robust frontal and occipital activation in all of the cases. Alpha wave asymmetry in the frontal lobes after visualization of “high value targets” was also identified and observed consistently even in non-expert subjects.

An even higher variability was observed in galvanic skin response (GSR) recordings, even on the same person on different sessions. A number of factors, such as clothing, electrostatic loading, emotional status etc. (unrelated to the study) have a major contribution to the variations in the GSR signal. However, by making multiple recordings and integrating the GSR recordings with the rest of the data obtained emotional polarity, emotional intensity variations or stress effects can be observed and measured.

On contrary, multiple sessions of eye-tracking led us to the conclusion that the visual search patterns (visual strategies) are relatively constant in an individual, and can be used for biometric recognition. The improvement of the visual search performance as a result of visual training and adherence to the study was best monitored using (first generation) eye tracking. In the context of the accelerated development of the brain-computer interfaces based on visual interaction, we consider eye tracking is a non-invasive method, easy to use and with a large potential.

The small number of subjects and the fact that our study was concept proof limited our possibilities of expressing the results in a statistical manner, but allowed comparative assessments or case studies to be carried out. The comparative assessments performed on the same subject (individual assessment) showed that the range of the improvement before and after the successful completion of all three interventions varied between 30% -100%.

Performance improvement in (presented as an average of end-of-run performance) between the control and the augmented lot was about 50%, but this assessment should be seen as a partial quantitative indicator. The most important indicators, with predictive capacity, were those used to evaluate the visual search strategies. In the case of electroencephalography there was an increased interpersonal variability which limited the possibility of being used in intergroup comparative evaluations.

The results obtained so far are positive and show a remarkable improvement in pattern detection, the speed of anomaly detection, a decrease in false-positive target detection, optimized visual search patterns, improvement of signal/noise ratio and general visual efficiency improvement.

Conclusions

The majority of authors acknowledges the necessity of a regulation framework for certain aspects of neuro-augmentation and connected emerging technologies. This is all the more true when considering the modern-day global race for increased social, economic, political and military competitiveness. For organizations dealing with national security, efficient management of resources is a crucial objective that needs to be met as a result of the current dynamics of the security environment. As such, any investments in neuro-augmentation technology needs to be balanced by its benefits and the extent of risk control arrangements.

Talking about the outcome of our study we consider that the research showed that the limits for human performance improvement and in particular for higher cognitive functions are not exhausted. Today's expanding technological environment is the main driver for human performance improvement development. Security risks and threats, and in particular terrorism and the proliferation of non-state hostile intelligence services, forced changes of strategy and human element improvement convergent with internet and artificial intelligence development.

Our proof-of-concept research highlighted the potential of neuro-augmentation methods and the possibilities for use in national security professions. Neuro-visual improvement can be useful in several professions of interest for national security and represent a complementary niche for research on computer vision and artificial intelligence.

Our final statement is that EEG-neurofeedback, mild pharmacological stimulation and visual training (together with other methods) can be useful in training and efficiency improvement for pre-flight airport x-ray security screening personnel.

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