

Cognitive Warfare, a Battle for the Brain

Francois du Cluzel

ACT

Norfolk, Virginia

UNITED STATES OF AMERICA

Francois-pierre.ducluzelderemaurin@act.nato.int

ABSTRACT

With the growing role of technology and information overload, individual cognitive abilities will no longer be sufficient to ensure an informed and timely decision-making, leading to the new concept of Cognitive Warfare, which has become a recurring term in military terminology in recent years.

Cognitive Warfare causes an insidious challenge. It disrupts the ordinary understandings and reactions to events in a gradual and subtle way, but with significant harmful effects over time. *Cognitive warfare has universal reach, from the individual to states and multinational organisations. It feeds on the techniques of disinformation and propaganda aimed at psychologically exhausting the receptors of information. Everyone contributes to it, to varying degrees, consciously or sub consciously and it provides invaluable knowledge on society, especially open societies, such as those in the West. This knowledge can then be easily weaponised. It offers NATO's adversaries a means of bypassing the traditional battlefield with significant strategic results, which may be utilised to radically transform Western societies.*

The instruments of information warfare, along with the addition of "neuro-weapons" adds to future technological perspectives, suggesting that the cognitive field will be one of tomorrow's battlefields. This perspective is further strengthened in by the rapid advances of NBICs (Nanotechnology, Biotechnology, Information Technology and Cognitive Sciences) and the understanding of the brain. NATO's adversaries are already investing heavily in these new technologies.

Hence, the advent of the concept of "cognitive warfare" brings a third major combat dimension to the modern battlefield: to the physical and informational dimensions is now added a cognitive dimension. The latter thus creates a new space of competition, beyond the land, maritime, air, cybernetic and spatial domains, which our adversaries have understood and sometimes already integrated. Warfare in the cognitive domain mobilises a wider range of battle spaces than the physical and informational dimensions can do. Its field of action is global and aimed to seize control of human beings (civilian as well as military), organisations, nations, but also of ideas, psychology, especially behavioural, thoughts, as well as the environment.

1.0 COGNITIVE WARFARE, INFORMATION WARFARE AND CYBER WARFARE

There is no commonly accepted definition of Cognitive Warfare. The notion of Cognitive Warfare is still not really well understood and is very often confused with *Information or Cyber warfare*.

1.1 Defining Cognitive Warfare

Historically, the term "cognitive warfare" has been referred to as the use of the means of action that a state or an influential group makes in order to manipulate the spontaneous mechanisms of the cognition of an enemy or its people, in order to weaken, penetrate, influence, or even subdue or destroy them.

Although it is an integral part of the military art, it is, in this sense, a new disciplinary field that requires to be better identified. It comes from the cyber techniques of information warfare, and from the human aspect of "soft power" (or influence), with the ambitions of manipulation of what we usually call "Psy-Ops" or Psychological Operations. It is most often a question of biased presentation of a reality, most often digitally altered, to facilitate or enhance one's own goals. The pervasiveness of Information Technology and the lack of attribution offer infinite opportunities, paving the way to new methods and new objectives.

Some of the Alliance's adversaries have clearly understood the military interest of CW. By nature, it has a global military dimension, and covers both the strategic and operational dimensions. It has undergone a remarkable surge with the advent of digitization of strategic decision support, and the exponential profusion of big data and analytics, for information, wargaming and the conduct of operations. It is progressively invading the entire field of digital usage, and silently allowing the implementation of policies of interference and counter-interference, of cognitive attrition and of defense of the populations that would be subjected to it.

The massive explosion of behavioural data made available by the advent of social media has empowered researchers to make significant advances in the understanding of the dynamics of individuals and large groups online **by combining system engineering with social sciences**. As this field of research expands, opportunities multiply to use this knowledge to forge powerful new techniques not only to understand but also to shape the behaviour and beliefs of people both individually and globally. "Behavioural economics adapts psychology research to economic models, thus creating more accurate representations of human interactions."¹

It is therefore both a reasoned set of attack processes but also countermeasures and preventive measures.

It could tentatively be defined as "the art of using technologies to alter the cognition of human targets, most often without their knowledge and consent".

Above all, cognitive warfare is a form of hybrid warfare, which aim is to alter the cognitive processes of the adversary, to exploit biases or mental automatisms, in order to provoke distortions of representations, alterations of the decision or even inhibitions of action, and to bring about disastrous consequences, both at the individual and the collective level.

While it is made possible by the human "hyper-connectivity", it is often confused with cyber warfare. Yet, it does not focus strictly on the field of "information" but on that of "cognition", i.e. what the brain does with information. It is therefore not reducible to the simple aspect of the human consequences of a "cyber warfare", robot and program engineering; the cognitive effect is not a consequence of the action, it is its goal.

The actors of cognitive warfare are very diverse; states or non-state actors, institutions or companies, terrorist organizations, religious movements, political groups are all potential actors with disparate degrees of excellence. It is used and implemented by specialized highly competent units, digital intelligence services, but also by agencies and industrial firms in their competition or in the field of marketing and the definition and manipulation of a potential customers.

1.2 Principles of Cognitive Warfare

According to Professor Bernard Claverieⁱⁱ, there are emerging theories of CW that address both notions such as resilience or weakness in "neuroscience", the use of "cognitive biases" and the spontaneous propensity for "cognitive error", manipulation of perceptions, attentional saturation or "tunnelling", and induction of cognitive stress. The consequences are predictable on the ability and overcoming of mental operations, on social relations and motivations, and on institutional disorganization.

"Cognitive warfare" represents the convergence of all the elements of "information warfare" expanded by operational notions of psychology and neuroscience, based on systemic and complexity theories at the service of warfare. It is at the interface of two operational fields that have been managed separately until now: on the one hand, psychological operations (PsyOps) and influence operations (soft power), and on the other hand, cyber operations (cyber defense technologies) that aim to compromise the integrity of physical means of information or to destroy them.

The main principle is not only to follow a strategy and win without fighting (a principle dear to Sun Tzu), it is also a war against what an opposing target thinks, likes or believes by modifying its representations of reality. It is therefore a war against its ways of thinking, its mental logics, its spontaneous representations and its conceptual processes. The goal is to alter the representation of the world, but this has the consequence of undermining the whole-of-society in a very likely durable way.

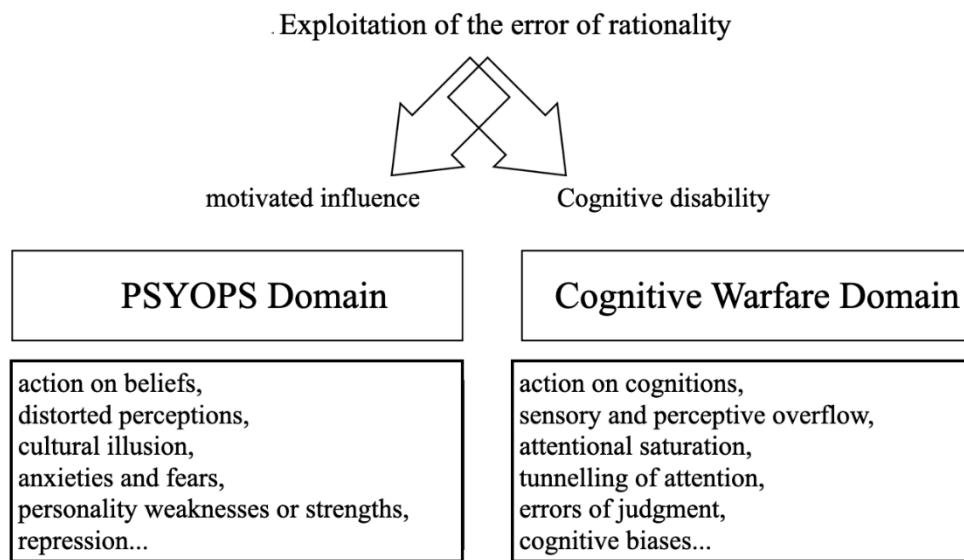


Figure 1: Differences between "cognitive warfare" and "PsyOps" (in which psychological operations proper and other non-kinetic actions such as influence actions and civil-military cooperation (CIMIC) are simplified, as defined by Professor Bernard Claverie.

CW is also based on knowledge of the psychology of actors, the psycho-sociology of populations and small groups, and the cultural influence on the rationality of actors. And its implications of the cognitive actions are extremely wide, ranging from decision making, error and cognitive biases, perception and illusion, cybernetics and the absence or rupture of control, influence and soft power, psychology and cyber psychology, human-machine teaming, robotics and drones, autonomy etc...

1.3 Cyberpsychology

The OODA loop (Observe, Orientate, Decide & Act) is highly dependent on the Orientate step, which can be the focus of our adversaries cognitive efforts.

Getting orientation wrong, no matter how well an actor can Observe, how quickly they can Decide, and how concisely they can Act, can nonetheless mean the actor is caught playing the wrong game.

Assuming that technology affects everyone, studying and understanding human behaviour in relation to technology is vital as the line between cyberspace and the real world is becoming blurry.

The exponentially increasing impact of cybernetics, digital technologies, and virtuality can only be gauged when considered through their effects on societies, humans, and their respective behaviours.

Cyberpsychology is at the crossroads of two main fields: psychology and cybernetics. All this is relevant to defense and security, and to all areas that matter to NATO as it prepares for transformation. Centered on the clarification of the mechanisms of thought and on the conceptions, uses and limits of cybernetic systems, cyberpsychology is a key issue in the vast field of Cognitive Sciences. The evolution of AI introduces new words, new concepts, but also new theories that encompass a study of the natural functioning of humans and of the machines they have built and which, today, are fully integrated in their natural environment (anthropo-technical). Tomorrow's human beings will have to invent a psychology of their relation to machines. But the challenge is to develop also a psychology of machines, artificial intelligent software or hybrid robots.

Cyber psychology is a complex scientific field that encompasses all psychological phenomena associated with, or affected by relevant evolving technologies. Cyber psychology examines the way humans and machines impact each other, and explores how the relationship between humans and AI will change human interactions and inter-machine communication.

For the Alliance, the cognitive dimensions of Command and Control (C2) go hand in hand with cybersecurity and human reliability, particularly in its multicultural dimensions, and can in no way be neglected.

2.0 THE WEAPONIZATION OF NEUROSCIENCES

Dr. James Giordano describes the brain as the new battle scape of the 21st Century, while there are many voices claiming that we have already transitioned from “wars of attrition to wars of cognition”ⁱⁱⁱ.

Hyper-connectivity alongside the ubiquity of information technologies, the explosion of data and the advances of technologies resulting from neurosciences allow us to foresee infinite possibilities in terms of brain manipulation.

With the advent of the aforementioned tools and techniques and new technologies such as neural and generative networks, augmented reality, virtual reality, artificial intelligence, voice recognition, brain scanning, machine-driven communications (MADCOM), our brains are increasingly being targeted.

Understanding the brain has become a key challenge for the future.

2.1 Brain as a Weapon

NBIC (Nanotechnology/ Biotechnology/ Information technology and Cognitive Science) is a scientific project that commits to the convergence of four domains that have been dissociated until now: nanotechnology (nanorobots, nanosensors, nanostructures, energy...), biotechnology (bio-genomic technology, Crisp-Cas9, neuropharmacology...), computer science (information technology, computer science, microelectronics...) and cognitics (cognitive technology, cognitive science and neuropsychology). This project was formalized in 2002 thanks to the US Department of Defense, and was then followed by major international institutions and nations, for the convergence of future technologies.

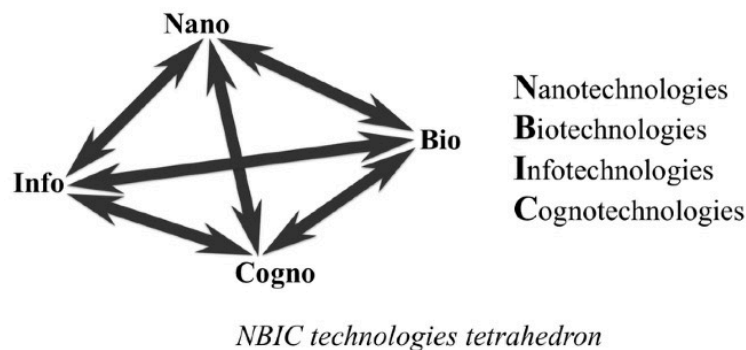


Figure 2: Convergent technologies as defined for the US DoD in Roco and Bainbridge (2012) report^{iv}.

The convergence of NBIC aim at developing tools to adapt or enhance individuals thanks to a real human-system hybridity, in the fields of health, security, defense and with the objective of adapting to new biotopes (space, sea, deserts...). Today, we are witnessing partial convergence of fields: computer science and health nanotechnologies/new chemical products to amplify cognition/implanted electronics, etc. The project is to eventually have an augmented human operator, or even a hybrid, with substances or nanotechnologies of amplification, resistance and informational superiority. In other words, we are coming to the augmented soldier.

When it comes to the connected brain, particularly that of the warfighter and the action that can be exerted on it, or the protections that can be applied to it, it is an offensive and a defensive aspect of "cognitive warfare". Many authors have anticipated these threats. For the time being, they are still mostly in the realm of science-fiction, but we are beginning to see the appearance of projects that are very seriously programmed, or even already concretely tested, notably on neuro-computational implantation or technical hybridization of perceptive amplification (vision, hearing), and even on genome modifications.

Beyond the more traditional, and very current, threat of "cognitive warfare" in the service of allied or competing States, or even non-state entities, we should be interested in the future of NBIC, and in its influence on human cognition, through detour, saturation, or even, we can envisage taking control and diverting the objective.

2.2 Militarisation of Neuroscience and Technology

The use of neuroscience and technology for military and intelligence purposes is realistic, and represents a clear and present concern. In 2014, a US report asserted that neuroscience and technology had matured considerably

and were being increasingly considered, and in some cases evaluated for operational use in security, intelligence, and defense operations. More broadly, the iterative recognition of the viability of neuroscience and technology in these agenda reflects the pace and breadth of developments in the field. A wide number of nations are currently pursuing neuroscientific research and development for military purposes.

The potential for neuroscience and technology to afford insight, understanding, and capability to affect cognitive, emotional, and behavioural aspects of individuals and groups render the brain sciences particularly attractive for use in security, intelligence, and military/warfare initiatives.

To approach this issue, it is important to establish four fundamental premises.

- **Firstly**, neuroscience and technology is, and will be increasingly and more widely incorporated into approaches to national security, intelligence gathering and analysis, and aspects of military operations;
- **Secondly**, such capabilities afford considerable power;
- **Thirdly**, many countries are actively developing and subsidising neuroscience and technology research under dual-use agendas or for direct incorporation into military programs;
- **Fourthly**, these international efforts could lead to a “capabilities race” as nations react to new developments by attempting to counter and/or improve upon one another’s discoveries.

This type of escalation represents a realistic possibility with potential to affect international security. Such “brinkmanship” must be acknowledged as a potential impediment to attempts to develop analyses and guidelines (that inform or prompt policies) that seek to constrain or restrict these avenues of research and development.

Neuroscientific techniques and technologies that are being utilised for military efforts include:

1. Neural systems modelling and human/brain-machine interactive networks in intelligence, training and operational systems;
2. Neuroscientific and neurotechnological approaches to optimising performance and resilience in combat and military support personnel;
3. Direct weaponisation of neuroscience and neurotechnology.

Of note is that each and all may contribute to establishing a role for brain science on the 21st century battlescape.

2.3 Military and Intelligence Use of Neuroscience and Technology

As global conflicts take on increasingly asymmetric forms, the ability to use current and emerging techniques and tools of neuro-cognitive science to manipulate human thought and behavior must be considered a current and growing challenge. Ongoing developments in neuroscience and technology make brain science valid, viable, and of increasing value for operational use in warfare, intelligence, and national security applications.

Over the past two decades, cognitive science and neuroscience have taken new and significant steps in the analysis and understanding of the human brain, and have opened up new perspectives in terms of brain research, if not of hybridisation of human and artificial intelligence. They have mainly made a major contribution to the study of the diversity of neuro-psyche mechanisms facilitating learning and, as a result, have, for example, challenged the intuition of "multiple intelligences". No one today can any longer ignore the fact that the brain is both the seat of emotions, the interactive mechanisms of memorisation, information processing, problem solving and decision-making.

Leveraging neuroscience and technology to achieve military effects is not new, but the revolution and the convergence in NBIC (Nanotechnology, biotechnology, information technology, and cognitive science) including advances in genomics, has the potential for dual-use technology development. A wide range of military applications such as improving the performance of soldiers, developing new weapons such as directed energy weapons are already discussed.

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Products of neuroscientific and neuro-technological research can be utilised to affect

- 1) memory, learning, and cognitive speed;
- 2) wake-sleep cycles, fatigue and alertness;
- 3) impulse control;
- 4) mood, anxiety, and self-perception;
- 5) decision-making;
- 6) trust and empathy;
- 7) and movement and performance (e.g., speed, strength, stamina, motor learning, etc.).

In military/warfare settings, modifying these functions can be utilized to mitigate aggression and foster cognitions and emotions of affiliation or passivity; induce morbidity, disability or suffering; and “neutralize” potential opponents or incur mortality^v.

2.3 The brain as the HQ of the body: the Chinese Cognitive Warfare

China has adopted an even broader definition of CW that includes the systematic utilisation of cognitive science and biotechnology to achieve the "mind superiority."

China has defined the Cognitive Domain of Operations as the battlefield for conducting ideological penetration (...) aiming at destroying troop morale and cohesion, as well as forming or deconstructing operational capabilities^{vi}.

It encompasses six technologies, divided across two categories (Cognition, which includes technologies that affect someone's ability to think and function; and subliminal cognition that covers technologies that target a person's underlying emotions, knowledge, willpower and beliefs).

In particular, “Chinese innovation is poised to pursue synergies among brain science, artificial intelligence (AI), and biotechnology that may have far-reaching implications for its future military power and aggregate national competitiveness.”

The goal of cognitive operations is to achieve the “mind superiority” by using information to influence an adversary's cognitive functions, spanning from peacetime public opinion to wartime decision-making.

Chinese strategists predict that the pace and complexity of operations will increase dramatically, as the form or character of warfare continues to evolve. As a result, People's Liberation Army (PLA) strategists are concerned about the intense cognitive challenges that future commanders will face, especially considering the importance of optimising coordination and human-machine fusion or integration. These trends have necessarily increased the PLA's interest in the military relevance not only of artificial intelligence, but also of brain science and new directions in interdisciplinary biological technologies, ranging from bio sensing and biomaterials to human

enhancement options. The shift from computerisation to intelligentisation is seen as requiring the improvement of human cognitive performance to keep pace with the complexity of warfare”.

As part of its Cognitive Domain of Operations, China has defined “Military Brain Science (MBS) as a cutting-edge innovative science that uses potential military application as the guidance. It can bring a series of fundamental changes to the concept of combat and combat methods, creating a whole new “brain war” combat style and redefining the battlefield.” The pursuit of advances in the field of MBS is likely to provide cutting edge advances to China. The development of MBS by China benefits from a multidisciplinary approach between human sciences, medicine, anthropology, psychology etc. and also benefits from "civil" advances in the field, civilian research benefiting military research by design.

Understanding the brain	Understand the risk factors of brain injury caused by military activities
Protecting the brain	Targeted prevention of the brain damage caused by military activities
Monitoring the brain	Monitoring brain function through new technologies and equipment
Injuring the brain	Promoting the research and development of sound, light, explosion, magnetic and other new types of weapons
Interfering with the brain	Causing brain dysfunction and a loss of control with “smokeless” methods
Repairing the brain	Achieving brain function reconstruction with advanced novel medical technology
Enhancing the brain	Improving the level of the brain function of personnel who carry out special tasks
Simulating the brain	Brain-inspired robot intelligence and predicting human decisions
Arming the brain	Studying the arming of the brain, with brain and machine interfaces as the focus

Figure 3: Chinese Military Brain classification of brain functions

3.0 TOWARDS A NEW DOMAIN OF OPERATIONS?

If NATO decides to adopt a very broad definition of CW, including all the elements mentioned above - the classical elements coming from information warfare, cyber warfare and PSYOPS but also the elements coming from the convergence of NBICs and the militarization of Neuroscience and Technology, it will become necessary if not urgent to think about defining a new domain of operations.

3.1 A new framework for operations

This type of cognitive approach is not to be considered according to the classical classifications of the instruments of war. The use of data, systems engineering and new technologies are tools for disrupting targeted individuals or masses, which can have training effects at several scales, from the individual to the entire socio-technical system. Its disruptive effects are useful before, during and after kinetic engagements, while not qualifying as acts of war under international treaties.

Neuroscience is not subject to any rules of international law. A neuroweapon that attacks the brain is neither a biological nor a bioweapon. As Dr. Giordano demonstrated, the two existing United Nations treaties -the Biological Weapons Convention (BWC) and the Chemical Weapons Convention (CWC) - do not contain any provisions for neuroweapons. Indeed, the documents were not drafted to cover all emerging trends, which means that some weapons can only be regulated *after* they have been put into service.

Non-kinetic actions are often elements of a global, discrete, even invisible action calling for an awareness of their danger and the use of effective defence and threat techniques to counter them.

Since everyone is much more vulnerable than before everyone needs to acknowledge that one may endanger the security of the overall. Hence, a deep understanding of the adversary's human capital (i.e. the human environment of military operations) will be more crucial than ever.

"If kinetic power cannot defeat the enemy, (...) psychology and related behavioural and social sciences stand to fill the void."^{vii}

"Achieving the strategic outcomes of war will necessarily go through expanding the dialogue around the social sciences of warfare alongside the "physical sciences" of warfare...(...) it will go through understanding, influence or exercise control within the "human domain"^{viii}.

Leveraging social sciences along with system engineering will support the combat operations by providing potential courses of action for the whole surrounding Human Environment including enemy forces, but also determining key human elements such as the cognitive centre of gravity, the "desired behaviour" as the end state. Understanding the target's goals, strengths, and vulnerabilities is paramount to an operation for enduring strategic outcomes.

3.2 Operational Challenges

The challenges for the military are numerous; whether it is to ensure the cognitive security of individuals in order to preserve the functioning of states, to gain and maintain cognitive superiority for action and competitiveness, to predict and certify the performance of intelligent or artificial intelligence systems developed to support human work, to increase the "collective intelligence" of the human-system relationship, to improve complex and shared decision making. Ensuring a human advantage requires new approaches to combine human and technology more effectively, and to master both the technical and psychological consequences.

The useful progress of NBIC in the field of C2 appears clearly; improvement of the cognitive capacities of leaders and combatants, development of Human-Machine interfaces allowing to take advantage of technological advances in robotics and cognitive technologies (AI/ML etc...) and optimization of staffs.

A thorough understanding of how the brain functions and how to model its dynamics is to decode the formula that transforms information into knowledge, and therefore into decision. Research in the cognitive domain must have as ultimate goal to improve our decision-making processes, and to define the means of offensive action against the decision-making processes of our adversaries.

While there are many voices claiming that “the Cognitive Domain is the overarching domain of conflict”^{ix}, the debate as to whether or not NATO should declare a new Domain of Operations is still to be launched.

A cognitive attack is not a threat that can be countered in the air, on land, at sea, in cyberspace, or in space. Rather, it may well be happening in any or all of these domains, for one simple reason: humans are the contested domain. The human is very often the main vulnerability and it should be acknowledged in order to protect NATO’s human capital but also to be able to benefit from our adversaries’ s vulnerabilities.

“Cognition is natively included in the Human Domain, thus a cognitive domain would be too restrictive”, argued August Cole and Hervé Le Guyader in “NATO’s 6th domain” and:

“...the Human Domain is the one defining us as individuals and structuring our societies. It has its own specific complexity compared to other domains, because of the large number of sciences it’s based upon (...) and these are those our adversaries are focusing on to identify our centres of gravity, our vulnerabilities.”^x

The practice of war shows that although physical domain warfare can weaken the military capabilities of the enemy, it cannot achieve all the purposes of war. In the face of new contradictions and problems in ideology, religious belief and national identity, advanced weapons and technologies may be useless and their effects can even create new enemies. It is therefore difficult if not impossible to solve the problem of the cognitive domain by physical domain warfare alone.

Thus defined by NATO’s major adversaries, the mastery of the field of perceptions is an abstract space where understanding of oneself (strengths and weaknesses), of the other (adversary, enemy, human environment), psychological dimension, intelligence collection, search for ascendancy (influence, taking and conservation of the initiative) and capacity to reduce the will of the adversary are mixed.

Within the context of multi-domain operations, the human domain is arguably the most important domain, but it is often the most overlooked. Recent wars have shown the inability to achieve the strategic goals (e.g. in Afghanistan) but also to understand foreign and complex human environments.

3.3 The need for cooperation

While the objective of Cognitive Warfare is to harm societies and not only the military, this type of warfare resembles to “shadow wars” and requires a whole-of-government approach to warfare. As previously stated, the modern concept of war is not about weapons but about influence. To shape perceptions and control the narrative during this type of war, battle will have to be fought in the cognitive domain with a whole-of-government approach at the national level. This will require improved coordination between the use of force and the other levers of power across government. This could mean changes to how defence is resourced, equipped, and

organised in order to offer military options below the threshold of armed conflict and improve the military contribution to resilience.

For NATO, the development of actions in the cognitive domain also requires a sustained cooperation between Allies in order to ensure an overall coherence, to build credibility and to allow a concerted defense.

For the military, meeting the many challenges posed by CW requires a concerted and broad approach to all aspects of CW. First and foremost, the purely scientific aspects; understanding the brain is one of the keys to CW, we will need to invest in the fields of cognitive science and neuroscience for both passive (defensive) and active (offensive) purposes. Defining a human domain as a field of operations also requires rethinking our expertise in anthropology, ethnography, history, psychology, and other social and human sciences. They will be required more than ever to cooperate with the military, to draw qualitative insights from quantitative data, for example.

In other words, if the declaration of a new battlefield consecrates the new importance of the human, it is above all a question of *rethinking the interaction between hard sciences and social and human sciences*. The rise of cognitive technologies has endowed humans with superior analytical and precision capabilities. In order to deliver timely and robust decisions, it is not only a matter of relying on human cognitive capacities but also of crossing systems engineering with social sciences (sociology, anthropology, criminology, political science...) in order to face complex and multiform situations. The modelling of human dynamics within the framework of what is called Computational Social Science will make it possible to use the knowledge resulting from the social sciences and relating to the behaviour of social entities, whether they are enemies or allies.

4.0 THE WAY FORWARD

Cognitive threats will be more and more frequent, and their consequences will be more and more global, leading NATO and the nations of the Alliance to anticipate the different dimensions of cognitive warfare. Failing to thwart the cognitive efforts of NATO's opponents would condemn Western liberal societies to lose the next war without a fight. If NATO fails to build a sustainable and proactive basis for progress in the cognitive dimension, it may have no other option than kinetic conflict. Kinetic capabilities may dictate a tactical or operational outcome, but victory in the long run will remain solely dependent on the ability to influence, affect, change or impact the cognitive domain.

While advances in technology have always resulted in changes in military organisations and doctrines, the rapid advancements in technology, in particular in brain science and NBIC, should force NATO to take action and give a greater consideration to the emergence of the threats that represents Cognitive Warfare. Not all NATO nations have recognised this changing character of conflicts. Declaring a new domain of operations is a way to raise awareness among the NATO Nations. NATO should consider further integrating human situational awareness in the traditional situation awareness processes of the Alliance.

Given that the Alliance is still at an early stage of understanding the cognitive dimension, initial priority goes to building a shared and broad definition of the scope of that dimension. Which amounts to having a thorough and continually updated understanding of all threats and opportunities raised by Science and Technology.

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