Cognition Workshop
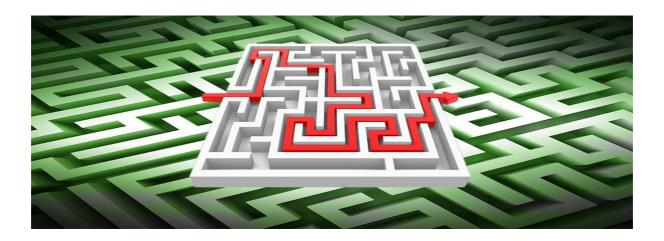# Innovative Solutions to Improve Cognition

June 1-3, 2021

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Introduction

The advent of Cognitive Warfare

While some of adversaries have strategized to avoid a kinetic confrontation with NATO nations using hybrid means as a way to destabilize and harm adversaries. Among these hybrid means, Information Warfare has often been perceived as a secondary sub-function in the planning of crisis management operations, which generally rely on traditional military capabilities. In today's world, Information Warfare and Cognitive Warfare will probably become permanent courses of action to obtain the desired end state which is the destabilization of a political leader, an enemy force, a country, or even an Alliance.

Firstly, it is necessary to briefly draw what defines Cyber Warfare, Information Warfare and Cognitive Warfare alongside the links that unite them.

Cognitive Warfare is the most advanced form of manipulation to date, allowing the influence of an individual or a group of individuals on their behavior, with the aim of gaining a tactical or strategic advantage. In this field of action, the human brain becomes the theater of operation. The objective is to act not only on what the target individuals think, but also on how they think, and ultimately, how they act. Cognitive Warfare is necessarily associated with other forms and domains of action to reach the 'target brains', such as Cyber Warfare and Information Warfare. In a very schematic way, in the cyber operational domain, the belligerents penetrate computer networks to reach the adversary software and disrupt or neutralize what this software contributes to produce. Information Warfare consists in manipulating information that is increasingly conveyed by computer and digital means (cyber means).

Cognitive Warfare, finally, acts on the way in which the target brains process this information. In its conceptualization, Cognitive Warfare thus integrates these other forms of Warfare, to which is added an essential part that has seen recent developments: cognitive neuroscience.

By facilitating the understanding of the brain's mechanisms, the way in which it integrates and processes different categories of information, neuroscience will make it possible to optimize the use of other Warfares, notably Information Warfare. The manipulation of an individual will be easier if his/her cognitive mechanisms have been correctly analyzed and if the information transmitted to influence him allows activating these mechanisms in the desired direction.

For NATO to better understand this cognitive warfare, it is essential for it to grasp the evolution of the information sphere, the impact on decision-making and the opportunities/ threats posed by the rapid evolution of neurosciences.

The workshop follows this same structure.

Introduction of the Workshop

The topic at hand is not a new one, however this event underlines that NATO is realizing something has to be done as a community. The aim of this workshop is to kickstart the new wave with which we have the mandate to double up solutions. Not only this, but it aims at implementing them as well. It seeks to give NATO the tools and capabilities to be better off, but also for humanity more largely as it is not an isolated topic and as entire societies are at stake.

Cognition includes three interrelated aspects that are reflected in the structure of the workshop: information, decision-making and neuroscience.

Cognitive warfare is much more than just information: advances in the field of information are all valid but there is a need to refresh this concept. There is uncertainty and fear about what is coming next. Thus, it will focus on the state of the art: what we understand; what we can do; what we are trying to do; what technology will disrupt what we understand and what are the societal effects that follow it.

Information Disrupted

Cognitive Warfare Dashboard

The findings are the product of a collaborative work with John Hopkins University, the Czech Technical University, Imperial College London and Georgia Tech.

Cognitive warfare is a combined arms approach that integrates the non-kinetic warfare capabilities of cyber, information, psychological and social engineering in order to win without physical fighting. It is a new type of warfare defined as the weaponization of public opinion by external entities. This is carried out for the purpose of influencing and/or destabilizing a nation. These attacks can be visualized as a matrix: spanning the few and many; influencing thought and action; targets ranging from the whole population to individual measures; across communities and/or organizations. Attacks seek to change or reinforce thoughts, influencing/confirming how people think to affect real world action. The way it is conducted differs from more traditional domains of warfare. Informational warfare attempts to control what the target population sees, psychological warfare controls what the target population feels, cyber warfare attempts to disrupt the technological capabilities of target nations, while cognitive warfare focuses on controlling how a target population thinks and reacts.

Student researchers have been developing a tool to identify cognitive warfare campaigns as they happen in real time. It consists of a dashboard envisioned to be a hub for tracking, compiling data on suspected campaigns, providing visualizations of how they spread and uncovering previously unrecognized patterns and methods of waging cognitive warfare. The dashboard will also identify patterns and signatures via machine learning and AI in order to monitor and track cognitive warfare campaigns. Ultimately, it aims at supporting NATO decision-makers in making precise and appropriate decisions in response to potential campaigns.

They have also developed a proof concept tool based on research from the Massachusetts Institute of Technology called "Tweet Watch". It is based on two key findings: (1) human thoughts are primarily responsible for the spread of false or misleading information and (2) tweets that express sentiments of surprise and disgust are more likely to be engaged with/ contain false or misleading information. It captures real-time twitter traffic and identifies messages with highly negative emotions and high virality. Tweet Watch can find messages that are most likely to be false and about to spread based on the emotional content of the message. In the future, it could serve the purpose of a circuit breaker that slows down highly contagious tweets.

Discussion on the Cognitive Warfare Dashboard

A. *Comparatively, were cultural disparities in the spread of information between Western and Asian societies (notably China) taken into account?*

Research done in the development of the cognitive warfare dashboard rests quite heavily on the experience the Taiwanese government had in reducing the spread of false/misleading information. Taking a look at other countries/regions of the world is very instructive in the elaboration of such a tool. The team also found that different actors in different regions of the world have different patterns with which they try to influence and potentially disrupt. Accordingly, patterns in which this warfare is conducted serve as signatures of who is in fact doing it. Human operators/machine learning/AI can then recognize specific patterns characteristic of certain actors to identify a campaign underway and provide a probabilistic estimate of who is believed to be waging it. Culture is an integral part of cognitive and information management as adversaries look at biases and assumptions of a culture in the weaponization information.

B. *Are there any gaps of knowledge associated with cognitive warfare?*

There is a number of gaps. The term 'cognitive warfare' is still a recent one. There are numerous opportunities and areas in which to conduct additional research. The semantic and emotional content analysis led by the MIT study has only been done in the English-speaking world. A strong emphasis has also been on disinformation, fake news and false information, however emotional content is incredibly relevant as a primary sword of how to address it from a technological standpoint. Moreover, once information is out there, little research on the ways to mitigate this type of warfare has been conducted. There is also more work to be done on the distinction between emotional thinking and reason thinking and how to use it to improve the defense, mitigation and repair of cognitive warfare.

Another gap consists of the incorrect emphasis thus far on the falseness of information. Fake news is not necessary for cognitive warfare campaigns, as they can be conducted with entirely accurate and correct news items. Embarrassing government documents/facts alone can serve as the basis for a campaign. The manipulation rests in the shading of the narrative and the emotional account that rouses matters.

Additionally, more research is needed on how information flows between individuals and communities and how it spreads throughout a graph network. In 2016, testimonies before American congressional committees on this topic focused on bots spreading false news, but the MIT study challenges this by underlining how there may be a strategy to hijack the human psyche.

There is also a lack of focus on the specific cultural themes within our society that trigger people and the role of trust in disinformation.

Some noted an insufficient amount of research conducted on the human need of narratives. The brain feeds on stories, facilitating the absorption of false information. Making stories more real and less interesting makes them less attractive, thus less dangerous.

C. *Do you believe that it is possible for war to be won using nothing but cognitive warfare strategies?*

If by winning a war is meant accomplishing a state actor's goals then yes it can be said to be possible. The successful weaponization of public opinion results in making certain activities and actions impossible for other actors. Such a strategy is especially used by an actor when its kinetic forces are inferior to those of its competitor(s). This is so, for the realm of cognition and thinking can be sufficiently used so that kinetic action is minimized or eliminated.

However, others believe that this is not entirely possible for the moment. The Kosovo conflict is an instance of this: the decision was made not to commit ground forces and only support operations in terms of PsyOps, but this strategy had to be modified eventually.

DTEX (Disruptive Technology Assessment Game) Synthesized Environment

With the help of the Innovation Hub DTEX (Wargame) last December, a virtual environment mimicking the dynamics of the sphere of information was developed. An SIR model was gamified in the context of the Wargame to help filter solutions related to problems around misinformation and cognition. The simulation served as a synthetic environment (SEN) that enhanced participants' experience and helped organizers achieve better results. Along these lines, the idea was to provide a standardized environment in which solutions could be processed and evaluated.

The NATO Innovation Challenge helped by collecting all the ideas around solving the problem of disinformation, which were then used to create "IoS" cards, in which participants of the game were asked to pick five technologies believed to be efficient solutions. These technologies were based on ideas provided by innovators and entrepreneurs in response to an open challenge to solve this problem. The effects of each IoS card were then tested individually and collectively on the synthetic environment provided. Participants were also asked to compete with the other teams in finding the best solutions. The DTEX process was the following:

1. Study the scenario

2. Review IoS cards

3. Pick the best solutions

4. Discuss your choices with your team along with your rationale

5. Decide the final set of IoS cards as a team based in the impacts of different combinations on the SEN

The results included a successful integration of a simulation into the DTEX Wargame format, a better understanding of team dynamics and a better idea generation and brainstorming.

One of its strengths includes its adaptability: the simulation was used for disinformation but the problem at hand is flexible (scenarios, cards and solutions can be adapted). This is especially relevant, as disinformation is only a small part of cognitive warfare as a whole.

Moreover, it also presents a great educational value, for it can easily be presented to students or vulnerable populations.

Discussion on the DTEX Synthesized Environment

A. *Was there a leader among the group who influenced the answers? Or were the solutions chosen individually?*

There were moderators in the team who made sure that there was no dominant person, with one background and one perspective, in the group. Certain NATO experts also intervened to answer questions on specific topics to diversify the perspectives. Usually, the simulation is balanced with a mix of military and civilian experts. The solutions were also sent ahead of time to allow everyone to go through them individually.

B. *What are the scientific validations behind the spread of information models? What are the models/theories that you have elaborated to advance in this direction?*

DTEX is a powerful model as it presents a visualization of how information spreads while also being based on science. Its oversimplification was limited by the complexity of the process and the received feedback from experts. However it still remains an abstract model and it has its limitations.

Multidimensional skilled analysis using clusters may be an alternative. A socio-mapping tool also gives a rapid snapshot of the dimensionality of an issue while highlighting the anomalies in a given environment.

The DTEX model could also be strengthened by being coupled with existing and specific cases and having actual actors involved, like seen in the cognitive warfare dashboard.

Building a Healthy Cognitive Immunity

Democracy is under attack today by groups that excel at creating and distributing infectious social media-ready viruses. They are designed to compromise our ability to think rationally and judge fairly. This makes us susceptible to misinformation that raises prejudices, fears and beliefs, working against a healthy democratic system. To preserve democracy, we need to upgrade our cognitive immune system both at the individual and community level. This can be done by developing tools, laws, regulations, cultural norms and skills that work in combination to form a socio-technical infrastructure which protects our network society.

The Cognitive Immune System Map is a guide to the dilemmas, drivers and future forces that will play important roles in the battle between disinformation tactics and healthy immune responses. There are seven main strategies with regard to which we can improve our cognitive responses.

This model is based on the idea that we have a cognitive immune system that can be trained to defend ourselves from disinformation and bias. It analyses elements, such as current vulnerability of democratic states to those types of attacks, a world of black boxes, how new evidence and authorities come into play, regulatory paralysis, the cult of innovation and the culture of extreme. Accordingly it focuses on these six elements, the tension between them and how we can defend ourselves from cognitive biases.

There is now a convergence between immersive environments, virtual reality and block chain technologies that can be utilised. If we are able to leverage these technologies to better monitor the content and to better identify its sources, then we can better fight against misinformation and cognitive bias. Block chain technology allows for a better identification of objects, time, messages and communication that happen within a platform. It can then help better monitor and eventually be sure of the source of the information.

Discussion on Building a Healthy Cognitive Immunity

A. *How has virtual reality technology evolved and what are its consequences?*

We are now faced with a new breed of virtual world, built on block chain-based infrastructures. The way users now handle content on these platforms is very different: block chain-based certificates (like NFTs) are used to identify and certificate the identity of every item.

Content related to web distribution is profoundly changing, in particular virtual reality and immersive experiences which are becoming powerful instruments of influence. The actual presence of a person in virtual reality can now be streamed remotely worldwide.

B. *Do you have statistics or data on how virtual reality would be taking more and more influence?*

Virtual reality has recently shifted from consumer to corporate use. Its use in the consumer market is not entirely satisfactory, while on the contrary its corporate application has picked

up, particularly in training employees. There are instances of virtual training simulations and research by the impact of virtual reality on employees.

This new structure of the internet is able to power these new types of immersive experiences. Past action network capabilities in their design and structure were not able to allocate the power needed to power up immersive experiences but today it is not the case anymore.

There are also new cases of adaptive learning simulations, where machine learning algorithms monitor how people perform training simulations so that they evolve as people do it.

The recent PPE and vaccine distribution situations have proven that combining modeling and simulation provides reliability of source and distribution. Along these lines, this technology is increasingly more valid and has major potential. An ideal simulation would be one created with a system of security and resilience needed to connect all this data live and leverage this power.

C. *What do you think will be the next technological disruption with regards to information? Do you believe there is a disconnect between current technology (big data, generic assumptions about profit) and the human?*

Generics about technology have an application and highlight a trend, but they also fail to say if it will work in every context. Every region of a country has a distinct historical perspective, hence one size does not fit all for the human. One has to think about how bias is going to be specifically used with regards to this technology. The enabling of innovation has a lot to do with the adaptors who take it to another level. There is a risk, but in it there remains an opportunity.

With every influence activity there is always an Achille's heel. Once you find it and express it during a scientific proceeding, it can be limited. One very possible disruption may also be the arrival of 5G, which has recently become a major threat on our territory.

Moreover, global surveillance is also a reality now and adds on to the element of vulnerability. Technology is not an option anymore but is a way of life.

At the NATO and military level, these technologies present major risks as well. However, since they also prove to be a strategic advantage, a solution may be to analyse each technology and use it according to one's own needs. To do that, one may explore how China is using those technologies in order to evaluate the most extreme cases of what can be done. This solution is an adaptive one: it allows certain technologies, but limits those who have access to their content and have a tight control on them. Nevertheless, this can only be conducted by tagging people with "good" and "bad" flags.

Along these lines, the question of trust is at the center of how to build a cognitive immune system.

All of these risks are the direct consequences of decisions we have made in the past. On the other hand, today with the emergence of a technology comes automatically a discussion concerning its potential consequences.

D. *How can we apply the teachings of the Cambridge Analytica Affair to the interests of NATO and the military? How do we cover the weaknesses of our decision-maker or everyone in general?*

Some argue that it eventually comes back to the critical thinking skills of the individual. Hence, the solutions consist in improving those skills at the individual level to prevent future challenges. We also need to think about how AI will support those critical thinking skills. Instances of this have been seen in Lithuania, where critical thinking has been taught to combat Russian disinformation. This initiative has been proven effective and is now taught in other communities. Challenging assumptions and divergent perspectives is the best way to obtain a certain objectivity and make rational decisions.

However, teaching critical thinking is problematic as well. One has to designate "true" arbiters of truth and others who are not. Moreover, human nature at heart is not objective, so one can ask if teaching critical thinking is a truly achievable solution.

It is also important to see topics through the prism of how they came about, based on the agenda data of an institution or entity. Assessing agenda data is then another possible solution to this.

Overall, technologies are simply magnifying things we observe on the human and microscopic level. They grow things out of proportion but do not introduce new problems.

Decision Making

Collective Decision Making

Efficient decision-making currently faces three main challenges.

The first one regards the deliberation space. There is more than one way of assessing how good a solution is when two different stakeholders are involved. As a result, some solutions will be bad for both parties, some bad for only one of them and others good for both of them. Thus, this space of possibilities becomes restricted. Only ideas in the upper-right corner of the graph (shown on screen) make sense as a target, since all the other possibilities are worse for both parties (lose-lose outcomes). The possibilities in this area are categorized as "the Pareto optimal front", defined as the best decision that can be made without deciding who is the more important stakeholder of the two.

A second challenge consists of the typical suboptimal outcomes observed in decision-making. Lawrence Sussking, a specialist in the mediation of large-scale deliberations, was asked how close their outcomes were to the Pareto front. He answered that "most deliberations can't see the Pareto front with a telescope", thus resulting in lose-lose outcomes. This occurs, for individuals in a group tend to produce ideas that are good for their own perspectives but will not be as good when generating win-win ideas (impoverished ideation). Additionally, it is due to the fact that discussion processes are often unsystematic, also suffering from emergent dysfunctions (attention wars and power dynamics). There is also an inaccurate evaluation of ideas: individuals themselves can be bad in evaluating ideas because they present limits when dealing with cardinal ratings, uncertainty propagation and critical reasoning. All of these elements jointly undercut the generation of win-win ideas, hence optimal decision-making outcomes.

The third major insight concerns the limits of bargaining. When there are multiple decision makers with different interests, then a bargaining negotiation model will be used. An individual will start with his/her own optimal outcome and then further concede as little as he/she can throughout the negotiation. It is perfectly suitable in simple negotiations, but produces suboptimal results in complex ones (many interdependent issues). With complex negotiations, the utility function of each individual is "bumpy", which further creates problems to create local optima.

Nevertheless, there are solutions that can improve the deliberation life cycle. This cycle can be divided in three distinct steps with their own specificities: ideation, assessment and agreement-making.

First, ideation can be improved using "deliberation-mapping". This provides a structure that makes people's exploration of the space of solution systematic and logical. It is not organized as a conversation, but as creating a largely organized space of solutions to allow for more objective and rational decisions.

The assessment of these decisions can also be further developed using the "Bag of Lemons Idea Filtering" (BoL). This tool asks people to identify the worst ideas to generate faster and more accurate responses.

Finally, improvements can also be provided to consensus-making. There are new non-intuitive negotiation mechanisms and protocols that have actually become better than the typical bargaining models we are used to. Complex negotiations now require innovative mechanisms. An example of this is the "SA Mediator", which asks agents to propose new ideas and then also vote on them. The result of this was that ignoring people, or certain votes, produced a more Pareto-efficient output than listening to them.

Along these lines, these solutions have the potential to limit the shortcomings of decision-making.

Discussion on Collective Decision Making

A. *How can different personalities influence collective ideation sessions?*

Indeed, different personalities in collective problem-solving increase the potential of dysfunctions. Personality differences, power dynamics and tribal signaling are all key reasons why work-involved ideation and problem-solving are mediated through a computer. Along these lines, to prevent individual bias, people interact asynchronously with software programs. The different incentives and problems provide a lot more room for a computer to help organize, track and guide discussion towards better results.

B. *Are there any tools, like AI-based, that could help achieve what you discussed?*

A tool that provides a kind of light structure over a debate could help prevent such biases. The advantage is that the structure of debates is just enough for AI tools to get a sense of how well discussion is going and which areas have or have not been covered well. AI can datamine the discussion activity and identify certain places where people should pay more attention.

There are such tools used already. The base system is called the delibaratorium, and has been worked on for about 12 years. It does include AI-based support in terms of metrics and attention-mediation.

C. *Are the most valuable solutions the ones most people tend towards prospectively?*

There are solutions that are more appealing and do appear to be inefficient. Nonetheless, evidence shows that it is an efficient design of problem-solving situations that grant it

success. There exists no guarantee that any group is going to get the right answer, but if the process is run well then the chances are increased that the proposed solution most people agree on is an efficient one. Hence, there are ways to increase chances to obtain a good outcome, but no guarantee.

D. *What thoughts on the role of context in shaping the value of the outcome?*

The development of the Touch-Tone telephone design provides evidence that a sense of urgency in a context stimulates efficient decision-making. Urgency, diversity of the team and the context of the situation drove collaborative innovation. It made good use of collective intelligence principles. For instance, there is the notion that it is often better to have a diverse than a homogenous one of experts, but also the power of idea synergy, many eyes and casting a wide net principles. With severe time constraints, having a systematic structure can speed up the process. A key point of deliberation mapping is enumerating options, criteria, evaluating them and picking the best. So, this process gives the opportunity to avoid a waste of time.

It appears evident that the framework influences the result. One has to now figure out how it does so. Evidence shows that more decisions are taken under pressure but this has to be confirmed within the framework of this model.

E. *How would this work apply to a single decision maker obtaining consultation and advice from the crowd, similar to a military context?*

The first two steps of the cycle of the deliberation process are what would be used if there was a single decision maker. He/she would use the crowd to lay out a space of possible solutions, capture their pros and cons and then filter them accordingly. That structure would represent a compact organized overview of the space of possibilities to aid decision-making. These scenarios are the one companies are also mainly interested in.

F. *How do you account for multinational or diverse values considerations with regard to the collective intelligence?*

In multicultural problem solving, cultural assumptions have a huge impact. There is nothing truly unique to offer from this work but more thought will be put into it. Problem types can be divided into two main classes: diagnosis and synthesis. Having people first discuss what the important criteria of a good solution are is elemental to efficient decision making. This would then have to be carried out while drawing together people's cultural assessment of information.

NATO/Military Perspectives on Decision Making

Our cognitive capacities are limited due to various unconscious biases.

According to the psychologist Daniel Kahneman, there are two systems of thinking. The first one is automatic and reactive, while the second is deliberate, rule-based and uses abstract analysis. These two systems impact our perceptions, further influencing our decision-making.

A Stroop Effect Test was conducted on students and underlined the presence of a neurophysical substrate that helps process information. It demonstrated that we all present unconscious physiological biases that may limit rapid decision-making.

People make decisions based on an entire lexicon of moves, actions and cues internalized to solve issues: this is a framing mechanism. They draw on prior experience using intuition and analysis.

The US Navy has recognized this and pushed for the development of "snap judgements" and adaptive decision-making. However, there are risks to this strategy: individuals may pick up on one cue and then stop taking additional information. By stopping to take input, decision-making capacities become constrained.

Biases shape these processes and can have detrimental effects when triggered by ambiguous evidence, stress/emotional/cognitive overload, fatigue effects, fear/threat. Mental models and schemas would then be triggered, impacting the storage and retrieval of information.

A solution to these biases is the Cynefin Framework. It allows decision-makers to see things from new viewpoints and assimilate complex concepts. It was applied to US Navy commanders who have complex responsibilities and decisions to make. The complexity of problems creates non-linearity, as there are multiple inputs at the same time. Responses to problems depend on how we sense the problem. Accordingly, it creates a mental schema to analyse the type of problem first to avoid giving rise to new challenges. It plays out a pattern of behavior according to a specific environment and analyses the steps needed to be taken.

Based on this, military leaders learn to define the framework with examples from their own organizations' history and scenarios. It allows them to make rapid and efficient decisions in a complex setting with a dynamic of emerging properties.

A. *At what moment of their career should military officers have that type of training?*

Ideally, the earlier this training is done the better but this is not the case in the US Navy. They are, however, new programs addressing some of this in the Navy. Nonetheless, the focus is not as much on decision-making. The institution is conscious that it should be teaching this, but it makes assumptions regarding individuals' own capacity to know about the topic. What has changed in the US Navy, is that they now have taken steps to attempt to deliberately develop the professional military officer. This may conflict with the other operational agenda: there is a limited amount of time in an officer's career, limiting the number of courses they can take (trade space).

Usually, this training happens quite late in one's career and there is an agreement on the fact that it should be carried out earlier. However, there is a fear that it will not resonate to young officers because they do not necessarily understand the picture painted. Such teachings require a specific understanding of the world and the environment which is not an automatic one.

Decision-making Support Tools

The main approaches to artificial intelligence are the expert systems. They are based on human intelligence or machine learning, based on computational intelligence. In terms of expert systems, computer systems emulate the decision-making ability of human experts. They are referred to as knowledge-based classical AI and are psychology inspired, mind-imitating, as well as focused on reasoning. They use different types of logic, that can be deterministic, probabilistic or fuzzy. On the other hand, machine learning is a mixture of methods and algorithms that give computer systems the ability to learn from data. It is referred to as data-based modern AI. Machine learning is physiology inspired, brain imitating and focused on learning. It also makes use of mathematics, sets, relations and functions.

Human intelligence can be defined as the ability to learn from experience, adapt to changes, grasp concepts and apply knowledge. It is the main source and role model for AI. There are three main strands: (1) reasoning and inference, (2) learning and adaptation and (3) search and optimisation.

Computational intelligence can itself be defined as computational approaches for implementing human intelligence in AI. It is the main driving force and an essential part of AI. It also has three main strands: (1) fuzzy systems, (2) neural networks and (3) evolutionary algorithms. Fuzzy systems imitate the cognitive process in the human mind. Neural networks

on the other hand, imitate the connectionist structure of the human brain. Evolutionary algorithms imitate the natural behavior of the human organism.

Recent directions taken by this technology in decision-making consist in combining modern and classical AI. This is done to complement learning with reasoning and extend observations with interventions. They have also recently integrated different computer intelligence techniques.

Current limitations include sensitivity to data quality; dependency on computational performance; black box context; reactive observation of the environment.

There are various improvements that could be made to this technology as well. They comprise data cleansing, interpolation, compression and reduction, but also white box context and proactive intervention.

Finally, the main challenges AI faces today are the following:

- task allocation to humans and AI;

- collaboration between humans and AI;

- interpretable and explainable AI;

- responsible and trustworthy AI;

- semi and fully autonomous AI;

- ethical and legal aspects of AI.

Discussion on Decision-making Support Tools

A. *Can we determine some level of reliability of AI so that we can feel more comfortable using it? How do we determine this level of reliability?*

Usually, AI is considered more reliable if the human working with it has a better understanding of the recommendations given by this intelligence. That is why explainable AI has become a "hot topic", since it is perceived as more reliable by the human of use.

B. *What cannot be expected from an AI? What is not possible?*

We cannot rely on AI to be the decision-maker at this moment in time. This is especially true in military decisions that could potentially lead to casualties. AI could still be very useful in

decision support, but the human(s) will have to discuss the recommendations given by the AI and then make a final decision.

C. ***Is there a way to build a defense mechanism into AIs so that the system itself can recognize intrusions and defend itself against them?***

There are some current trends in AI designs, which include adaptive or evolving systems. They could potentially reconfigure themselves and be more flexible in these situations. A redundancy type of built in a system could permit another level to take over in the case of an attack. The Enigma System presents a solution: it could generate a random code that would defend itself against attacks, having an adaptive response and reconfigurable systems. Similar to a "Firewall", it would build multiple levels of defense to combat the intrusion in the system. It is still a very challenging issue today and there are no solutions at the general level.

Human Considerations in AI for C2

Report of Science & Technology Organization (STO)-IST Panel 157
Herve Le Guyader

The NATO Science and Technology Organization (STO) is a network of scientists and military personnel teaming to develop future military capabilities and advice for the alliance. Most people who collaborate are not part of NATO and are scientists collaborating according to a framework that has been decided by the Science and Technology Board (STB).

It is organized according to seven panels and a research facility called Center for Maritime Research and Experimentation. Two of these panels are Human Factors in Medicine (HFM) and the Information Systems Technology (IST).

AI, big data and machine learning are ubiquitous today. One cannot address any issue without applying AI to the environment studied. This is reflected in the STO organization. In the amount of projects accomplished every year, the presence of AI is growing. AI and big data occupies 50% of the total amount of workload for the IST panel. A year from now this number will increase to 55% and then to 60%. There is another major trend within the STO group: no serious issue can now be solved by only specializing in one particular discipline.

AI and human factors in AI are everywhere in the HFM portfolio. The innovation hub was conducting a study on cyber psychology, showing the necessity to mix psychology and cyber to reach any usable conclusion. HFM is in the same boat: human factors for studying AI are mandatory today.

The IST panel also reflects this by focusing on the "Human in the loop Considerations in AI for C2" project. All the questions of trust, autonomy, delegation, how one harnesses AI and where the technologic limit resides are present. These issues are studied in an operational context to confront the solutions to reality on the field in a coalition environment. It consists of a report thought to address classically the main questions related to AI. This is complemented by a participation in a NATO exercise to confront these theories to a real life situation in the most complicated context, i.e. a coalition exercise. The project could not be carried out due to Covid-19 but will be done in 2022. However, the report is due by July 11th 2021.

The prototype developed with industrial partners and labs addresses and focuses on CCIR, highlighting the concept of membership teaming. This tool augmented real-time instrumental critical information processing and evaluation.

Discussion on Human Considerations in AI for C2

A. ***What do you recommend we do in order to elaborate AI for NATO decision-making support?***

This answer assumes the number of divisions in unlimited. The idea is not to "reinvent the wheel" but to utilize the knowledge that has been produced so far. It would be ideal to focus on the "think-and-do-tank" attitude in the most changing environment you can think of, a coalition environment with people coming from very different backgrounds. It should further explore the application of AI on specific coalition topics, in difficult situations and in diverse teams. Along these lines, the idea is to clearly define what the playground is and who are the actors interacting in it. Based on this, devices, equipment and prototypes can be chosen and confronted to the reality of NATO. This is why participating in a large NATO exercise is so important, as it concretely puts the theories to the test. Thus, there is a prerequisite of defining the playground and the team players first, in order to then design the experiment.

B. ***Have you already started to build the AI agent with the capacity for any kind of moral and ethical reasoning or is this more a situational awareness tool? This question assumes the human will shift from having a supervisory role to simply a collaborating one in future decision-making.***

The prototype that has been developed addresses the second part of the question.. It is a tool that helps commanders in terms of situational awareness, to assist his/her decision making.

However, some AI-based agents have to be autonomous as no human being can beat an AI-optimized tool. There is a whole continuum in terms of autonomy: from the cyber instantaneous attack to human issues like triggering Article 5. This whole gradient of situations makes it obvious that there is no "one-size-fits-all" solution. There is still a lot of research to be done. The biggest difficulty today is to merge the different time scales phenomena into one system in the AI field that will help the commander make decisions.

C. *Did you design any kind of alert system in this prototype?*

This IST project is more on the practical operational side than on the conceptual one.

D. *When you say coalition aspect two things pop up immediately: fragmented information and cross-cultural aspects. Is this correct and/or do you have anything to add to this?*

Regarding AI, the coalition aspect consists of teams composed of people from different backgrounds. The issues are of recruitment, training and real life situations. These are of paramount importance regarding the use of AI in a coalition environment.

E. *How do you relate what you have just said with the tool you have developed?*

For the moment, it is a prototype that only a handful of people can operate. If it is successful, then it will be presented in other contexts and coalition-related challenges will be introduced. However, this prototype is not user-friendly at this stage and it is too early to know. If it raises interest then it will be industrialized and training solutions will be elaborated.

It does seem that in coalition settings, certain frameworks become obsolete, such as the Ooda Loop. There is a common understanding of the complexity of the problem at hand, but there is no system for the moment that copes with it.

F. *Could there be a way to actually tackle operational complexity?*

Scenario-driven exercises in a virtual environment might help tackle this issue. These created immersive experiences give the opportunity to introduce complexity, like one seen in coalition settings.

It is now time for us to define how far we want to go: what the technology's role is going to be. If we keep pushing it, then AI will be the ultimate decision-maker. Thus, when we design technology we need to consider the security of its development as a lesson from the past.

Neuroscience - Ethics

Battlespace Brain Neuroscience and Technology
Dr. James Giordano

Neuroscience and Technology (NeuroS/T) has allowed us to "put the brain at our fingertips". It has become a global, both a cooperative and competitive, enterprise. The number of programs, institutes and philanthropies dedicated to it has amplified greatly in recent years.

Today the capacities of neuroscience comprise the assessment of the brain using tools such as biomarkers, imaging, genetics, genomics, phenotyping and big data. Those levels can also be seen as machines of reconnaissance, accessing the brain so as to affect it and influence behaviours. One can use the available models and maps of the brain to become a cartographer and develop means to systematically access targets on a variety of scales. It allows to harness techniques and technologies in a convergent multidisciplinary way. It is done in order to study, define, predict and influence human ecologies. This further influences the posture and conduct of national security and defense agenda, as there resides great power in influencing the brain.

Zbigniew Brezinski stated that he foresaw "a time when we shall have the means and therefore, inevitably, the temptation to manipulate the behavior and intellectual functioning of all the people through environmental and biochemical manipulation of the brain". He was speaking of a potential future, but these means are now very palpable. If we are going to employ the brain sciences on the cognitive and behavioral domain, it can be done in two ways. These consist of (1) fortifying one's own forces and (2) affecting competing/hostile forces.

Concerning the former way, a project called HOPE has been run. It is an acronym for health, operational, protection and enhancement for mission effectiveness. The project works "left-of-bang" in the realm of preventive and occupational military medicine, so as to be able to keep warfighters, intelligence operators and personnel healthy. It maintains a level of operational protection and optimizes operational effectiveness. Nonetheless, a technical and ethical question arises: is anyone engaging with preventive military occupational medicine in those ways to instill HOPE modifying the operator to the point of being perhaps a biological agent? Are we currently weaponizing the individual? This further brings us to the realm of neuroenablement. Alongside, another technical and ethical discourse arises: what constitutes treatment preventatively and what constitutes enhancement? There are long-standing projects examining the capabilities of neuroaugmentation and neuroprosthetics. These can change the sensorium of the human person, so as to be able to allow us to have sensory capacities that go beyond the norm of our physiology.

Furthermore, we can also impair the capabilities, desires and behaviours of opposing elements. A weapon can be defined as a means to affect others, need not be to be devastating

or harmful. Brain science can, thus, mitigate the things we do not want our competitors to do and make them do the things we want them to do. Some may ask if this domain is an inviolable space we should not intrude. However, we have already gone there, with propaganda, trying to affect cultural means and the use and ubiquity of cognitive capabilities by the internet. We are becoming more specific in our intent and capability to do so directly by affecting the substrates of the brain. These actions can be exemplified by the use of drugs, microbes, viruses, various toxins, devices and data. Additionally, there is a growing engagement in neuroscience systems and technologies not only kinetically in classical warfare, but increasingly in the non-kinetic domain. It ranges from commercial and economic effects to leveraging hegemonies on the global stage and influencing research, tourism, medical tourism, finances and subtle social/individual control by virtue of markets. Recent probes, such as Novichok and Havana provide the ability to affect the neurological systems of individuals from a distance.

Brain sciences and its tools are constrained, at least in part, by the current language and parameters of the Biological Toxins and Weapons Convention, the Chemical Weapons Convention and signatory treaties such as the Declaration of Helsinki. However, their uses are not bounded by these current treaties, particularly when certain countries do so under a commercial umbra. These nations are also resistant to surveillance as they put forth strict boundaries of what represents proprietary information. Neurosciences are further affording particular capabilities to developing countries to leverage the brain sciences to give them power. On the world stage, the current key players are China, Russia, Iran, North Korea, virtual nations and non-state actors. Neuroscience has been and is currently viewed as a leveragable capability to engage power on a variety of levels, from the cellular to the social, from the individual to the international.

The lack of focus and commitment on our part provides exponential growth opportunities for others. A possible solution to this is the "Four Thrust Strategy". It consists of (1) increasing awareness, (2) quantifying the threat, then (3) countering it and finally (4) preventing/ delaying future adversary effectiveness.

 Progress in brain sciences is being advanced in a number of global arenas, primarily through the use of whole-of-nation approaches. It is also enhanced by triple helices of government, research and commercial spaces that allow tremendous advances in a short amount of time. We must also carry out these strategies to identify, characterize, counter and exploit emerging technologies that pose clear threats to global security and stability. This demands tractionable action.

A. *Is this new cognitive battle space of the brain going to give rise to a new uncertainty of attacks? What are their psychological impacts?*

The Havana events that occurred have continued to remain in the public eye and there has been misinformation and relative ambiguity concerning what happened. However, there has also been a consideration of mass psychogenic effects. This event saw the rise of mass hysteria, with waves of people presenting signs and symptoms of what they are seeing in the press. Through a misinformation program, of sponsored capability of fostering worry and significant concern, there is an ability to fracture the fiduciary between public health system and the public. What becomes increasingly important is awareness, but also actually qualifying and quantifying what represents capabilities of limitations, real risks and what does not. This is a true balancing act with regard to relative transparency and « prudent parentalism ». The scope and focus of the battlescape changes as the capability to affect individuals and groups is expanding over.

B. *Any ideas about how you might do something to increase the ability of today's generation who are overwhelmed with media influences, with regard to the presentation's Fourth Thrust?*

There have been discussions on whether or not we are creating a digital dementia. With the ubiquity of information and accessibilities, the younger generation may have suffered from something of a dementing effect. In countering information overload, what becomes important is to remain apace with the digital and technologic capabilities. We have to maintain some level of educational precision that allows individuals to remain in step with what the technologies are doing. One has to be able to use what is available in the environment. Part of the issue is developing programs that allow education on an earlier level. These have to establish the balance between scientific and technologic capability along with literacy and fluency in the humanities and social sciences. Such programs would then guide students to utilize sciences and technologies in real-world practices. This process is referred to as « in-steps ». Its aim is to aid the understanding of the technologic tools and the rational accounting of these tools. However, for this to happen there needs to be a readjustment of what the economic allocations are. This would allow to foster education on those levels that will keep individuals, groups, societies if not humanity at pace with the sciences and technologies it creates.

C. *What can I take today as an augmentation of my cognitive capabilities that is based on neuroscience and that works concretely? Are there any available teachings?*

There are a number of products available in the consumer market. The general caveat is that consumers should do a bit of diligence, such as look at the quantity and validity of research done on the product. Although there are attempts to inform consumers and guide the commercial industry, sometimes things fall to the cracks. Hence, there are some devices, forms of transcranial electrical stimulation, coupled with forms of neurofeedback that are available to consumers. These are springing up with greater frequency in a number of different places. There is also an expansion of what might be considered as « boutique » neurology and neuro-psycho-pharmacology.

It is an expanding domain, not one without contention. Some may ask if the expanding of the commercial space will also result in it being gated. If those technologies cannot be found in certain countries, then we may see the development of neuromedical tourism. Hence, global leveraging can be expected.

Regarding specific occupations, such as the military, these performance capabilizations represent a reality as a low-hanging fruit. There are dedicated programs to examining the use of a variety of neurotechnologies that are ongoing. Whereby, the use of these particular devices is no longer on the drawing bord but is moving to applications.

D. ***Do you think these technologies create the possibility of new security threats as well, such as armies of manipulated individuals who lack reflection or moral values?***

There is nothing one can particularly target in the brain that will affect morality. Morality and moral constructs are a consequence of the culture in which they are embedded and articulated in.

Nonetheless, a discussion can be conducted about the viability of neurocorrectives. This is contentious as societies are going to differ on their understanding of good. It is a new frontier as the technology expands. There is also a question of who is making the decisions. It is very easy to pathologize certain things that groups of individuals seek to deem as repressible. It is a slope that we need to explore as we move forward.

Thus, a failure to understand what is capable of being viable opens up a huge window of opportunity (Thrust 4) for other groups to exploit.. The field is rife with key points of consensus and dissensus that need to be resolved in an ongoing fashion. Simply moving away from the topic is dangerous. Brain sciences are ready for this discussion: they represent something real, viable, valuable, employable and currently engaged in an expanding field.

It is important to make actual predictions, and allowing sufficient modeling becomes difficult after about a 15-20-year period. We must then also adopt our competitors' deductive strategic approach.

E. *What areas are most likely to present a threat to our own forces in the future?*

There are four risks that will have the greatest technological readiness over the next 5 to 10 years.

1) The first one consists of the manipulation of psychological information. It is based upon a deeper understanding of how the brain processes various narratives, icons and symbols. There are programs, called narrative networks, that follow this strategy. They use neuromarketing knowledge and apply it to the national intelligence security and defense agenda. This allowed them to understand what makes people tick on a neurocognitive and behavioral level.

2) Another future threat is enhanced warfighter intelligence operators. This would occur in a context of increasing cooperativity between brain and computational systems (neurological intels).

3) A further area of considerable concern is clandestine emerging devices capable of affecting human brains, therefore cognitive emotional and behavioral function relatively remotely.

4) Finally, the last one consists of utilizing large neurological data to gather information about the neurocognitve, physiological and social characteristics features of individuals and groups. This would provide insight to target those factors in a variety of ways. It could be used to corrupt this same data: manipulate it in subtle ways to affect how certain individuals are regarded and treated. It could also be exploited to develop precision pathologies.

Those all represent tech-readiness levels that need to be quantified and prepared for.

Other Ideas to Consider

The technologies included in this presentation had to first respond to a few criteria. They had to be seldom mentioned with regards to cognitive warfare. This is in opposition to ones such as information operation, pharmacology, genetics, brain computer interfaces, simulations and AI. They also had to have the means to be researched and explored within the next five years.

Finally, they had to be competitively important, with near-peers that are close or ahead of us on the development and use of these tools.

The first one consists of "Real" Cognitive Electronic Warfare (CEW) tools. It is defined as the use of cognitive systems, AI or machine learning, to enhance the development and operation of Electronic Warfare (EW) technologies for the defense community. More of an automated warfare, it differs from a true cognitive system that would have plans laid out in terms of considering thoughts and behaviors one would want out of one's adversaries. It consists of two types of CEW tools. The first one is non-kinetic and uses EW systems to change an adversary's thoughts/behavior by way of targeting their information/influence systems. On the other hand, the kinetic warfare one uses these systems to change an adversary's thoughts and behaviours by way of directly targeting their nervous system.

The second technology is 3D bioprinting with neural tissue. In terms of funding, China has invested a lot in synthetic biology. It makes use of a 3D printed model of the brain, where one can plan to resect a piece of the brain, where neural stem cells will be placed. It incorporates both CrispR and nanotechnology.

Another technology is a VR Cognitive Performance Trainer. By incorporating virtual reality training and neural data analysis, it enhances human performance for military missions. It integrates virtual reality with electroencephalography (EEG) sensors and an athlete management system (AMS) to improve performance via the analysis of neural data generated during training. Operating in a stressful environment often puts additional demand on individuals, resulting in human cognition as being the most critical factor. Thus, allowing individuals to train their information processing abilities with motor skill-specific techniques can deliver operational performance. The user's headset has sensors that gather EEG data during specific rounds and the entire gameplay sessions. As part of the Stroop Test, the user is asked to shoot targets in three separate rounds, while being exposed to distractions and increasing time pressure. After every round, the user is placed in a "relaxation room" where their stress levels can return to baseline before being exposed to another round of the Stroop Test. A detailed after-action report tracks technical and tactical outputs, such as accuracy, decision-making and arousal. It is all formulated in a unique performance score at the end of the simulation. Every session is measured, stored and analyzed in an athlete management system where data is displayed via a virtual dashboard.

The last one consists of quantum computing and technologies. It presents the only way to handle giant disperse datasets and produce rapid insights. In the future, it is going to be critical for being able to do neural stimulation at the nano-level in humans. Adversaries have already started exploring this path.

Nonetheless, there are two major concerns with regard to AI. Attack success rates in security prove that these technologies are fragile. They can improve and are not close to a system-level of security. Moreover, one can never assume a perfect information and communication environment that will allow for the constant utilization of these technologies.

A final aspect that should further be mentioned is the cultural one. The Cognitive Warfare Atlas is based on the idea that one should never assume the same cognitive domain in every country. Instead of forcing the use of cognitive warfare terminology, it looks at the indigenous terminology for specific biases, fallacies, narratives and aphorisms. NATO is today uniquely positioned to carry it out. Diversity and inclusion will be the winning differentiator, as there is no way China's amount of data will be matched. This example is how a global alliance can have an overmatch. However, there still is a lot of work to be done.

A. *What is the validity of technologies randomizing and anonymizing for cloud computing, supposedly securing it?*

On the encryption level, the more it is encrypted the better it is for now. Getting these tools ready for quantum, on an encryption level, is actively being worked on. In terms of other technologies, it depends on what their backend is.

B. *Is training to respond only to one stimulus the opposite of critical thinking? Is it the right direction or does it have side effects?*

There are training situations in which one would want it to feel like it is automatic. This would attempt to get to the level of tacit knowledge and become "thoughtless". However, there are going to be situations where the strong discerning eye is paramount, as routine may become dangerous. Hence, it is dependent on specific situations, environments and games. If we want the individual to avoid acting automatically, then the situation should be modeled to be entirely unique and new to the individual.

C. *How can cognitive overload be defined?*

The term cognitive overload is an umbrella of different components. To define it, one must look at the tool sets typically used. That is why coalitions of experts are paramount to study this topic and help build the future.

A conventional way to see it is that it affects mainly four psychological systems: the cognitive, physiological, behavioural and emotional one. Nevertheless, some agree that it remains helpful to see and study it as a whole embodied system.

The Neulearn Technology

Alertness has been proven to be paramount for military operations. Both undertraining and a lack of alertness at sea are preventive and have engendered accidents. In response to this, Neulearn consists of real-time alertness tracking as part of a holistic situational awareness project.

As data (EEG and eye-tracking) is gathered, trends are normalized and conclusions can be drawn. Thus, the product is constantly improving itself.

It somewhat gamifies the brain data gathered, just like a Fitbit would require an individual to do more steps, providing a psychological incentive to improve situational awareness.

This technology can also be used off the field in presentations, such as NATO's. It could track when people stop listening and work on improving the framework of presentations. It would also provide real-time feedback on gathered data.

A study conducted in Canada with this technology proved that, with 95% accuracy, it could predict if an individual was vigilant or not. Classrooms in China are also already equipping their kids with similar tools using a light to represent the students' awareness.

Similarly, the goal would be to have a dashboard on a ship where the officer on deck would evaluate the alertness of individuals. In this situation, a false positive would not be negatively impactful.

Discussion on the Neulearn Technology

A. *For how long can you be alert for?*

The Hawthorne Effect has a major impact on the longevity of alertness. It pushes individuals to perform better, here pay more attention, when someone is monitoring them. It is a placebo effect incorporated in the study. This then increases the alertness of individuals.

B. *Wouldn't individuals need moments of inattention? And wouldn't their attention spans differ?*

Indeed, and this is why it is important to have a human monitor a dashboard. Typically, there are twelve people on deck, so certain moments of inattention are allowed if they are balanced out by other individuals. It depends on a global percentage of alertness among a group. This data will then be the basis of the commander's decision making, which can be trained in advance. Next, the aspect of social loafing should be considered. This describes that an individual relaxes in the context of a group. Here, the individual relies on the performance of others. This can also take place in the area of cognitive abilities. It can be assumed that this action is more likely to occur in lower grade groups, as they are more likely to have high numbers than higher grade groups

C. *How does this technology face information overload?*

There is a balance that has to be maintained with this technology. A selection of the information shown on the dashboard is carried out based on specific functions. Certain professions will require the use of particular parts of the brain and this will be shown accordingly. It will be customizable to only show certain information. The overload may be very subjective to individuals, hence customization is paramount.

The key is not to maximize but optimize the technology. Along these lines, it may be reasonable to limit the information at hand.

D. *How should we, not maximize, but optimize our activity, including things like sleep and attention?*

You cannot manage what you cannot measure, thus monitoring tools are very important for this. However, monitoring everything is a very personal task. It can be carried out using simple tools, like a Fitbit. Today's technology is actually making more measurements possible, hence allowing for such observations and adaptive responses. These also have no side effects, so it would be a good way to improve one's capabilities regarding attention.

E. *Do you see this technology's application in other settings, such as perimeter security?*

It would be, indeed, interesting to see it in other settings. One such example would be a military base that would grant non-attributional data used for the normalization of trends. The dashboard could then be customized and adapted to those settings.

F. *How many people would we need to examine and for how long to come up with the statistics that would help us progress?*

It is not the general number that matters but the costliness of data in a very specific context. Hence, this explains the importance of scoping what we are trying to do and observing trends accordingly.

Discussion on Ethics of Neuroscience

The ethical aspects of neurosciences remain very cultural. Hence, there is a need to set the boundaries as a community.

Not even in one same culture and society is there going to be a pattern of agreeing and disagreeing. There is a big difference between what is regarded as "good" for the society, individual, military and security. These technologies can be assessed from a multiplicity of perspectives.

There may also be a discussion on the pertinence of this debate, as these technologies are still being used whether or not our consent is given. This is especially true for certain nations. including adversaries, are going forward with them.

Then, if there are going to be rules and ethics, they should apply to everyone. A current discrepancy exists between what the private industry is carrying out and the other domains. The government and military should then be equalized with the private industry today, and hold them to account and work on further considerations.

We may hold some ethical principles in the military or NATO, but it does not mean that we are able to enforce them. This is not only in regards to other countries, but to other citizens in general.

There are generational differences that complicate the issue at hand. Younger generations are more comfortable with their data being used as they see it as a trade off. They are aware of the use of their data, but are willing to do it to receive a certain service. It can be also seen as an analogical reasoning: similarly to taxes, it is expected that the final outcome will not be visible and inefficiencies will appear.

We are still in time to come up with things we do not want to be used by the military or the government, and impose standards in the industry and the field of neurosciences.

Overall, there is a difficult balance to maintain between security and ethics. This balance is culturally loaded, especially in the United States. The key resides in working to increase trust, so transparency. Along these lines, ethics should then be very clearly defined and enforced.

Non-kinetic concepts here impact the nature of the issues at stake, as they are more complex and covert so difficult to regulate. The difficulty of attribution makes the abuse of data very easy: you do not know you are being harmed until you are actually being harmed.

In contrast, information warfare is made of clear rules, such as the prohibition of targeting one's own domestic population. However, the question of responsibility with these technologies is difficult. Unexpected consequences in a complex technological system do happen.

Insurance industries may also be used to bring forward certain measures as they will financially hit businesses specifically where it hurts.

The approach NATO wants to put forward is a defensive one. It will happen against us if one is looking at the history of the alliance. Thus, a preventive strategy should be adopted.

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