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THE WAR WITHIN

Neuroscience to understand today's violent conflicts

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THE WAR WITHIN

COLOPHON

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EDITORIAL

As a child, I imagined adulthood would come with some oddly specific challenges, such as avoiding quicksand in the streets, picking out matching clothes, or organizing important documents into folders. Among all these imagined threats, one thing I never worried about was war. War, I believed, was a problem of the past—historical, unfortunate, and resolved. It belonged to another era.

And yet, now that most of us have figured out how to file documents into folders, the threat of war looms closer, especially in regions where generational prosperity in the 21st century fostered a sense of permanent safety. For many people, however, war has never been distant; they were born into its shadow and have lived with it for decades.

What is most perplexing is that, despite war being universally condemned as one of the most immoral acts, humanity continues to be trapped in its cycle. Perhaps collective morality is a delusion of grandeur that overestimates actual behavior. Or perhaps we simply do not yet fully understand what the concept of war entails. After all, three letters attempt to condense a vast spectrum of evolutionary and psychosocial phenomena.

Faced with this complexity, many disciplines continue to ask: Why does war recur? Why do we fail to learn from past mistakes? Can we even call them mistakes, or is the drive toward violence (or its justification) rooted deep within us? In the book *Our Brains at War*, author Mari Fitzduff recalls a reflection from a veteran war correspondent, who confessed: "There is a part of me that remains nostalgic for war's simplicity. The enduring attraction of war is this: even with its destruction and carnage, it gives us what we all long for in life. It gives us purpose, meaning, a reason for living."

For centuries, thinkers have tried to explain such paradoxes, but countless loose ends remain. That is why the present publication turns toward neuroscience, not as a mere reductionist alternative, but as a necessary complement; not to offer simplistic mechanistic answers, but to explore whether neurocognitive science can serve as a foundation for the collective dynamics already observed in conflict settings, including threat perception, group identity, and trauma.

This volume is both a scientific manual and a plea for awareness. It stands as the voice of those who refuse to accept violence as a given. It is an effort to understand the human condition not only to describe it, but to change its trajectory. Predisposition is not predestination.

Welcome to The War Within, the seventeenth edition of ABC Journal.

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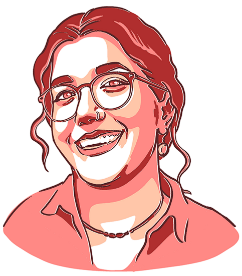


Idil Su Cervatoglu

Intergroup violence seems not to be a product of modern civilization; archaeological evidence and studies on chimpanzees, ants, and other species support the idea that aggression and warfare are evolutionarily ingrained. However, some modern theories suggest that, despite our "nature", cultural structures could help regulate human violent tendencies.

War has been a constant presence in human civilization. Throughout history, people have fought against each other, from ancient times to the present day. The reasons may change, and the weapons may evolve, but the outcome remains the same: loss, destruction, shattered lives, and long-lasting traumas. Unfortunately, this remains a harsh reality worldwide in today's world. From childhood, we are surrounded by war—whether through history classes, news articles, or, for many, as an unavoidable part of daily life. The presence of war in our world seems endless, but why? What drives humans to wage war again and again? Is it an unavoidable part of our nature?

HOW CAN WE DEFINE WAR?

How we define 'war' shapes the answers to our questions about the history of war. Is it a violent conflict between sovereigns[1] with significant resources such as weapons and large-scale effects such as a high death rate[2]? This definition may limit the understanding of the history of war, particularly from an evolutionary perspective, which will be discussed deeply in the next section. Therefore, throughout this article, we refer to 'intergroup coalitionary violence'[2] when we mention war. We will also use the terms 'conflict', defined as the incompatibility between groups[3], and 'aggression', which can be defined as the actions aimed at causing harm to one another[3], usually involving a conflict.

SHALLOW VS. DEEP ROOTS OF WAR

The history of war is a current topic of debate amongst researchers. While some argue that warfare emerged mainly with the rise of agricultural and settled societies, some state that it is an ancient and inherent part of human nature[2,4].

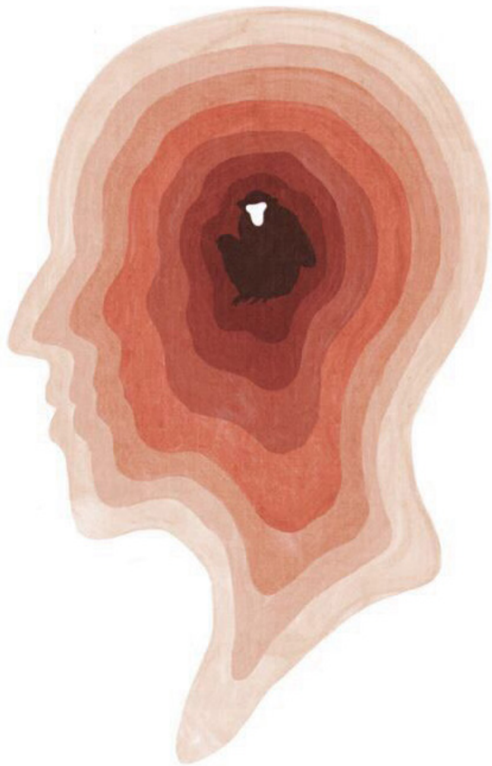
What drives humans to wage war again and again? Is it an unavoidable part of our nature?

This debate is captured in 'Shallow Roots Theory' and 'Deep Roots Theory', respectively. Shallow Roots Theory states that hunter-gatherers were less violent, experienced conflicts that were different, and had mostly peaceful systems[4]. Thus, the theory suggests that as humans transitioned to a sedentary life with the agricultural revolution, they began accumulating land, food surpluses, and wealth, which created competition and the need for defence, and this led to organized armies and large-scale wars[4]. On the other hand, Deep Roots Theory claims that human war has roots in natural selection and adaptation[2,4,5,6]. The aim of this article is not to compare and analyse two different theories and find an answer to this debate. For a detailed review of this debate, Glowacki[2] and Meijer[4] provide a comprehensive analysis. Here, we are going to focus on the Deep Roots Theory, since we aim to explore the evolutionary perspective of war by focusing on the innate human nature. One of the strongest pieces of evidence of the Deep Roots Theory comes from archaeological studies, which show that nomadic hunter-gatherers had war[6,7,8,9].

For example, Lahr et al.[7] present evidence for inter-group violence within early Holocene (approximately 10,000 years ago) hunter-gatherers in Nataruk, Kenya. They discovered the remains of 27 individuals with extensive traumas such as sharp object traumas and bound wrists, and they concluded that these individuals were killed in an encounter between rival groups. In another study[8], researchers examined skeletal remains from prehistoric California, which had a significant number of traumatic injuries consistent with violent conflict. They argued that when resources are becoming limited, lethal aggression increases. This aligns with the concept of natural selection favouring individuals or groups that successfully compete for limited resources, potentially leading to an increase in violent conflict as a survival strategy. This perspective suggests that aggression may be an evolutionary adaptive response, which will be discussed in detail below. Overall, these studies show that organized conflict was not exclusive to settled agricultural communities.

ARE WE ALONE?

Up to this point, we have discussed the history of human war. However, are we the only species that engage in war? The answer is surprisingly 'No'. Wolves, ants, meerkats, and chimpanzees also engage in intergroup lethal violence in their own ways[4,10,11,12]. Such findings suggest that organized aggression may have deeper biological and evolutionary underpinnings. Researchers that support the Deep Roots Theory, argue that humans inherit 'war' from their primate ancestors, mostly chimpanzees[4].



Chimpanzees, which are thought to be the last common ancestors of humans according to the 'Chimpanzee Like Hypothesis'[4], engage in territorial raids and intergroup coalitionary killings[12,13,14,15]. One of the most famous studies on chimpanzees' violence is the 'Gombe Chimpanzee War'[14]. Jane Goodall[14] documented this violent conflict between two chimpanzee groups between 1974 to 1978 in Gombe Stream National Park, Tanzania. The chimpanzees in Gombe, which were once one single community, split into two different communities over time, and the war began when one community (Kasakela Group) attacked the other community (Kahama Group) co-ordinately. This was especially important since it was the first recorded case of organized and strategic attack and violence in chimpanzees[15]. This kind of behaviour of chimpanzees supports the idea that human warfare has deep evolutionary roots.

As it is mentioned above, chimpanzees and humans are not the only species that engage in intergroup aggression. For instance, Mofett[10] states that the ants in supercolonies kill ants from outer groups when they encounter them since they outnumber the other group. This behaviour demonstrates lethal interactions between ant groups. This brings us to the next question. Is war related to the survival instinct in the context of natural selection and the survival of the fittest?

NEURLOGICAL BASIS OF AGGRESSION

We have mentioned that the definition of war changes our understanding of the evolution of war. So far, we have discussed 'intergroup violence' amongst animals. But what about aggression? Aggressive behaviour is commonly observed across various species, manifesting in different forms such as territorial disputes, competition for resources, and social dominance[16,17,18]. It plays an important role in survival, reproduction, and maintaining hierarchical structures within animal groups[16,18]. Although there are differences in aggressive behaviour between species, there are underlying neurobiological similarities[16,17,18].

Through conscious effort, humanity has the power to break free from the cycles of violence.

Research on songbirds, cats, rodents, non-human primates, and humans has shown that aggression is associated with activation in specific brain areas, such as the hypothalamus and prefrontal cortex (PFC)[16,18,19]. One of the most important brain areas associated with aggression is the hypothalamus. The study of the hypothalamus in attack behaviour started with the studies on cats[16]. This is followed by electrical stimulation studies that show that stimulating the ventromedial hypothalamus in male rats[20] and non-human primates[21] results in aggressive behaviour. With the recent technologies in neuroscience, Lin et al.[22] showed that optogenetic activation of the ventromedial hypothalamus induces aggression in male mice, while pharmacogenetic silencing of that area inhibits aggression. Additionally, PFC, especially medial PFC (mPFC) and orbitofrontal cortex (OFC), activity has also been linked to aggression since it sends projections to the hypothalamus, amygdala, and dorsal raphe nucleus (DRN), which are also linked to aggression[16,17,23]. Research has shown that optogenetic activation of excitatory neurons in mPFC inhibits aggression behaviour in mice, whereas their inhibition results in elevated aggression behaviour[23]. Lastly, studies have also highlighted the potential role of the nucleus accumbens (NAc), DRN, amygdala, and periaqueductal gray (PAG) in aggression[16,17,18,19]

The presence of similar neural mechanisms across species suggests that aggression has evolutionary roots and serves as an adaptive behaviour for survival. Given its role in intergroup conflict, aggressive behaviour may have a role in the emergence of today's human warfare.

IS WAR INEVITABLE?

In this article, we have discussed archaeological and neuroscience studies that support the evolutionary root of aggression and war. Their findings lead us to an important question: If aggression and war is evolutionary rooted, does this mean war is inevitable?

The claim that 'war is inevitable' is an oversimplification[2]. If we go back to where we started, while Deep Roots Theory suggests that war has an ancient evolutionary origin, it does not claim that this vicious war cycle is endless. This theory suggests that although we might have an evolutionary tendency towards war and aggression, this tendency is managed through cultural, political, ideological and social structures. Therefore, while our instinct to fight is deeply evolutionary rooted, it is not unchangeable.

Through conscious effort, cultural evolution, and the creation of political and social structures aimed at cooperation and conflict resolution, humanity has the power to break free from the cycles of violence. A world without war is possible if we choose to confront the factors that drive modern conflicts while acknowledging our instincts. By addressing those, we can build toward a future of peace and shared prosperity.

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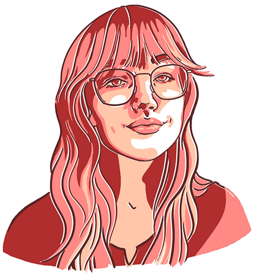
5	Fortunate Son Music video • Creedence Clearwate...	Willy And The Poor Boys (Expan...
6	Should I Stay or Should I Go - Rem... Music video • The Clash	Combat Rock (Remastered)
7	When Doves Cry Music video • Prince	Purple Rain
8	For What It's Worth Buffalo Springfield	Buffalo Springfield
9	We Can Work It Out - Remastered... The Beatles	1 (Remastered)
10	Take A Minute E K'NAAN	Troubadour

INTO THE MIND'S TRENCHES

Hits from the past blending classics with themes of conflict. Play and keep reading!

The Cognitive Effects of

Sensationalist Media



Tirza Ester

Media outlets may, under specific circumstances, employ strategies to steer public opinion and polarize social groups. While almost all of us continue falling victim to these mechanisms, psychologists aim to inform the public by disseminating concepts such as algorithm-driven news, echo chambers, willful ignorance, cognitive warfare, and cognitive dissonance.

No matter the topic, media aims to instigate emotion. This sensational storytelling that media sources have perfected, makes reading the Sunday papers more emotionally charged and engaging, possibly at the cost of factual accuracy. To start off, in this article media is conceptualized as a provider of information, often being one of the primary sources of information for an individual1. Nowadays, media can be found in many forms; newspapers, radio, TV, and the newest additions of websites, apps, and social media. Together with this rise in media accessibility, news outlets are now part of a competitive market, increasing the need for thrilling storytelling and the risk of exposure to unreliable information[1,2].

Singh et al.[1] define sensational events as events that deviate from the norm, are extraordinary, unusual, unexpected, bizarre, or generally uncommon. Sensationalism has its roots in yellow journalism, a method of reporting with the sole purpose of entertaining people, with no regard for the level of authenticity. Sensationalism is defined as the practice of writing to entice, stimulate, arouse, exaggerate, or provoke emotional responses in the reader[1]. Our shared ability to stay updated and make informed decisions is fundamental to our functioning political environment, economic functioning, and social cohesion. The rise and use of digital platforms has facilitated the creation of cyclical communication and the spread of misinformation; certain narratives are able to thrive in this online environment by exploiting cognitive biases in readers. Now that online social media platforms are being used as news outlets, algorithms can also influence the information that is fed to individuals[3].

THE LONG-LASTING EFFECTS OF SENSATIONALISM

Occasional thrilling storytelling is by no means harmful, as long as it is not utilized to warp public opinion on social and international issues. However, sensationalism and sensational events affect change in political thought and policy[1,2]. Most people form, or adapt, opinions based on the acquisition of new information or experience1. Once initial opinions are formed, however, echo chambers can start to form. An echo chamber refers to any environment in which a person is surrounded only by beliefs that coincide with their own, resulting in the reinforcement of existing ideas and a lack of consideration of alternative ideas[4]. In the new online media landscape, algorithm-driven echo chambers increase the effect of these segregated environments.

Social media algorithms analyse past behavior, predicting an individual's opinion to provide agreeable and personalized content for everyone[3]. This limited serving of agreeable posts and opinions not only reinforces echo chambers, but also provides people within echo chambers more chances to converse with like-minded others. Levy and Razin[4] point out that historically, echo chambers have been thought of as the engine behind political turmoil, the rise in extremism, populism, and polarization. It is the combination of communication with those with similar beliefs and the separation of individuals who do not share similar views, that then induces polarization within a society.

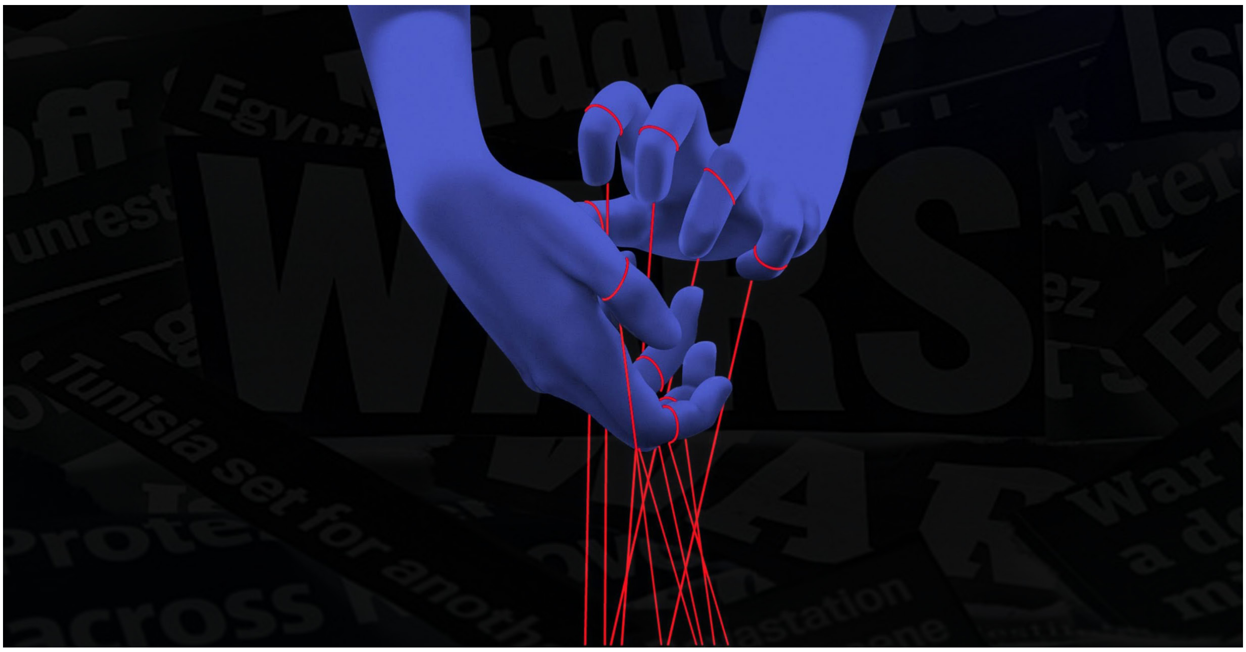
Echo chambers are driven by the phenomenon of willful ignorance, which is defined as the intentional avoidance of engaging with specific information. This behavior not merely encompasses the absence of knowledge, but it concerns a deliberate choice to dismiss information and perspectives that could alter one's understanding of a situation[3]. This disregard of non-conforming information feeds into another cognitive bias, known as confirmation bias. Confirmation bias regards the tendency to only seek out information and conversation in manners that confirm one's current perspective, filtering out information that contradicts existing beliefs. The differentiating factor between confirmation bias and willful ignorance regards the awareness behind the mechanism. In confirmation bias, individuals are unconsciously disregarding information while this is done intentionally in willful ignorance.

Confirmation bias is the tendency to seek out information in manners that confirm one's current perspective, filtering out information that contradicts existing beliefs.

Zooming out, willful ignorance within echo chambers, supported by confirmation bias, can lead to groupthink. Youvan[3] defines groupthink as the pressure to conform to a collective state of willful ignorance, resulting in the suppression of divergent views and deliberate ignorance regarding outside information that holds the possibility to disrupt group cohesion.

THE SOCIAL AND INTER-PERSONAL ASPECTS

These echo chambers and social influences on our thoughts feed into how we conceptualize narratives. The availability heuristic concerns a mental shortcut that relies on immediate examples coming to one's mind when evaluating a specific topic, concept, or decision[3]. As mentioned before, this can steer public opinion on governmental policies and international relations.



Active steering of public opinion can be utilized by institutions. Menicocci et al.[2] discuss the concept of cognitive warfare, concerning the use of means of action that one group makes to manipulate another group's cognitive mechanisms, with the intention of influencing, deceiving, or subduing them. Davidson[5] conceptualized the third-person effect (TPE), which states that people have the tendency to perceive a greater influence of persuasive communication on others' than on personal beliefs. This could be driven by the assumption that arguments will have a greater effect on the "wrong" side of any issue[5]. Lim[6] mentions that public perceptions are strongly affected by symbolization within media coverage. Some studies suggest that self-exposure to information often matters when the stories are relevant to personal safety; when creating ingroup and outgroup polarity, the effects of reporting on individuals categorized into the outgroup could have a diminished effect on our personal perspectives. Additionally, strategic information warfare entails controlling and securing one's own information space, while acquiring, utilizing, and disrupting the opponent's information[2].

At the individual level, the openness people express towards a range of political perspectives is a key determinant in social polarization and the emergence of echo chambers. This can then be utilized to radicalize public opinion and alienate outgroup opinions[7]. The use of sensationalism in media also leads to desensitization towards sensational content, because the continuous use of this type of content has led readers to believe that sensational content is the norm within media[8].

The acquisition of information that contradicts current beliefs can have lasting effects as well. Cognitive dissonance theory (CDT) posits that cognitive dissonance arises when an individual holds two or more contradictory beliefs or perspectives, or when new information is adopted that contradicts existing beliefs[9]. Within the context of war, people who are not directly involved in the war can experience cognitive dissonance in various manners. A common example of this is simultaneously feeling a sense of empathy and duty to provide help, but also experiencing feelings of helplessness or restraint when speaking out. Additionally, people can experience cognitive dissonance in the form of disbelief regarding national or military actions being reported on in the media[9].

Besides the spread of false information, misinformation can also be weaponized in conflicts.

JOURNALISM IN THE DIGITAL WORLD

Online media and especially algorithm-driven media often fall victim to misinformation and disinformation. Pokropek et al.[9] differentiate misinformation and disinformation; concerning the sharing of false content, either non-deliberately or deliberately, respectively. People often rationalize or justify beliefs in order to reduce cognitive dissonance. This may lead to increased susceptibility to misinformation and disinformation[9]. Exposure to misinformation itself is not sufficient to influence an individual's perspective, the manner of information processing is also of importance. Kahan[10] lists two modes of information processing; one fast and associative manner that is driven by simple heuristics, and a slow and rule-based manner that relies on systematic reasoning.

When consuming media, individuals often unknowingly aim at protecting one's viewpoint, whether that be a personal perspective or one shared within an affinity group. As a form of 'identity self-defense', individuals are unconsciously motivated to disregard information that is contradictory to ingroup beliefs. This not only concerns the perceived credibility of content, but also an individual's ability to understand information that competes with ingroup views[10]. Besides the spread of false information, misinformation can also be weaponized in conflicts. It can be used as a means to disrupt social cohesion and manipulate public opinion, intensifying international tension[2].

The current news landscape and global events call for increased media literacy. Awareness of how you yourself, and the people around you, can be influenced and steered in a certain direction is an important factor of influence regarding social cohesion and politics. However opinions might diverge from one another, it is important that opinions are formed based on freely available, complete, and unbiased reporting as well as unbiased digestion.

How can obedience and carrying out orders lead to horrific acts such as the Holocaust or the genocides in Rwanda, Cambodia, or Bosnia?

For the most part, it is a mystery why obeying instructions from an authority can convince people to kill other human beings, sometimes without hesitation and with incredible cruelty.

This book sheds light on the process through which obedience influences cognition and behavior.

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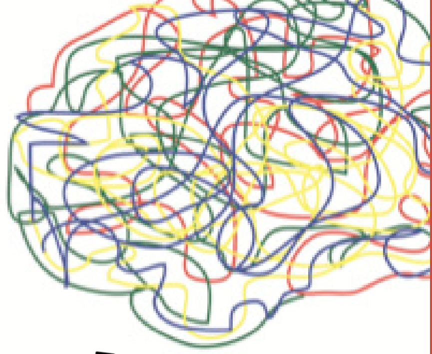


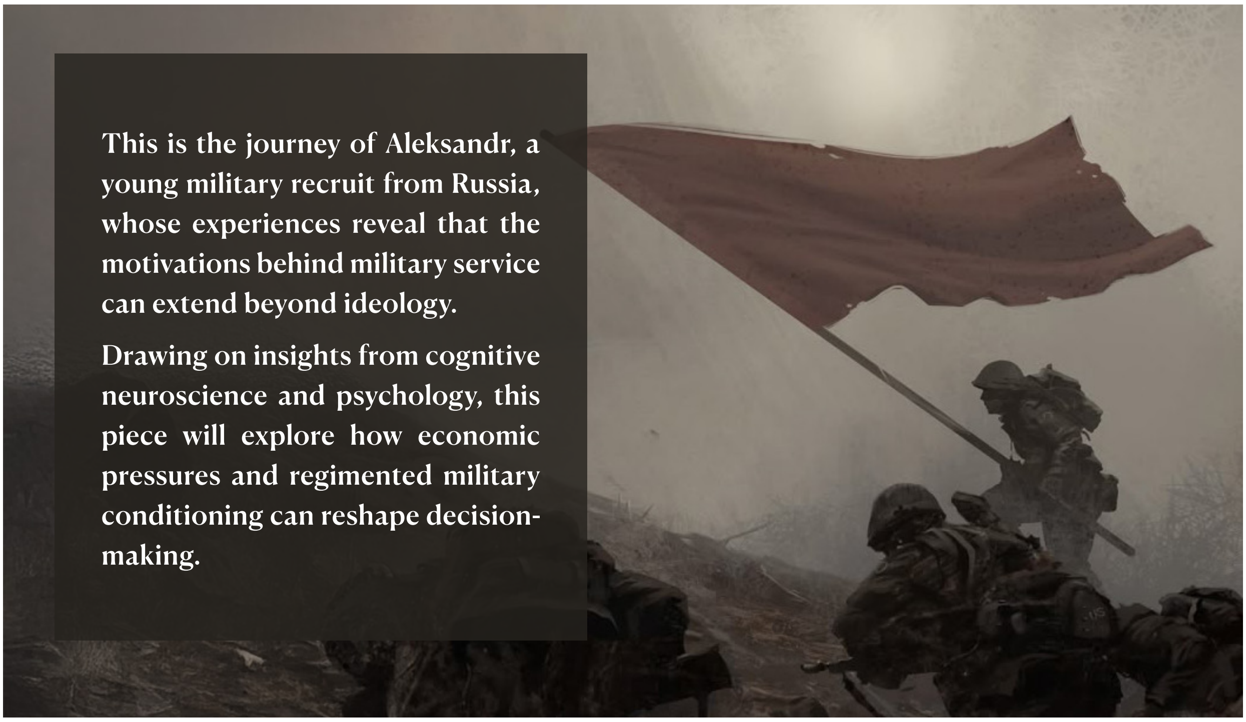
JUST FOLLOWING ORDERS

By Emilie A. Caspar.

Dr. Caspar is a professor at Ghent University, Belgium, specializing in social and cognitive neuroscience.

BEYOND IDEOLOGY:

Alexandr's Experience and a Cognitive Perspective on the Pragmatic Realities of Military Life



This is the journey of Aleksandr, a young military recruit from Russia, whose experiences reveal that the motivations behind military service can extend beyond ideology.

Drawing on insights from cognitive neuroscience and psychology, this piece will explore how economic pressures and regimented military conditioning can reshape decision-making.

Anya Povolotskaya

Western mainstream media often simplifies the portrayal of soldiers into two categories: ideologically driven monsters or unfeeling machines. However, a closer look at individual experiences reveals a far more complex picture. I had the opportunity to talk to Aleksandr[a], a young recruit from Russia, who studied in a military college for five years before being deployed to Ukraine when the war began, where he spent six months. His story offers insight into the profound impact of military conditioning on personal identity, revealing how prolonged exposure to the structures of military life can suppress individuality and blur the boundaries between personal agency and institutional control.

I was introduced to Aleksandr through a mutual friend, and we arranged to speak over a video call[b] . During our conversation, I first focused on understanding the role of ideology—what beliefs led Aleksandr to join the army, the motivations of his fellow soldiers, and how commanders emphasized the importance of being at war. To my surprise, Aleksandr consistently responded: "What ideology or motivation? We're simply trying to survive. There's no grand purpose, no deep-seated hatred—just the simple, mechanical effort to survive." His answer made me reassess my assumptions, revealing that my own perspective, shaped by years of living in Europe, was narrower than I had realized.

> ***"What ideology or motivation? We're simply trying to survive. There's no grand purpose, no deep-seated hatred—just the simple, mechanical effort to survive."***

I want to make it clear from the start: I neither condone the war in Ukraine nor seek to rehabilitate those who support it. Instead, my goal is to shed light on a perspective that is rarely explored—the cognitive and neurological processes underlying the behavior of those fighting in conflict, such as depersonalization, effects of coercion, and decision-making under stress. I aim to present a balanced perspective that contextualizes military behavior by integrating his narrative with relevant research in cognitive neuroscience and psychology. At the same time, this exploration does not excuse any actions, as the war crimes committed by the Russian army in Ukraine are unquestionably reprehensible, and have to end as soon as possible.

Aleksandr's Journey: From Socioeconomic Pressures to Military Enrollment

Aleksandr grew up in a remote region of Russia where economic opportunities were scarce. Despite his passion for robotics and aspirations for higher education, the financial realities made such ambitions difficult to attain. The military presented itself as an attractive alternative: it promised not only a stable income but also free education, guaranteed housing, and access to better healthcare (benefits that conferred significant social prestige). His decision to enroll in a military college was influenced strongly by familial expectations. Aleksandr's mother, convinced by state propaganda and cultural narratives that glorify military service, saw the armed forces as a secure, respectable path to success. She pressured the 18-year-old Aleksandr to follow the path that she believed was right. Thus, what might have been an academic pursuit became a pragmatic, even if reluctant, entry into military life.

Aleksandr noted that many people who join the military are young, uncertain about their future, and come from less privileged backgrounds. A significant number enter military education with the intention of staying only temporarily—expecting to spend a year in the army, benefiting from provided food and housing, clarifying their life goals, and then leaving to pursue their dreams. However, once they are integrated into the system, they often find it difficult to leave—the army offers a predictable, predetermined path that makes the unknown outside seem daunting. Even if they do decide to leave, the army structure makes it both psychologically and practically very difficult, as Aleksandr experienced firsthand. Once he joined the military college, Aleksandr quickly recognized that the advantages were accompanied by a significant price. "As soon as the checkpoint doors closed behind me, I realized that leaving would be problematic. I didn't like how the commanders spoke to the cadets or how most people there didn't seem interested in learning or improving. It felt like everyone was just surviving and slowly degrading. That first evening, I was lying in bed weighing the pros and cons of being there, and the next morning I submitted my quitting papers for the first time."

His initial attempt was met with strong appeals to the benefits he would receive through his education, arguments presented by both his commanders and his mother, which were persuasive enough for a young man still uncertain about his future. However, as time went on, leaving became increasingly difficult. By his third year, Aleksandr was sure of his desire to return to civilian life. When he submitted his quitting papers again, his commander threatened to send him to a military prison forcing him to withdraw his request. Since the military invests heavily in the training of each recruit, commanders are penalized when members of their division quit. As a result, they are quick to resort to coercive measures to keep soldiers from leaving.After several unsuccessful attempts to exit the military through official channels, Aleksandr decided to complete his education and seek help from a civilian lawyer to facilitate his dismissal. He made a few attempts at his assigned military base, but before any legal process could be finalized, the war began. He, along with his unit, was reassigned to the front lines. "Me and most of the guys were against being there, knowing we had no business being there at all.

But a few were more aggressive, waving huge Russian flags. These people of course also exist". After spending six months in active combat, Aleksandr was granted a short leave, during which new mobilization orders effectively closed any remaining legal avenues for departure. Facing limited options, he chose to desert. As a result, he is now considered a criminal in Russia, and the consequences extend to his family as well: his mother, who had once pressured him into military service, now lives in a secluded village to avoid police visits and house searches. She regards him as a traitor and has cut off all communication with him. Aleksandr has since founded a volunteer organization that assists individuals like him in fleeing the war in Ukraine, escaping to Europe, seeking asylum, and ultimately saving their own lives as well as the lives of many others.

Military Conditioning and the Erosion of Personal Agency

In Aleksandr's story, one recurring theme was the loss of personal agency . You are told when to wake up, when to eat, when to go to sleep. Aleksandr described how the army training is designed to take away one's ability to choose. He shared the story of a retired soldier that he met, who was only 35 but already felt like he couldn't do anything besides serve in the army. Lacking basic life skills, he felt as if his ability to make even the simplest choices had atrophied. These experiences align with theories of learned helplessness, where repeated exposure to environments that strip away personal control can lead to a diminished belief in one's ability to influence outcomes[1]. As a result, individuals may become more passive in accepting negative events, without trying to change or resist them. This reduction in perceived agency is not only a psychological consequence—it is also accompanied by neurobiological changes. Animal studies have found that learned helplessness affects the brain's immune environment[2]. For instance, prolonged stress increases the infiltration of tissue-resident T cells into the hippocampus, a region involved in emotional regulation. Tissue-resident T cells are a type of immune cell that persists in tissues after inflammation and can offer prolonged protection. The accumulation of these cells in the hippocampus was associated with a lack of recovery from learned helplessness, indicating that this immune response may contribute to reduced resilience to future stressors[2]. This demonstrates that learned helplessness can have lasting effects on the brain, leading to persistent changes in neural function.

Cognitive and Neuroscientific Insights into Stress and Depersonalization

During their training, soldiers were often exposed to coercive discipline, such as threats from the commanders, or collective punishments. This environment was designed to instill fear and obedience. As a result, soldiers were already conditioned through training to function under fear and surrender personal decision-making. These pressures became even more intense once they arrived at the front. "In the first few weeks, you just learn how to survive—how to take cover during shootings, dig trenches, and so on. There's no strategy or bigger plan; they simply tell you what to do, and you do it mechanically because you know that if you don't, something bad will happen. You hear rumors of people being shot in the foot, beaten, locked in basements, or even tied to trees by their commanders or fellow soldiers. Although these things aren't openly discussed, you know that if you don't follow orders, you'll face the consequences."

Research indicates that prolonged exposure to coercive environments, combined with the intense trauma experienced at the front, can trigger dissociative states and depersonalization[3]. Research has shown that people who experience depersonalization have diminished activity in the regions responsible for the evaluation of emotional salience and regulation of emotional responses, such as the dorsolateral prefrontal cortex and the anterior cingulate cortex[4]. This diminished neural activity supports the idea that under extreme stress, people detach from their emotions and bodily sensations, resorting to survival-driven behaviors.

This state of depersonalization leads people to do things that they would never have considered in everyday life. Aleksandr says: "Everything that remains of you is left somewhere in civilian life. Now, you don't have the option to call your parents, pet your cat, talk to your friends, or even plan for tomorrow. You live only for today—you never know where you'll eat or sleep, or if you'll be alive by the evening. You exist solely in this moment. This is why laws no longer hold sway: a person acts as they are able. If someone wants to steal, they can, because no one can stop them. If they want to go out and shoot, they simply do it. People become entirely different; you act in a completely different way." Of course, this state of depersonalization does not excuse any criminal actions committed by soldiers at the front. However, as illustrated by Aleksandr's experience, it does offer a glimpse into the altered mental state that can develop under relentless stress and coercion. Furthermore, the dissociative effects of sustained stress can be long-lasting. For Aleksandr, this meant that even after leaving the military, he still struggles with decision-making in everyday life. Simple choices, like planning leisure activities, can be challenging because years of rigid conditioning have influenced his capacity for autonomous decision-making. This enduring impact is well documented in clinical studies, which suggest that depersonalization can persist long after the original stressors have been removed[5].

> ***"Everything that remains of you is left somewhere in civilian life. Now, you don't have the option to call your parents, pet your cat... You live only for today."***

Going Beyond Ideology

Many people expect soldiers to be driven by ideological commitments. However, Aleksandr's experience challenges this notion. He explained that ideology and personal beliefs are rarely the most important thoughts in people's minds. Instead, their motivations, including Aleksandr's, were largely pragmatic: economic stability, social status, and the collective pressures inherent in military life. Overall, genuine ideological commitment seems to be found mostly among the "sofa warriors"—those who follow the conflict from the comfort of their living rooms watching state TV. While state media and cultural narratives promote the idea of national glory and political idealism, the day-to-day reality on the ground is far more pragmatic.

Aleksandr's experience illustrates the profound and lasting impact of military conditioning on personal agency. Behaviors observed in military settings are not solely the result of ideological indoctrination or moral deficiency; they can also stem from neurobiological processes. It is important to recognize, however, that the experience of a single individual cannot capture the full spectrum of perspectives within the Russian army or any military force. Nonetheless, his story challenges the oversimplified portrayal of soldiers as a homogenous, ideologically driven group, and adds nuance to our understanding of military behavior.

Acknowledgement

a. Aleksandr agreed to use his real name.
b. I am deeply grateful for Aleksandr's trust in sharing his experiences with me, especially given the deeply personal and emotionally charged nature of this topic.

NEUROwarfare

Mait Filipozzi

Military neuroscience is creating smarter and stronger soldiers through neurostimulation, drones and weapons controlled by thoughts alone, and much more. As these technologies evolve, ethical concerns about their impact continue to grow.

Brain and mind sciences have played a noteworthy role in the history of modern warfare. From neuropharmacological manipulation experiments in the MK Ultra project[1] to the amphetamine-fueled Blitzkrieg ("lightning war") in WWII[2], targeting the brain for a tactical advantage has been a military objective for over a century.

The rapid advances in neuroscientific methods, techniques, and technologies in recent decades have culminated in the emergence of a new field within the brain sciences: military neuroscience. As described by military neuroscientist Armin Krishnan[3], this field applies neuroscientific findings to the military in two ways: applying neuroscience and technology to enhance one's military and targeting the brains and minds, or "neurospace", of the enemy. While research has explored both sides of neurowarfare, in this article I focus on the former.

SELECTION AND TRAINING

One of the earliest contributions of the mind sciences to the military is in the selection and screening procedures of recruits. During World War I, intelligence tests were used as a screening method for recruits in the U.S. Army to determine aptitude for military roles based on cognitive abilities. Though rudimentary at the time, this set an important precedent: psychological aptitude tests remain a fundamental tool in military recruitment[4]. As with intelligence tests in WWI, the United States continues to lead the way in military applications of the brain and mind sciences. Although military neuroscience is investigated all over the world, the majority of publicly available information comes from the United States. With new developments in neuroscience and technology, psychological tests are being complemented by increasingly advanced neuroscientific screening techniques. One promising technique for selection procedures is electroencephalography (EEG). For example, researchers have found that alpha wave activity in the left temporal lobe is noticeably higher in expert marksmen compared to amateurs[5,6].

fMRI and machine learning could be used to identify individuals who are fast learners based on their brains' connectivity patterns.

This is thought to be a signal of lower levels of local neuronal recruitment, which results in higher neural efficiency. Experts suggest that for military roles requiring neural efficiency, such as snipers, this alpha-wave marker could be a useful tool in selection procedures. Functional magnetic resonance imaging (fMRI) could be another valuable tool for screening.

There is evidence that fMRI combined with machine learning tools can be used to identify individuals who are fast learners based on their brains' connectivity patterns, and even decode individuals' preferred decision-making strategies[6,7]. This technology could allow for the identification of optimal candidates for roles requiring different decision-making strategies, such as special forces agents, who must be able to make quick, high-risk decisions with limited information, whereas mission planners and strategists must rely on methodical reasoning, weighing all options with the goal of minimizing risk and ensuring long-term success.

In addition to recruitment, neuroscientific research shows promise for accelerating and enhancing military training. Neurostimulation techniques, such as transcranial magnetic stimulation and transcranial direct current stimulation (TMS and tDCS) are most

promising. For example, tDCS has been shown to accelerate the learning of cognitive tasks and these results have already been replicated in military training [6,8]. One trial showed that applying tDCS to the frontal cortex improved soldiers' ability to detect hidden targets compared to a sham control condition[9]. This can even be enhanced by fMRI, which could be used to locate optimally responsive areas for stimulation, thus enhancing the training effects. Although not widely used yet, these advances show great promise for the optimization of military recruitment and training. As these techniques become more refined, they may significantly improve the efficiency and effectiveness of military preparation.

BATTLEFIELD NEUROENHANCEMENT

The use of drugs to affect the mental state of soldiers has been common in the past, and neuropharmacological stimulation remains an important tool. For instance, amphetamine-based stimulants, such as "go pills" (Dexedrine), continue to be used by U.S. Air Force pilots on long missions to maintain alertness and wakefulness[10]. However, battlefield neuroenhancement is expanding beyond pharmacology. Here too, the United States is leading the way, with most published research in military neuroscience being funded by them.

As in selection procedures, EEG has been of great interest for neuroenhancement. One potential use is, similar to pharmacological stimulation, fatigue, and stress management. EEG could be used to monitor markers of cognitive load and, coupled with a computer, these markers could be used to deploy automated aid[5,11]. For example, pilots could be monitored during flights, and when fatigue or cognitive load is too high, an autopilot can be deployed[7]. Another way to use this "neurofeedback" mechanism is in target detection. Trials have demonstrated that EEG can detect signals from the visual cortex elicited by targets that are below the level of conscious perception[5,6]. This EEG signal could be translated by a computer to an auditory or visual cue, indicating to the soldier that there is a target present which they have missed, enabling the detection of previously "invisible" targets. Neuroenhancement can also be performed directly by stimulating the brain with TMS and tDCS. When applied properly, these methods have been shown to suppress pain perception, as well as improve cognitive ability and working memory[6]. These effects have been replicated in military tests; furthermore, it has been shown that TMS and tDCS can even aid in target detection from radar images[7]. One research team from Arizona State University is even working on a Transcranial Pulsed Ultrasound device with similar effects as TMS and tDCS that can fit into the helmet of a soldier[1]. All of these technologies show great potential for enhancing the endurance and cognitive abilities of deployed military personnel.

BEYOND CLASSICAL NEUROSCIENCE: BRAIN-COMPUTER INTERFACES

The more traditional methods of neuroimaging and stimulation offer great potential for military applications, yet a new frontier of military neuroscience is gaining popularity: brain-computer interfaces (BCI). These systems can convert neural signals into digital commands, allowing users to control external devices, interact with artificial systems, or enhance cognitive and physical performance[12]. Initially developed for medical rehabilitation, BCIs gained widespread attention after NeuroLife created an EEG-based interface that enabled a paraplegic man to control a robotic arm using only his thoughts[12]. This exciting advance did not go unnoticed by military experts and agencies, such as the Defense Advanced Research Projects Agency (DARPA) in the United States, who has invested over $300 million in BCI research.

The "Silent Talk" project, one of DARPA's initiatives, exemplifies one potential avenue for BCI in military neuroscience. Silent Talk aims to create an EEG-based system that allows user-to-user communication by decoding verbal thoughts from EEG readings and translating them to another person[13]. Such a system could prove invaluable in stealth operations, allowing soldiers to coordinate silently, or in medical emergencies where injured soldiers cannot speak.

In addition to communication, BCIs offer the opportunity to control military equipment. Studies on flight simulations have shown that pilots can be trained to execute additional tasks, such as attention tasks and communication using Morse code, using BCIs with no decline in piloting performance[12]. This could be of great use in high-intensity situations that require multi-tasking. Furthermore, research is being conducted on remote-controlled vehicles using BCIs, like drones and airplanes[14]. Much like the introduction of drone warfare, this offers the potential to engage in military operations from a safe location, reducing battlefield casualties[14]. Some experts even suggest that BCIs could eventually be used to operate personal firearms with improved accuracy[15] and even more ambitious applications are on the horizon. In 2019, DARPA awarded a grant to the NeuroLife team to develop an injectable BCI capable of controlling military vehicles[16]. In spite of this excitement, BCI technology is still far from ready to be deployed on the battlefield. Several problems still hinder their effective use, most notably their unreliable performance. However, BCI might soon revolutionize modern warfare[12].

ETHICAL CONSIDERATIONS

Military neuroscience has great potential from a national interest perspective: their effective use can create an armed force where recruits' competencies are matched with their role, trained more effectively, and aided pharmacologically and technologically on duty. From a soldier's perspective, there is also much to be said for these developments: a well-trained and equipped soldier's chances of survival are much increased. However, there is growing ethical concern in the academic literature regarding the use of these technologies.

The most widely discussed issue is the "dual-use" problem of military neuroscience[7]. That is, neuroscientific findings that are beneficial can be put to use in a harmful way. Ultimately, there is no way of controlling this problem after a finding has been made. Once new knowledge is published, researchers have no control over how it is used in the future, whatever their original goal was. Furthermore, Yuste et al.[10] warn that applied research often creates new, unpredicted ethical concerns. This problem is further complicated by the fact that ethical discussion often lags behind scientific advances[6]. Without proactively considering ethical issues in military neuroscience, a snowball effect is created. As new military applications are developed without addressing existing concerns, ethical debates fall further behind[10].

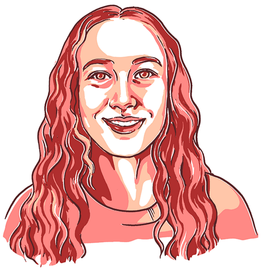
Another ethical concern relates to the effects of enhancements on military personnel. Although it is true that enhancing a soldier's alertness and cognitive ability increases their chances of survival in the short term, it is unknown in many cases how extensive use of performance-enhancing stimulation affects their health[7]. This is an even bigger cause of concern when considering the problems of coercion and peer pressure. In the U.S. military, for example, soldiers are compelled to accept medical interventions that make them fit for duty[8]. Furthermore, if enhanced soldiers are preferred over unenhanced soldiers due to improved performance, soldiers might be pressured into accepting enhancements. Without knowing the long-term effects of these interventions, this could pose a serious risk to their health.

The effective use of military neuroscience can create an armed force where recuits' competentices are matched with their role, trained more effectively, and aided pharmacologically and technologically on duty.

Finally, let us consider the idea of creating a more effective military. Is it ethical at all to strive for a stronger armed force, that is, one that is more lethal? As exemplified by their dual use, these technologies can also be used for other, arguably more beneficial purposes, such as medical rehabilitation. It could be argued that militaries are necessary for national security and keeping peace in unstable and potentially violent times, however, unchecked advances in military neuroscience could lead to more deaths than necessary for security and peace. The ethical concerns regarding military neuroscience, which go beyond the ones mentioned here, must be seriously considered, especially, as new ones are sure to arise with the further development of military neuroscience.

NEUROTOXIC BATTLEFIELDS

Poisoning the mind and body



Meike Jongen

Imagine a weapon that can paralyse, suffocate, and alter your cognition. With a single drop, chemical and biological agents have the ability to cause lethal and devastating effects on the nervous system. How do these agents work? And can we defend ourselves from them?

On March 4, 2018, the former Russian spy Sergej Skripal and his daughter, Joelia, were found slumped over, unconscious, on a bench in Salisbury, a city in the United Kingdom. The British authorities confirmed later that they had likely been poisoned with a nerve agent called Novichok[1]. Two years later, on August 20, 2020, Russian opposition leader Alexei Navalny was also poisoned with Novichok in Russia. Although the hospital Navalny was brought to initially stated there was no case of poisoning, after a transfer to a hospital in Berlin, the doctors there quickly concluded that Navalny was indeed poisoned with Novichok[2]. These two incidents are some of the most recent cases where neurochemical weapons were used to attack people. While Skripal, Joelia, and Navalny all recovered from their Novichok poisoning, Novichok remains one of the most lethal neurochemical substances to date.

A DEADLY DISCOVERY

As a neurochemical weapon, Novichok belongs to a group of lethal substances that is often referred to as nerve agents. Unlike more traditional weapons, nerve agents only require a relatively small amount to cause high numbers of casualties, which is why they are considered to be agents of mass destruction[3]. The discovery of these agents started in the 1930s, when I. G. Farbenindustrie, a German chemical and pharmaceutical conglomerate, started a project on synthetic insecticides. Chemist Gerhard Schrader, who was in charge of this project, became interested in organic phosphorus (OP) compounds. In 1936, one of the OP compounds synthesized during this project was the highly toxic tabun. A year later, Schrader and his colleagues discovered and synthesized an even more lethal OP compound, which they called sarin[4,5]. Their work was handed over to the German Army Weapons Office, who continued working on these agents, leading to the discovery of soman, an analogue of sarin. By 1945, the Nazi regime had produced around 10.000 tonnes of these three nerve agents, although they were never used. After the collapse of theNazi regime, the Allied forces took the German research on these nerve agents and began projects to develop their own supply. One of these projects led to the discovery of OP ester VX as the "most promising substance" of these projects[4]. Later, Russia and China developed their own variants of VX. During the Cold War, the Russians continued their work on OP compounds, which eventually led to the development of Novichok, an agent that is reportedly five times more potent than VX[5].

Unlike more traditional weapons, nerve agents only require a relatively small amount to cause high numbers of casualties.

THE NERVOUS SYSTEM UNDER ATTACK

As mentioned before, the development of nerve agents started in the 1930s. However, they had not been used in warfare until the Iran-Iraq war. During this war, the Iraqi military used tabun against Iranian troops, killing 300 men on the field and leading to several thousand poisonings[5]. Sarin has also been used during multiple terrorist attacks organized by the religious sect Aum Shrinrikyo in Japan during the 1990s, resulting in at least 19 deaths and nearly 4000 injuries[5].

One of the factors that make these nerve agents so dangerous is that they are mostly colourless liquids that become vaporous at higher temperatures. This means they are difficult to detect, until it is often too late. In case of exposure (respiratoryinhalation or dermal), factors like concentration, temperature, and duration of exposure play an important role in symptom development. However, a small dose (vapour: 10-400 mg-min/m3, dermal: 10-1000 mg depending on the agent) has the potential to cause death within minutes[6]. In case you are exposed to a nerve agent, the first thing you will start to feel is usually stimulation or hyperactivity of muscles. Then, those muscles start to become fatigued, and eventually, you become (partially) paralysed. At the same time, nerve agents will affect your brain, leading to cognitive and behavioural changes. Exposure to sarin or tabun could cause mental confusion, difficulty with concentration, insomnia, and vivid and/or disturbing dreams. If the exposure has been too much, seizures or respiratory failure could kill you within minutes to several hours. However, if you survive, symptoms can last for days or weeks. There have even been reports of lasting for several months, but the long-term effects of nerve agents are currently poorly understood[6].

Within the body, the toxic effects of these nerve agents stem from their ability to inhibit the breakdown of the neurotransmitter acetylcholine. Acetylcholine is essential for both the parasympathetic (rest-and-digest) and the sympathetic (fight-or-flight) parts of the nervous system. Additionally, it is a key neurotransmitter at the neuromuscular junction, (where nerves meet muscle), and regulates functions such as wakefulness and sleep, as well as learning and memory[5]. Nerve agents act as inhibitors of acetylcholinesterase, which normally breaks down acetylcholine. This causes a severely toxic accumulation of acetylcholine at the synapse, leading to the terrible symptoms described earlier.

NATURE'S DEADLIEST TOXINS

Instead of synthetic nerve agents, neurobiological weapons refer to toxins originating from bacteria, viruses, fungi, etc., and are just as dangerous as nerve agents. For example, during World War II, a Japanese biological warfare unit fed prisoners bacillus cultures of Clostridium botulinum. This species of bacteria produces one of the deadliest substances known, botulinum toxin, and was indeed lethal for the prisoners whothat ingested them[7]. Botulinum spores can be ingested and inhaled and are quickly absorbed by the gastrointestinal and respiratory epithelium. Like nerve agents, the mechanism of botulinum toxin also involves acetylcholine. At the presynaptic terminal of neuromuscular junctions, acetylcholine is present in neurotransmitter vesicles. These vesicles fuse with the presynaptic membranes, which SNARE proteins facilitate. Botulinum toxin can cleave these SNARE proteins, preventing acetylcholine from being released and ultimately inhibiting muscle contraction[7]. Blurred vision and dysphagia are some of the first signs of contamination, followed by paralysis of skeletal muscles and respiratory failure. However, because the toxin cannot penetrate the blood-brain barrier, the mental status is largely unaffected.

Another case of neurobiological weapon use was in October of 2001, while the United States was still reeling from the 9/11 attacks. Letters were sent to media outlets in Florida and New York City containing a mysterious powder. An investigation would later conclude that this powder contained anthrax spores, leading to multiple diagnoses of pulmonary anthrax. Such letters were later also found to be addressed to Senators Tom Daschle and Patrick Leahy. In the end, 22 people had been infected with either cutaneous or pulmonary anthrax, with 5 cases of pulmonary anthrax leading to death[8]. Anthrax is acquired from the spores of the Bacillus anthracis, a bacterium strain present in soil, which usually affects animals[7]. After inhalation, anthrax spores are transported to pulmonary lymph nodes, further leading to a massive release of the spores into the bloodstream. The spores can become vegetative bacilli producing toxins that interfere with lymphocyte function[6]. Neurological symptoms caused by these toxins include headaches, mental status changes, and visual impairments. The biggest threat is the development of bacterial meningitis, which can lead to bleeding in the brain tissue, eventually resulting in hemorrhagic stroke. Pulmonary anthrax is by far the most lethal with a 90-99% mortality rate (compared to the 20% for the cutaneous form), which is why it is considered "an ideal biological weapon"[7].

A RACE AGAINST TIME

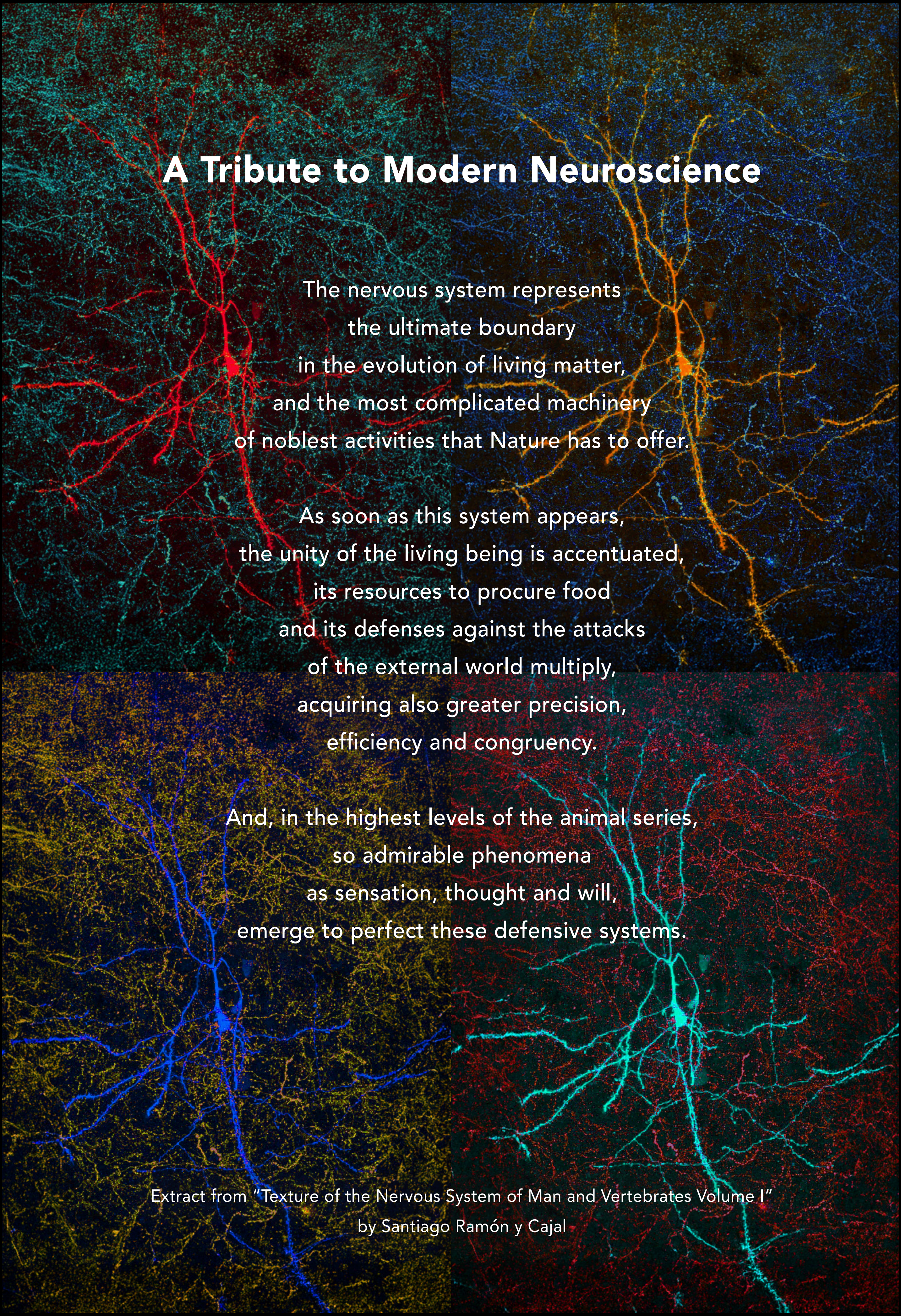
Now that we have established the lethal dangers from nerve agents and biological weapons, what can we do if we get exposed to these weapons before it's too late? The most common antidote for nerve agent exposure is atropine, which blocks the effects of excess acetylcholine by binding to acetylcholine receptors. This means that it does not directly interact with the nerve agent but rather reverses its effects indirectly[5]. Another nerve agent antidote that could be used is pralidoxime, or 2-PAM. This antidote can reverse the inhibition of acetylcholinesterase that is caused by nerve agents. Sadly, these antidotes have limited efficacy. Atropine can only bind to a subset of acetylcholine receptors called muscarinic receptors, and while 2-PAM is effective against sarin and VX, it does not work as well against soman[5]. A broad-spectrum antidote against nerve agents would be ideal, but has currently not been found. This would mean that the exact nerve agent needs to be established first to effectively treat nerve agent exposure, which could be a critical race against time.

Pulmonary anthrax is the most lethal with a 90-99% mortality rate, which is why it is considered "an ideal biological weapon".

Equally problematic is the treatment of the neurobiological weapons mentioned earlier. Regarding botulinum toxin, antibiotics cannot be used as a treatment for contamination with botulinum since the symptoms are caused by the toxic spores of the bacteria and not by the bacteria itself[6]. On the other hand, it is possible to treat anthrax infection with antibiotics and although a pre-exposure vaccine is available and seems effective against infection, it is currently not recommended for the general public[6,7]. Thus, like nerve agents, exposure to botulinum toxin and anthrax spores is also extremely challenging to treat, further establishing the lethality of these weapons.

UNSEEN AND UNSTOPPABLE?

The lack of effective treatment options, combined with the fact that these neurochemical and neurobiological agents are often very hard to detect, make it seem as if these weapons are unstoppable. Therefore, the current Biological Weapons Ban states that member states are prohibited from producing and stockpiling biological and chemical weapons[6]. However, since this ban has been instated in 1972, there have been several attacks using nerve agents or neurobiological weapons. Especially the Novichok attacks in 2018 and 2020 highlight that there are still groups willing to use these agents to hurt or kill people. The current threat of these agents also emphasizes the importance of neuroscience in developing better treatments. Currently, there are some promising compounds such as RS194B and catalytic bioscavengers. RS194B is designed to reactivate sarin-inhibited acetylcholinesterase, but has not been tested in humans yet[5]. Besides treatment after exposure, catalytic bioscavengers serve as possible pretreatment options. They are engineered enzymes that can degrade nerve agents before they inhibit acetylcholinesterase[5]. Hopefully, further development and research into antidotes and treatment options will reduce the destructiveness of these weapons. In turn, improved protection against neurochemical and neurological agents could make them less appealing as weapons.



A Tribute to Modern Neuroscience

The nervous system represents
the ultimate boundary
in the evolution of living matter,
and the most complicated machinery
of noblest activities that Nature has to offer.

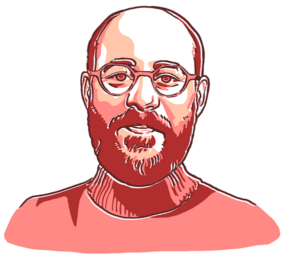
As soon as this system appears,
the unity of the living being is accentuated,
its resources to procure food
and its defenses against the attacks
of the external world multiply,
acquiring also greater precision,
efficiency and congruency.

And, in the highest levels of the animal series,
so admirable phenomena
as sensation, thought and will,
emerge to perfect these defensive systems.

Extract from "Texture of the Nervous System of Man and Vertebrates Volume I"
by Santiago Ramón y Cajal

Simulating Strife

Computational Models of Human Conflict



Afon (Mohammad) Khari

Can AI help us predict and prevent war? Agent-based modeling is integrating neuroscience, machine learning, and game theory to simulate complex social interactions and decision-making scenarios. This approach, beyond its limitations and ethical challenges, could offer valuable applications in real-world peace-making diplomacy and collective cooperation.

Understanding human conflict through neuroscience and psychology has long been a challenge due to the complexity of social interactions and the unpredictability of human behavior. Traditional approaches such as historical analysis, observational studies, and experimental psychology face limitations in isolating causal mechanisms and testing hypothetical scenarios ethically and efficiently. For instance, while historical analysis can identify patterns of conflict recurrence, it struggles to establish causal relationships due to confounding variables and the lack of experimental control. Observational studies, such as research on intergroup aggression, can document behavioral trends but cannot manipulate key variables to test counterfactual scenarios. Experimental psychology, though useful in controlled settings, often fails to capture the complexity of large-scale conflicts, as ethical constraints limit the range of scenarios that can be directly tested.

Computational modeling provides an alternative framework for researchers to simulate conflict dynamics under controlled conditions systematically. These models offer a testbed for exploring scenarios that would be impractical or unethical to study in real-world settings by encoding decision-making rules, cognitive biases, and strategic interactions into artificial agents[1].

Researchers can explore the underlying mechanisms of conflict, cooperation, and aggression by employing models that replicate group dynamics. These models have practical applications in diplomacy, military strategy, and social policy and can help predict the emergence of tensions and test potential interventions before they manifest in real-world scenarios[2].

Computational models are also compatible with key theoretical perspectives in neuroscience and psychology. Theories such as **reinforcement learning** and **bounded rationality** suggest that decision-making in conflict is shaped by cognitive constraints and adaptive strategies, both of which can be simulated in artificial agents. Additionally, advances in social neuroscience provide insights into the neural substrates of aggression, cooperation, and in-group bias[3], which could be integrated into more biologically inspired models of human conflict.

Finally, the rise of big data analytics and machine learning has enhanced the predictive power of computational conflict models. Agent-based simulations can be trained on real-world patterns and improve their applicability to forecasting diplomatic crises and civil unrest by incorporating historical datasets such as the Uppsala Conflict Data

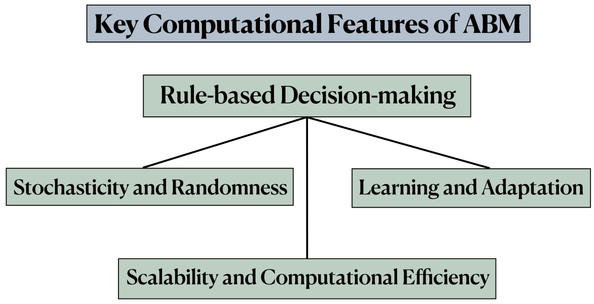
Program[4]. Among computational approaches, agent-based modeling stands out for its ability to simulate conflict through individual interactions and emergent behaviors.

AGENT-BASED MODELING (ABM)

Agent-based modeling (ABM) is a computational approach in which autonomous agents, individuals or groups, are programmed with specific behaviors and allowed to interact in a simulated environment. These models rely on rule-based decision-making, where agents operate according to behavioral rules derived from established frameworks such as game theory, evolutionary dynamics, or empirical psychological research. These rules dictate how agents interact, strategize, and respond to various stimuli in the simulated environment.

To enhance realism, many ABMs incorporate stochasticity and randomness, which allows for unpredictable variations in agent behavior that mirror real-world human interactions. This unpredictability ensures that simulations do not follow rigid, deterministic patterns but instead reflect the complexity and variability of actual social dynamics. Additionally, ABMs often feature adaptive learning mechanisms by integrating reinforcement learning algorithms which enable agents to adjust their behaviors based on past experiences. This ability to learn and modify decision-making strategies over time adds depth to the simulations and makes them more reflective of real-world human cognitive processes.

A key strength of ABM lies in its bottom-up approach, wherein complex system-wide patterns emerge from the interactions of individual agents rather than being dictated by predefined equations. Unlike system dynamics models, which use aggregate mathematical equations to describe the behavior of entire populations, such as predicting economic trends or the spread of infectious diseases, ABMs simulate local interactions and allow for individual heterogeneity and adaptive learning, which makes it particularly useful for studying group dynamics and conflict escalation, as they can capture emergent phenomena such as polarization, alliance formation, and shifts in cooperation or hostility over time[5]. Finally, scalability and computational efficiency play a vital role in the practical implementation of ABMs. Large-scale simulations often require significant computational resources which necessitate optimization techniques such as parallel processing. These advancements ensure that even complex, high-density simulations can be executed efficiently, which provides valuable insights into conflict dynamics and potential resolution strategies. In recent years, machine learning-assisted ABMs have introduced hybrid models, where agent behaviors are dynamically learned from real-world datasets rather than being hardcoded. This approach enhances realism and predictive accuracy but raises challenges regarding data bias and interpretability.



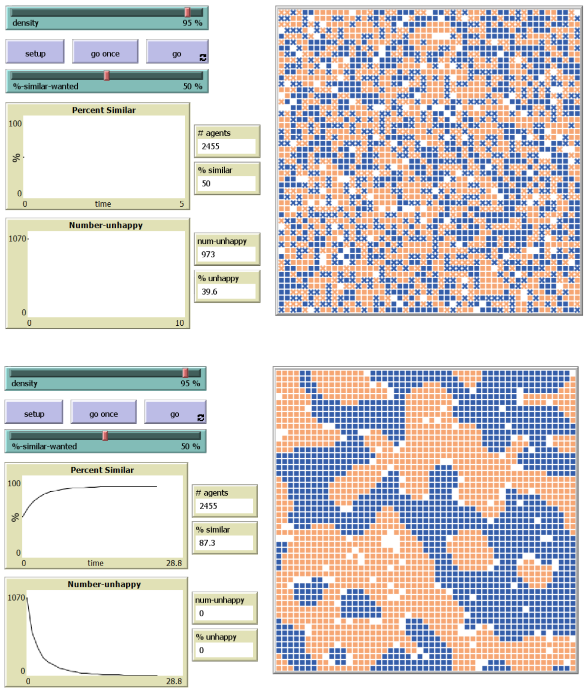
EMERGENCE

Emergent behavior in complex systems refers to the spontaneous and self-organized patterns that arise from simple interactions among individual components without a centralized control. A classic example is the flocking behavior of birds, where each bird follows simple local rules: maintaining distance from neighbors, aligning with their direction, and moving towards the group's center, which results in a coordinated and dynamic movement pattern at the collective level[6]. These emergent properties result from decentralized interactions rather than being directly programmed, which show how local behaviors evolve into large-scale patterns observed in both natural and artificial systems.

ABM has been employed to simulate various social behaviors, including competition for resources, tribalism, and intergroup aggression. Through these simulations, researchers can explore how individual decisions scale to collective phenomena, such as riots, warfare, or peaceful coexistence. ABM enables the testing of different peacekeeping strategies in a controlled virtual space by tweaking parameters such as communication, trust, and access to resources[7]. These insights are invaluable for policymakers and social scientists seeking data-driven approaches to conflict resolution.

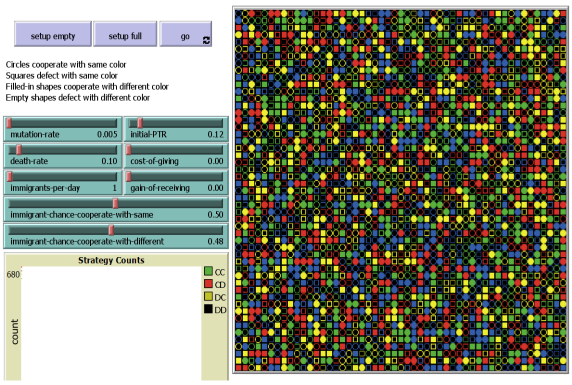
KEY THEORETICAL BACKGROUND AND MODELS

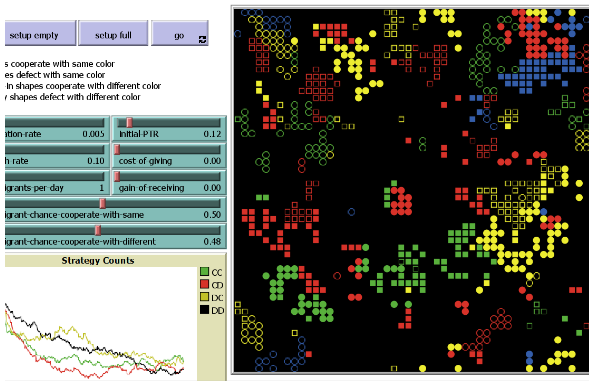
The foundation of computational conflict modeling lies in Complexity Science, which studies how simple rules can lead to intricate patterns of behavior[8]. One of the earliest models applied to social conflict is Thomas Schelling's Segregation Model, which demonstrates how small individual biases can lead to large-scale social divisions[9]. Even when individuals only slightly prefer to live near those similar to themselves, the model shows that complete segregation can emerge over time.



SEGREGATION - NETLOGO

Another influential model, the Ethnocentrism Model, explores how in-group favoritism and out-group discrimination shape group dynamics. This model has been used to study how bias and cultural identity contribute to cooperation and hostility and to provide valuable insights into real-world conflicts such as ethnic controversies and nationalism[10].



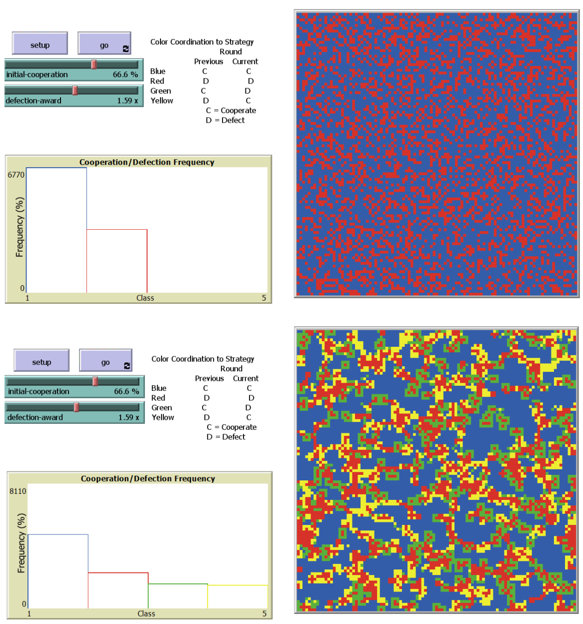


ETHNOCENTRISM - NETLOGO

These models capture essential features of human behavior, such as self-organization, tipping points, and feedback loops. Researchers can test how societal interventions, like reducing economic disparities or promoting intergroup dialogue, might mitigate conflict before implementing them in reality[11] by experimenting with different variables.

CASE STUDY: THE PRISONER'S DILEMMA

A well-known and widely recognized computational model for understanding conflict is the Prisoner's Dilemma (PD), a game theory model that explores the tension between cooperation and competition[12]. In its classic form, two agents must decide independently whether to cooperate or betray the other. While mutual cooperation yields the best collective outcome, individual incentives often push agents toward betrayal, which leads to suboptimal outcomes for both agents.

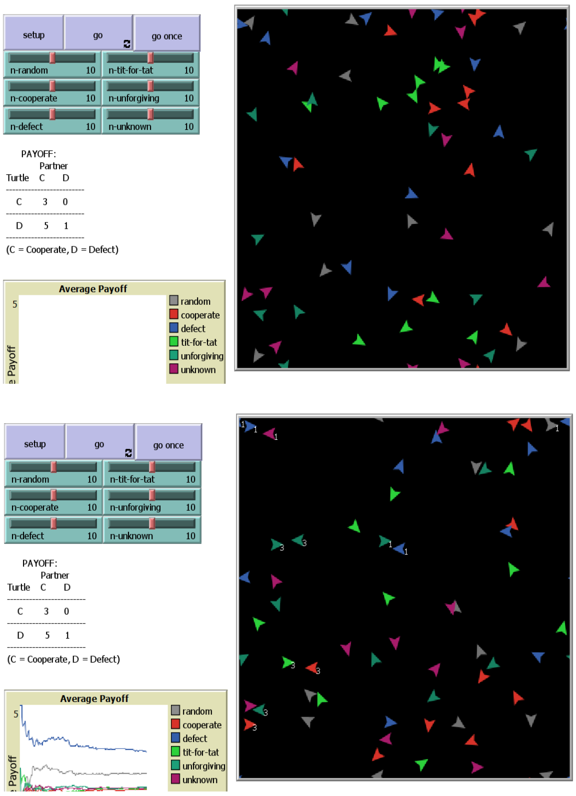


PRISONER'S DILEMMA BASIC EVOLUTIONARY - NETLOGO

While the classic Prisoner's Dilemma is useful for modeling bilateral conflict, more complex real-world conflicts often involve multiple stakeholders with shifting alliances and asymmetric power dynamics. Multi-agent extensions of PD, such as the N-person Iterated Prisoner's Dilemma (IPD), introduce additional complexity by allowing dynamic strategy adjustments over repeated interactions. These advanced models can capture coalition formation, trust erosion, and cascading defection patterns.

Neuroscientific research has further refined our understanding of decision-making in PD-like scenarios. Functional magnetic resonance imaging (fMRI) studies have identified brain regions involved in cooperation and betrayal, particularly the prefrontal cortex (responsible for rational planning) and the amygdala (associated with emotional responses to betrayal)[13]. Incorporating such findings into ABMs could improve their fidelity in simulating human behavior under conflict conditions.

NetLogo, a widely used simulation platform, has been instrumental in implementing the PD model to study variations in human decision-making within competitive environments[14]. The model's setup includes



PRISONER'S DILEMMA N-PERSON ITERATED - NETLOGO

multiple agents that engage in repeated interactions, adjusting their strategies based on past experiences. Researchers can introduce factors such as memory, punishment mechanisms, or communication between agents to examine how these elements influence trust and cooperation[15].

Findings from these simulations have direct applications to real-world scenarios, such as arms races, trade negotiations, and diplomatic relations[16]. For instance, when repeated iterations of the game allow for learning and trust-building, cooperation becomes more stable: a phenomenon that parallels long-term peace agreements between rival nations. Moreover, introducing communication into the model drastically alters outcomes, which reinforces the importance of dialogue in conflict resolution[17].

INTERPRETATIONS AND IMPLICATIONS FOR UNDERSTANDING HUMAN BEHAVIOR

Findings from ABM simulations provide valuable insights into human psychology and the dynamics of conflict. Models reveal how biases, resource distribution, and group identity shape behaviors that often lead to self-reinforcing cycles of aggression or cooperation. A deeper understanding of these mechanisms informs interventions aimed at breaking negative feedback loops and encouraging stability.

Furthermore, computational models highlight the role of perception in conflict. Even when two groups have equal access to resources, differences in perceived fairness can fuel hostility[18]. Such psychological triggers

These models bridge the gap between theoretical psychology and practical applications and allow researchers to test conflict resolution strategies with unprecedented precision.

can be identified by policymakers to enforce strategies that preemptively reduce tensions before conflicts escalate. Additionally, these insights extend beyond geopolitical conflicts and inform approaches in corporate negotiations, community disputes, and law enforcement[2].

CONCLUSION

Computational neuroscience and agent-based modeling offer transformative insights into human conflict by simulating social interactions in controlled environments. These models bridge the gap between theoretical psychology and practical applications and allow researchers to test conflict resolution strategies with unprecedented precision. As computational power advances, future models will integrate more nuanced aspects of human cognition, such as emotions and social learning, which will enhance their predictive capabilities[1].

Future advancements in the field will likely integrate deep learning and reinforcement learning and allow agents to evolve more sophisticated strategies over time. Hybrid models, ABM combined with large-scale empirical datasets, promise greater predictive accuracy but also present challenges in balancing interpretability and computational complexity.

However, as these models become more powerful, their ethical implications must be considered. The use of ABM in military AI systems raises concerns about autonomous decision-making in warfare, while biased simulations may inadvertently reinforce harmful stereotypes in policy planning[11]. It is crucial to establish guidelines for these models' responsible development and application to ensure they promote peace rather than intensify conflict. Despite their advantages, computational models are not without limitations; the accuracy of these simulations depends on the validity of their underlying assumptions and parameter settings. Addressing these challenges requires ongoing interdisciplinary collaboration between computer scientists, neuroscientists, and political analysts.

Scientists and policymakers can work toward developing more effective strategies for peacekeeping by refining these approaches, and ultimately, leveraging computational tools to nurture a deeper understanding of human conflict and cooperation in an increasingly complex world.

Photo by James Waincoat on Unsplash

Acknowledgement

I sincerely thank Prof. Dr. Han van der Maas and his team for their insights and guidance in the Complexity Science course, which provided a strong foundation for understanding the dynamics of human behavior and conflict through computational modeling.

"The brain is wider than the sky"

- Emily Dickinson

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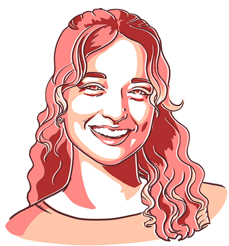
PROSOCIAL DISOBEDIENCE

The Neuroscience of Moral Decision-Making in Civilians & Military Personnel



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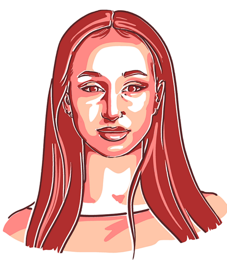


Rheandra Groenenberg

Evelyne is a young neuroscientist originally from the south of the Netherlands. At the age of 18, she moved to Amsterdam to pursue her passion for psychology and biology, completing her Bachelor's in Psychobiology. After that, she pursued the research Master's in Brain and Cognitive Sciences, the alma mater of the ABC Journal, specializing in cognitive neuroscience. She describes her passion for neuroscience as the drive to understand the interconnection between the brain and behaviour. In January 2024, she joined the Moral & Social Brain Lab, led by Professor Dr. Emilie Caspar, at the Ghent University as a PhD student.

What is the central focus of your PhD research?

My research investigates the neurocognitive processes that support resistance to immoral orders, using non-invasive neuromodulation methods. But that's quite a fancy way to put it. To put it simply, I'm interested in how people respond when they receive an order - especially when that order comes from an authority figure and involves harming someone. Some may follow the order because they see it as coming from an authority figure and assume it must be obeyed. Others, however, resist and refuse to comply. The act of resisting an immoral command to help others is called prosocial disobedience, and it's the central focus of our lab.

> ***"My research aims to investigate whether empathy for pain and sense of agency are causally involved in prosocial disobedience."***

How does your work connect to already existing research on obedience?

Our research ties back to the famous Milgram's experiments[1], which are among the most well-known studies on obedience. Those studies primarily examined the social and cultural factors that influence whether people obey authority. For example, they found that people were more likely to comply if the authority figure wore a white lab coat. However, these studies had ethical concerns and did not explore the underlying neurobiological mechanisms of obedience, what happens in the brain during these decision-making processes. After Milgram's studies, obedience research became less of interest because of the controversial nature of the topic. Fast-forward to 2021, my supervisor, prof. Dr. Emilie Caspar, developed a new paradigm to revive this line of research[2], allowing us to investigate obedience and disobedience from a neurocognitive perspective.

Let's dive into the neuroscience of it: what are the main cognitive processes tied to prosocial disobedience which you are interested in?

My PhD specifically examines two cognitive processes: empathy for pain, our ability as humans to share another person's feelings, and sense of agency, the feeling of ownership over our own actions. To illustrate the latter, I often use an example: imagine I instruct one person to slap another person's hand. If the person slaps the hand voluntarily, they own that action - it was their choice. But if I coerce them by saying, "Slap their hand, or I will harm you", the question becomes: is that person still fully responsible for the action? This is where the sense of agency comes in - the feeling of responsibility for one's actions and their consequences. My research, using non-invasive neuromodulation, aims to investigate whether empathy for pain and sense of agency are causally involved in prosocial disobedience. By manipulating neural activity in brain regions associated with these processes, we can directly test whether they influence the act of resisting immoral orders.

Milgram used behavioral observations to understand to what extent subjects would agree to administer a painful shock to others. Your research takes a step deeper, as you're trying to unlock the neural basis behind the decision to follow or not an immoral order. What kind of cutting-edge technology do you rely on to answer this question?

In our lab, we primarily use EEG, though we also conduct some fMRI research. EEG is a great tool because it allows us to measure brain activity easily using electrodes on the scalp. It's affordable, user-friendly, portable, and provides high temporal resolution, making it ideal for our studies. Portability is especially important because our lab conducts research outside of traditional lab settings. For example, I will conduct research at military academies. My supervisor and other PhD students also work in diverse settings, including research in Rwanda and prisons. In these environments, an fMRI machine wouldn't be possible - it's large, expensive, and, in certain contexts such as rural remote areas, intimidating for participants.

Additionally, my research will incorporate non-invasive neuromodulation, which is a first for our lab. Specifically, we will employ Transcranial Direct-Current Stimulation (tDCS), which involves using positively and negatively charged electrodes to increase or decrease cellular activity in different parts of the brain. This method allows us to manipulate brain activity and test whether specific regions are causally involved in prosocial disobedience. For example, tDCS enables direct observation of whether inhibiting the somatosensory cortex, a superficial brain region involved in the empathy for pain network along with deeper structures like the anterior cingulate cortex and anterior insula, may reduce empathy for pain in subjects. Forming direct and causal evidence is important as in neuroscience, there are different types of evidence. We can make behavioral observations and measure physiological responses like brain activity or heart rate, but experimental manipulation is considered the strongest form of evidence - it's the final piece of what's known as the "Golden Triangle of Evidence"[3]. Policymakers and other stakeholders want to see strong, causal results rather than "vague" correlations, and neuromodulation helps establish causality.

We imagine that in order to conduct this type of research, it is important to consider the population you will sample your participants from. Can you share more details about your pilot studies - what populations you'll be working with?

Yes! I plan to conduct four experiments during my PhD. Two will involve civilian participants (i.e., students and the other general population), while the other two will involve military personnel. I'm collaborating with the Military Academy in Brussels and potentially military academies in the Netherlands and France. For each population, I'll conduct one experiment on empathy for pain and one on sense of agency. Right now, I'm piloting the two empathy-for-pain studies - one in civilians and one in a military setting.

We are all neuroscience geeks here, so we have to ask: what are your hypotheses regarding the brain regions involved in prosocial disobedience?

Previous research from our lab has shown that in coercive situations, where participants receive orders from an experimenter - they tend to have reduced empathy for pain for the person they are harming, compared to when they freely choose to harm them[4]. We measure this using EEG event-related potentials (ERPs), particularly the P3 and late positive potential (LPP), which are markers of empathy for pain[5]. When someone observes another person receiving a shock, the amplitude of these ERPs is typically higher compared to not seeing someone receiving a shock. In coerced conditions, however, we see a reduction in ERP amplitude, suggesting lower sensitivity for empathy for pain[6,7]. In addition to this, we hypothesize that stimulating certain brain areas, such as the somatosensory cortex, could increase empathy responses, both in subjective empathy for pain ratings (i.e., "How painful was this shock for the participant?") and in ERP measurements. However, subjective ratings can be influenced by factors like social desirability bias, so we rely more on objective neural markers. Ultimately, we hope to show whether positive/negative neuromodulation can enhance/reduce empathy for pain and prosocial disobedience.

That's really interesting. How about individual differences, like personal values? Do you have any insights into how these subjective factors may influence prosocial disobedience?

Yes! My lab discovered several patterns about prosocial disobedience when taking into account external, subjective factors. For example, people with higher moral reasoning scores demonstrate more prosocial disobedience regardless of their background[2]. Second, we found that someone's general attitude toward authority significantly impacts their willingness to disobey across both populations[2]. Those who are more skeptical of authority more readily refuse orders that harm others.

The military is a population that one doesn't often come across in psychology studies. Why do you find it important to include this perspective in your research?

You're totally right! The military is an understudied group that operates within a strict authority structure, yet international law[8] requires them to disobey acts involving crime or delict. This creates a complex decision-making scenario that echoes the debate around prosocial disobedience; on one hand, soldiers are trained to follow orders, but on the other hand, they must disobey if an order involves committing a crime or a delict, per national and international laws. That's a very intricate scenario. Military personnel may have to disengage their own moral feelings in order to obey orders. Military organizations can require actions that are considered unacceptable by society during peacetime, such as killing. This disengagement can be very hard for soldiers and may lead to moral injuries, and in some cases, conditions like PTSD. Although soldiers are trained to disobey illegal or criminal orders, doing so in real-life situations is extremely difficult and requires significant personal courage. With the research in my lab, we aim to understand why disobedience is so hard, develop training that strengthens moral judgment, and create systems that support soldiers in saying "no" when necessary.

Soldiers and civilians lead very different lifestyles. Do you expect differences in empathy and sense of agency between them?

From the literature, we know that military students tend to have a lower sense of agency compared to civilian students[9]. However, this sense of agency increases again with experience and rank; officers, for example, show levels of agency comparable to civilians. With neuromodulation in military populations, we might find that the sense of agency is already naturally reduced. This could mean it's either not as important in this group or that it is highly flexible and can change quickly. Since the military population is not frequently studied, we don't have strong hypotheses yet. But we do know that the balance between empathy and the sense of agency could differ between civilians and military personnel[9].

> ***"Previous research from our lab has shown that in coercive situations participants tend to have reduced empathy for pain for the person they are harming."***

Your lab put emphasis on including non-WEIRD populations in your research. This is a new term for us. What does it stand for, and why does your lab put emphasis on these populations?

Psychological research mostly focuses on WEIRD (Western, Educated, Industrialized, Rich, Democratic) populations, which are not necessarily representative of the global human experience. That's why I appreciate Professor Caspar's work, she focuses on studying non-WEIRD populations. Specifically, she conducts research in Rwanda, where the genocide against the Tutsis took place in 1994[10]. In this country, most of the former perpetrators and those who instead risked their lives to save others are still alive. Since they share similar cultural and social backgrounds, this provides a unique opportunity to study what distinguishes those who committed atrocities from the rescuers. She investigates questions like: Why did some people choose not to help, even when they could? Why did others decide to intervene, even at great personal risk? It's impressive how she manages to conduct research in such complex and sensitive settings.

Are there potential moral or ethical concerns in your study setup? i.e., especially since your research has some similarities to the Milgram experiment[1].

During my first year, I faced some challenges in obtaining ethical approval due to my research's sensitive nature: using shocks, involving military participants, and studying obedience to harmful orders. I appreciate how strict the ethics committee was. It is clear their standards are there to make sure all populations are treated with respect. Their feedback really pushed me to think deeply about every aspect of my work. However, I also believe these ethical sensitivities actually highlight why this research is so important - these challenges reflect the importance of this research, as such decisions are difficult in real life. There are indeed similarities to the Milgram experiment; however, our paradigm includes crucial differences[2]. We use real but safe shocks, calibrated to each participant's threshold and unlike in Milgram's experiment, none of our participants have experienced extreme emotional distress, seizures, or other severe reactions. The research has already been approved by seven ethical committees across more than 10 studies involving over 2,000 participants. For the neuromodulation component, we screen participants, among others, for metal implants and ensure the stimulation is safe, though it may cause temporary effects like fatigue or tingling on the head. Also, we made sure to implement safeguards: participation is voluntary, withdrawal is allowed at any time, monetary compensation and no educational credits are provided to avoid coercion, and we exclude individuals with direct ties to the researchers. In the military context, we address authority dynamics by recruiting through student representatives, group messaging, and posters, ensuring superior officers remain unaware of participants. This approach protects participants from potential coercion and navigates the unique ethical challenges posed by military power structures. Additionally, when sharing my work, especially in non-academic settings, I take great care to ensure that the results are not misinterpreted or used in ways that could discriminate against certain populations.

> ***"We know that military students, especially lower-ranking ones, tend to have a lower sense of agency."***

Given the state of the world right now, we're definitely living in some tense and unpredictable times, especially with discussions around rearming Europe gaining traction[12]. How do you see your research on prosocial disobedience playing out in real-world scenarios? Could your findings help shape policies, improve training programs, or offer approaches to handling conflicts?

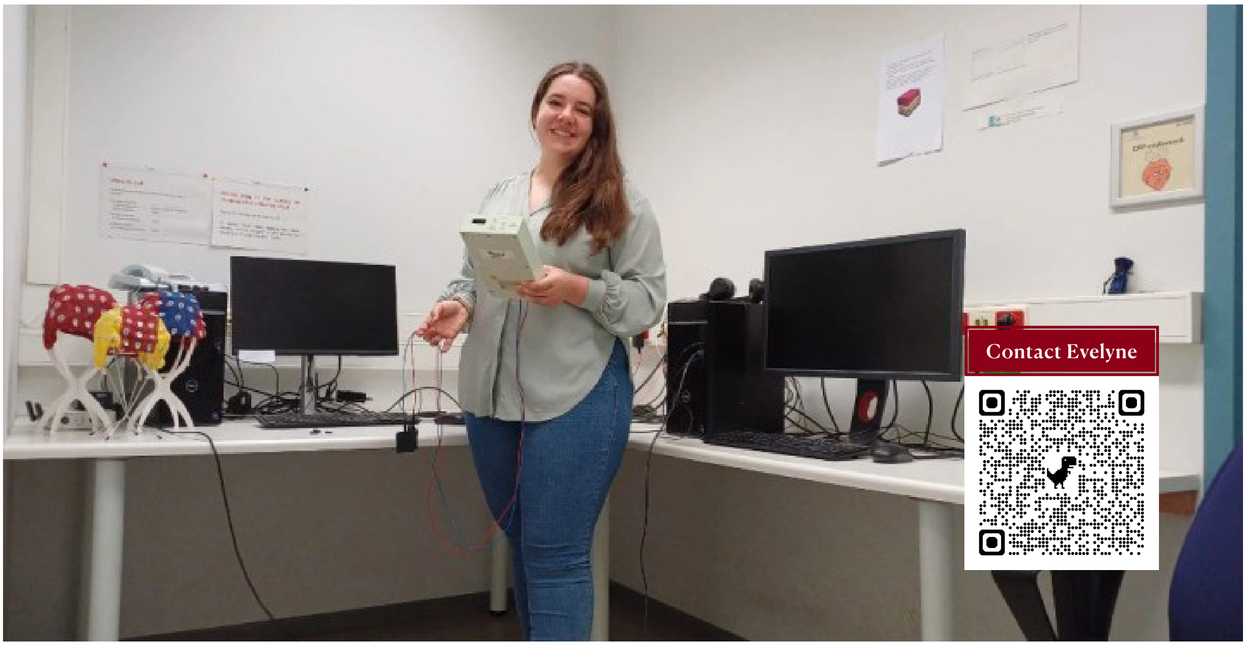
I view my research as part of a broader team effort led by Prof. Dr. Emilie Caspar. Prof. Dr. Caspar has many PhD students working across these populations, and ultimately, we want to understand the behaviors that drive blind obedience - what are the social factors, situational effects, neural cognitive factors, and how do they relate? Once we understand how these mechanisms work, we'll know where to focus our efforts and develop effective interventions to prevent blind obedience. For example, if my sense of agency manipulation doesn't work, in the sense that my approach simply isn't effective, then maybe we should focus more on empathy levels. Or if we find no clear difference between military and civilian populations, then the strict hierarchical education system may not be the key factor, and we would need to identify what other factors are driving these differences. Overall, Prof. Dr. Caspar aims to develop educational programs in collaboration with NGOs to address blind obedience, prevent illegitimate violence due to authority pressure, and help people resist propaganda and manipulation in civilian and military populations. She has already worked to reduce racial bias and promote active bystander intervention, published a book for the general public[11], and is currently creating a comic book for teenagers titled "The Incredible Real Stories About Ordinary Human Beings", which highlights real-life stories of standing against discrimination and defending welfare.

How have the interdisciplinary and international collaborations in your PhD influenced your research approach, and what challenges have you faced working across multiple countries and institutions?

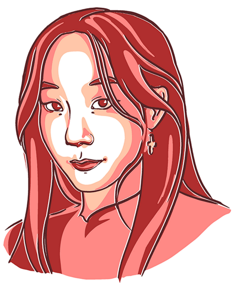
My PhD involves a collaboration between the Ghent University's Moral & Social Brain Lab, where I work with Professor Dr. Emilie Caspar, and the Leibniz Research Center for Working Environment and Human Factors in Dortmund, Germany, where I work with Professor Dr. Michael Nitsche, specializing in non-invasive neuromodulation. I am also collaborating with the Royal Military Academy in Brussels, with likely extensions to the Netherlands and potentially France, to study military personnel. My research bridges psychology and neuroscience, thanks to my promoters' expertise in psychology/neuropsychology (Prof. Dr. Emilie Caspar) and neuromodulation (Prof. Dr. Michael Nitsche). I enjoy this intersection because it allows me to explore fundamental questions by combining psychological insights with neuroscientific understanding. However, I definitely experience some challenges, mainly with communication and administration. Working with these academic and military institutions involves diverse cultures and people. Initially, I struggled to adapt my communication style, often being misunderstood. I had to overcome my insecurities and ask for feedback on how to communicate effectively. Additionally, administrative tasks are complex, as I need to obtain ethical approvals from multiple institutions. This process can be overwhelming at times.

That indeed sounds very challenging, what advice would you give to aspiring researchers in neuroscience?

My advice to upcoming researchers would be that it's okay to struggle. It's okay to fail. It's okay to apply 20 times to a PhD position and be rejected 19 times. I'm quite an advertiser for being real and open, hence I have introduced and promote #**ResearchGoodsAndBads** hashtag on LinkedIn as I see that young researchers, including myself, struggle with always seeing only the good things - "Oh I got this grant," "I accepted this paper," "I got two million dollars," or "I have this collaboration." I just don't think that's the reality, so I promote a bit more realism in how we talk about academic life. My advice in neuroscience specifically, is that gaining practical experience is crucial. I strategically chose internships to work with EEG and MRI, which helped me secure my current position. Initially, I wasn't selected, but I was the second choice, and when the first candidate didn't work out, I was offered the role. My professor emphasized that experience, particularly in specific techniques like neuromodulation, was key.



PTSD
&
Women After War



Weike Huang

Female veterans face unique, gender-specific challenges in coping with Post-Traumatic Stress Disorder (PTSD), as their combat stress is often combined with interpersonal trauma. Most research on PTSD in veterans has predominantly focused on men, leaving a gap in understanding the experiences of female veterans. Women after war should not only be seen and heard, but truly considered in research, policy, and support systems.

When you think of a "veteran with PTSD," what comes to mind? Perhaps someone like Chris Kyle in *American Sniper*—a legendary figure on the battlefield, but also a troubled, middle-aged man haunted by nightmares, struggling to adjust to home life. This image is typical, yet also stereotypical. Have you ever considered the possibility that the veteran could be a woman? In fact, more than two million female veterans currently live in the United States, and this number is growing rapidly. Women are now the fastest-growing demographic in the veteran population, with projections indicating they will make up 18% of all veterans by 2040.

Post-Traumatic Stress Disorder (PTSD) is a well-known consequence of war, but much of the early research on this disorder has focused primarily on male populations, leaving female veterans' experiences understudied[1]. Female veterans often face not only combat-related stress but also gender-specific traumas such as sexual violence and harassment. These experiences are disproportionately common in female veterans compared to their male counterparts and can significantly worsen their PTSD symptoms[2].

POST-TRAUMATIC STRESS DISORDER

PTSD is a psychiatric condition that can arise after exposure to traumatic events, e.g., actual or threatened death, severe injury, or sexual assault. It affects cognitive, emotional, and behavioural functioning of individuals. Symptoms include intrusive recall or flashbacks, ongoing avoidance behaviours, negative mood and cognitive alterations (e.g., guilt,shame, emotional numbing), and physiological hyperarousal (e.g., hypervigilance, sleep disturbances, irritability). These symptoms can interfere with daily life, interpersonal relationships, and employment, often persisting for months or even years after the traumatic event[3].

The development and severity of PTSD symptoms could be determined by several factors like coping ability, trauma type, and social support. For example, those who experience multiple traumas or have a history of mental illness are more vulnerable to develop PTSD. Aside from this, PTSD risk can also vary depending on the kind of trauma experienced.ndividuals who have faced violence, sexual assault, or combat are more likely to develop more severe symptoms than those who have experienced accidents or natural disasters. In American Sniper, the protagonist Chris Kyle experiences PTSD after his service in Iraq. Initially, Kyle's sharp focus on combat and his "killer instinct" earn him great fame in the military, however, the experience of being a master life-ripper later casts an indelible shadow over his mind, making it challenging for him to adjust to normal civilian life.

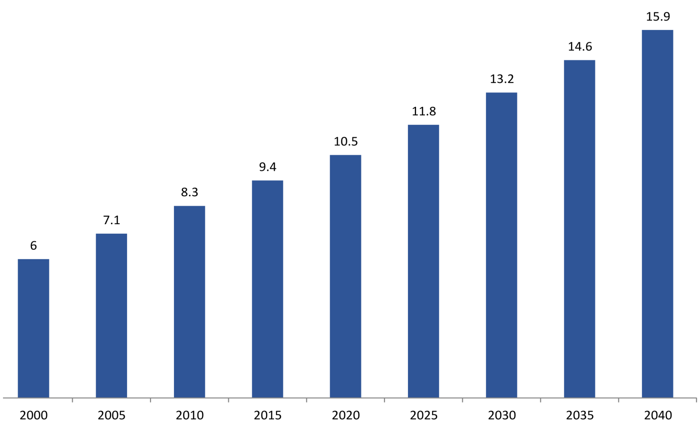
THE COGNITIVE MECHANISMS IN PTSD

Kyle's PTSD is portrayed through his difficulty reintegrating into home life. The emotional numbness and detachment suffered by Kyle is a powerful illustration of how PTSD can distort an individual's relationship with themselves, the family, and even reality itself. As the disorder affects numerous cognitive processes in the brain, particularly those involved in memory, emotional regulation, and decision-making, the cognitive mechanisms involved in PTSD remain unclear and complex.

One key brain area implicated in PTSD is the hippocampus, which plays an essential role in memory consolidation. Trauma has the potential to reshape how memories are encoded and stored. In PTSD patients, traumatic memories are often fragmented and isolated from other life experiences, thus unfortunately, individuals are unable to integrate them into their life story[4]. These memory dysregulations caused by stress-caused changes in the hippocampus tend to result in intrusive thoughts, flashbacks, and nightmares, as the trauma is replayed repeatedly and vividly in the mind as if it is happening in the present. Other brain regions are also involved in the underlying cognitive mechanisms of PTSD. The amygdala, for example, which processes emotional responses, especially fear, is hyperactive in PTSD patients. Normally, in our response to a threatening situation, as our primitive instinct, the amygdala initiates a fight-or-flight reaction. Afterwards, the prefrontal cortex (PFC) which is responsible for higher cognitive processes like decision-making, problem-solving, and emotional control modulates amygdala's emotional reaction by introducing rational thoughts.

But in PTSD, the hyperactivation of amygdala may result in overwhelming emotional responses like far-beyond-threshold anxiety or fear even in the absence of any threatening situation. What's worse, in PTSD patients, the PFC often shows decreased activity, further triggering inadequate emotional control and inhibited rational thinking. This results in symptoms like irritability, impulsivity, and increased sensitivity to stress. This persistent distorted mental state dominated by hyperarousal and impaired regulation gradually disrupts the individual's ability to manage distress effectively – they slowly deteriorate, as the inner turmoil consumes them, yet they feel powerless to do anything about it[5,6].

Women are vulnerable to developing PTSD from combat and also likely to face other gender-specific challenges, such as feelings of isolation, discrimination, and stigmatization.



WOMEN VETERANS AS A PERCENT OF THE VETERAN POPULATION

Source: U.S Census Bureau, American Community Survey, Public Use Microdata Sample, 2015. Prepared by the National Center for Veterans Analysis and Statistics

ERSTORY: SUFFERING DURING AND AFTER MILITARY SERVICE

While Chris Kyle's experience with PTSD provides a powerful example of the psychological toll of combat, his story represents just one facet of the broader issue. Now, let us shift our attention to "herstory"—the experiences of female veterans, whose struggles with PTSD are shaped by both combat and gender-specific challenges. Combat is one of the most stressful situations that humans can cope with[7]. It exposes soldiers to extreme psychological and physical challenges, which result in long-lasting effects on their overall well-being. The high-stress nature of military and combat-related environments amplifies the environmental factors that deeply impact human physiological and cognitive functions. Some veterans with combat stress reactions remain trapped in PTSD symptoms for years, even decades, after their service[8]. In 2015, two million female veterans made up roughly 10% of the total veteran population in the United States[9]. This growing demographic faces unique challenges in coping with PTSD, as their military trauma is often compounded by gender-specific issues. Female veterans are not only exposed to combat trauma but also suffer gender-based violence, sexual assault and harassment, and systemic discrimination, which are more prevalent for female as opposed to male service members[10 11].

Recent investigations done in American veterans groups show that approximately 32% of female and 5% of male subjects screen positive for military sexual trauma (MST) [12]. While MST is reported by both genders, its prevalence is significantly higher among women. This kind of trauma, when combined with combat stress, creates a unique set of PTSD symptoms in female veterans, who have to cope with interpersonal trauma alongside combat-related stress. The overlap between these two different types of trauma renders more complex PTSD symptoms in female veterans. Not only are they vulnerable to developing PTSD from combat, but they are also likely to face other gender-specific challenges, such as feelings of isolation, discrimination, and stigmatization[13]. Additionally, female veterans are anticipated to be more susceptible to co-morbid mental disorders including depression, anxiety, and substance abuse, which can further complicate PTSD treatment[14].

GEDER-SPECIFIC CHALLENGES IN PTSD

Research has shown that PTSD manifests differently across genders, not only in prevalence but also in how symptoms are experienced. Recent studies suggest that hormonal differences, such as the estrogen and progesterone, may contribute to the heightened susceptibility of women to PTSD, influencing stress response and emotion regulation[15]. Chronic PTSD in female veterans leads to significant emotional and cognitive challenges. Women with PTSD tend to experience more intense physical and emotional symptoms than men, such as higher levels of depression, anxiety, and somatic distress[16]. They are particularly prone to intrusive thoughts, mood shifts, and feelings of guilt or shame. These affective reactions are compounded by social and cultural pressures that often discourage women from seeking help, resulting in delayed intervention and more severe symptoms in the long run. Additionally, women are more likely to internalize their trauma, fostering self-blame and self-distorted perception. This prolonged emotional dysregulation further complicates their recovery, trapping them in a mental quagmire that's difficult to escape.

Reintegrating into civilian life after leaving the military plays a crucial role in veterans' post-deployment psychological well-being[17], especially for women. This gender group faces the added challenge of balancing caregiving roles, which women are traditionally expected to take on within their families and society'. For many female veterans, long periods of separation from their social relationships leave them with little time to adjust to their social roles. They often feel "overwhelmed by caregiving responsibilities", with deployment being particularly stressful for those managing family concerns and covering household expenses. Stress and anxiety are common byproducts during their coping process, and if left unaddressed, persistent and inflexible mental health issues may escalate into more complex PTSD, which further hinders female veterans' homecoming.

GLOBAL TRENDS: CALL FOR GENDER-SENSITIVE SUPPORT SYSTEMS

As the unique experiences and challenges faced by female service members and veterans in the military have been increasingly recognized, it is also evident that gender-sensitive support systems and policies remain underdeveloped worldwide. To help female veterans successfully reintegrate into civilian life, with lowered unemployment rates and improved prognosis of their mental health problems, it is essential to consider practical implications at both the community and societal levels. Local communities play a critical role in guiding and assisting female veterans during their readjustment by providing reliable direct support and easily accessible resources. Clinical healthcare providers, in particular, should serve as responsible and trusted therapeutic partners that offer a strong therapeutic alliance to address mental health concerns, including PTSD[18]. As intermediates between individuals and the broader society, communities are uniquely positioned to assist female veterans in reclaiming and readjusting to their social identities and responsibilities. This includes helping them reintegrate into family units and offering support to their family systems, which may also need assistance in their own post-deployment readjustment. Beyond the community level, more systemic and structural interventions are needed. At the societal level, government policies promoting gender-sensitive treatments are crucial to ensuring that female veterans receive necessary targeted mental health support, employment assistance, and social services.

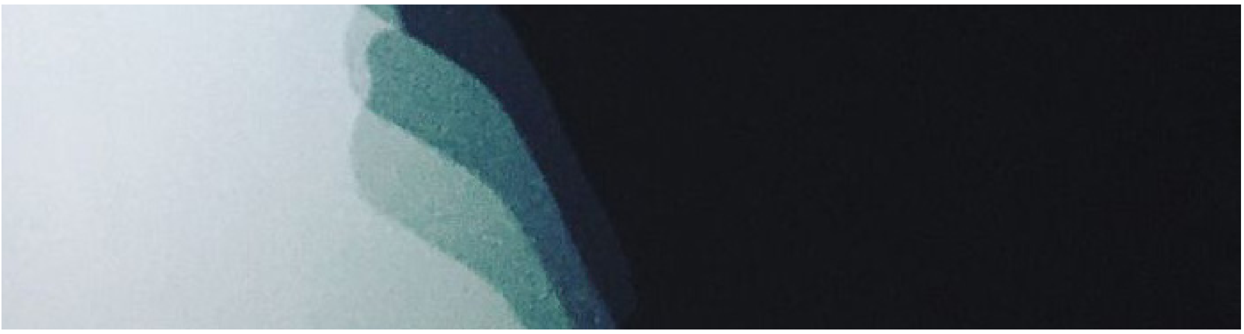
Supporting female veterans' reintegration into society requires practical efforts at both community and societal levels to improve employment and mental health outcomes.

By addressing both individual and the family needs at the community level while ensuring that societal policies and services are tailored to the specific needs of female veterans, we can create a supportive environment that promotes healing, personal growth, and successful reintegration into society.

If we are to benefit from the security and peace the soldiers have fought to protect, we must ensure veterans' rights are guaranteed. If these courageous women have given us their sweat and blood, we must be ready to wipe away female veterans' tears and shield them from storms. As the presence of women in the military continues to grow globally, we hope to see more artistic works that portray their stories, more people paying attention to the challenges faced by female veterans, and more comprehensive support systems in place that ensure a secure and brighter future for them.

ALUMNI RESEARCH

Beyond the war within



Welcome to one of our favorite sections of the ABC Journal, where we take a moment to look back, celebrate, and spotlight the brilliant work of our recent master's alumni. While the main theme of this issue is The Neuroscience of War, the abstracts featured here aren't necessarily matched with that theme, and that's the beauty of it. This section is about honoring the diversity, creativity, and intellectual curiosity that has come through our halls.

This year, we had the pleasure of reviewing 66 Literature Theses and Research Projects submitted by our graduating students during the 2024 academic year. From that impressive pool, a group of journal volunteers applied a detailed evaluation process to shortlist 20 standout pieces. These were then put to a community vote, and after much deliberation, five final works were selected to be featured here. Each of these projects brings something unique to the table. Whether exploring the internal battles of borderline personality disorder, the unpredictable reward systems of the adolescent brain, or the quiet biases embedded in language models, these alumni have tackled complex topics with rigor and originality. We also journey through a cutting-edge review of how reinforcement learning systems can be inspired by the brain, and end with the intersection of social choice theory and cognitive modeling.

This section is a tribute, not just to the ideas, but to the effort. To the long nights, the heated debates, the revisions (and re-revisions), and the spark that drove each of these students to keep asking better questions.

So, as you dive into these abstracts, we invite you to join us in celebrating not just research, but the people behind it: **Mariëlle Baelemans, Rosalie Ursinus, Eshine Wang, Paolo Agliati, and Matheus Boger**. Here's to our alumni, their incredible work, and the paths they're paving for the future. And a big shoutout to all the other students whose projects were part of this year's review: your work continues to inspire and push the boundaries of what's possible.

Afon Khari, on behalf of the ABC Journal Peer Review Team

The Subjective Experience of the Punitive Parent Mode in Individuals with Borderline Personality Disorder Following Schema Therapy: A Qualitative Study, **MARIËLLE C.E. BAELEMANS - RESEARCH PROJECT**

Borderline Personality Disorder (BPD) is often characterized by self-critical and punitive behaviors, conceptualized within Schema Therapy (ST) as the Punitive Parent Mode (PPM). This mode involves internalized punitive messages from attachment figures, leading to self-criticism, self-hatred, guilt, and self-denial. Despite clinical observations of PPM manifesting as auditory verbal hallucinations (AVHs), this phenomenon is frequently overlooked in ST and related research. This study explores the possible manifestation of PPM as AVHs. A qualitative approach was employed using semi-structured interviews with 16 participants who completed ST at two Dutch mental health institutions. Participants were interviewed about their experiences with PPM before, during, and after therapy. An independent, double-coded thematic interpretative phenomenological analysis was conducted. Approximately half of the participants reported experiencing AVHs linked to PPM before therapy. These AVHs were characterized by pervasive self-critical voices contributing to intense emotional and physical distress, as well as maladaptive coping strategies. ST techniques, including group therapy, Imagery Rescripting (ImRs), and the Empty Chair Technique (ECT), effectively reduced the power and credibility of PPM. This led to decreased frequency and intensity of AVHs, with improvements maintained through social support and adaptive coping mechanisms. The study highlights the prevalence of PPM as AVHs in individuals with BPD and demonstrates the therapeutic efficacy of ST in mitigating its impact. Future research should explore the broader spectrum of psychotic experiences in BPD and consider the integration of PPM as AVHs in the assessment and treatment of BPD.

Within-person Variability in Neural Responses to Reward-sensitivity Tasks and the Relationship with Risk-taking Behaviour in Adolescence, **ROSALINE URSINUS - RESEARCH PROJECT**

Adolescence is a time of increased risk-taking. Previous work has shown a positive relationship between risk-taking and neural activation of reward related areas including the ventral striatum (VS). Within-person consistency of neural measures is generally assumed, based on consistency of findings within studies. However, important psychometric issues concerning individual differences in behaviour (e.g. impulsiveness and aggression) across measurements are often not measured. Therefore, within-person variability in neural activation in the short term remains poorly understood. Overseeing within-person variability can result in inaccurate estimations of mean-group differences. This because assessing behavioural performance from a single measurement might be less accurate and representative, especially when the within-person variability in a measure increases. The current study used a repeated measures design to test the internal consistency of VS activation within a 7 day interval. Participants aged 16 and 17 years old (n=19) performed a reward-sensitivity card task in which they could win or lose money while undergoing fMRI. Intra-class correlation analyses showed within-person variability in VS activity in the short term (ICC = 0.482). In order to understand the meaning of this variability, the relation with VS activation and several behavioural questionnaires (i.e. card task ratings, daily risk-taking behaviour, BIS-11, BIS/BAS, BPAQ, and RT-18) was examined. While the questionnaires showed good reliability, linear mixed effect models revealed a significant effect of VS variability on BAS score (p = 0.015). Thus, this study provides new insight in within-person variability in neural measures and invites future studies to further examine the meaning of this variability.

"He is honest." vs. "He is not deceitful." — Exploring biased language use patterns in pre-trained language models,
ESHINE WANG - RESEARCH PROJECT

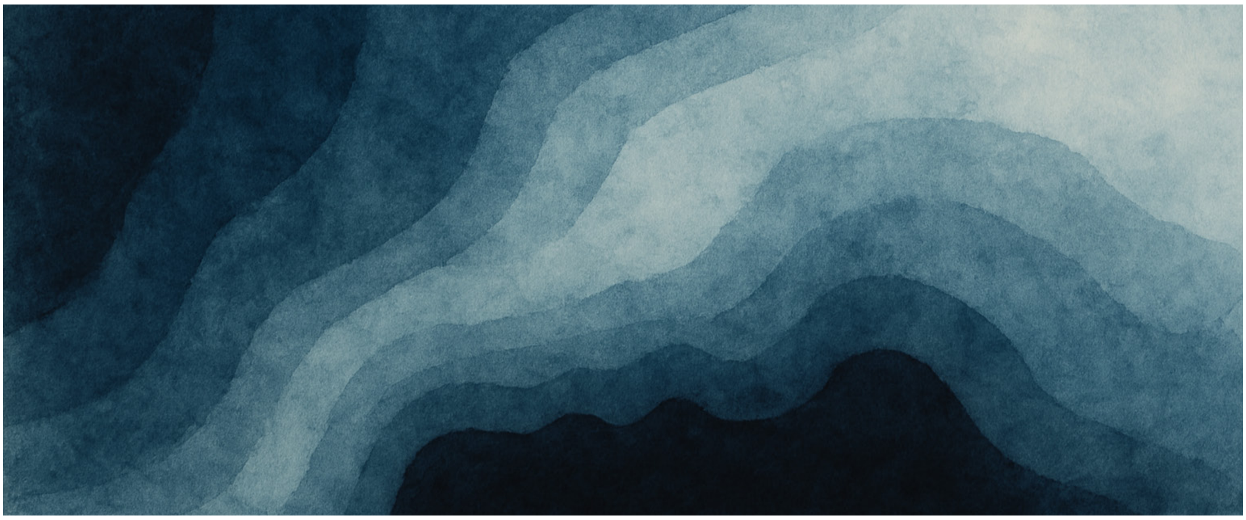
Warning: This paper contains content that may be offensive or upsetting. Language models have been shown to exhibit stereotypes reflected in their training corpora. Previous studies have primarily focused on the stereotypical content associated with demographic groups. The current work explores whether the stereotypes picked up by language models extend to language use patterns. The key contributions of this study are: (1) the development of a high-quality challenge dataset designed to evaluate language use patterns that reflect stereotype expectancy (i.e., Negation Bias) in language models; (2) an experiment using the dataset to evaluate biased language use pattern in BERT, along with an analysis on the limitations of widely used likelihood-based metrics in bias evaluation literature; and (3) bringing research on bias in language models into a deeper dialogue with the rich and nuanced field of stereotype studies in social sciences.

Learning from the brain: exploring neoHebbian plasticity and memory replay in reinforcement learning,
PAOLO UMBERTO AGLIATI - LITERATURE THESIS

Learning in realistic environments remains a novel domain within the fields of artificial intelligence and neuroscience from which researchers could step towards unveiling the principles of brain functionality and advancing models in their capabilities. Focusing on reinforcement learning, this review addresses the use of currently known principles from computational neuroscience and biology to tackle the main challenges in the field, with particular emphasis on improving inductive biases and preventing catastrophic interference. The current work proposes the interaction of two bio-inspired features, namely neuromodulation of synaptic plasticity and memory replay as a promising avenue to face these obstacles and to provide artificial systems with a human-like learning process. The majority of studies support the idea that neuromodulation and memory replay are highly intertwined events, both needed for the learning process in humans. Moreover, attempts at including these features in reinforcement learning agents proved to be beneficial for the model's performance in ecological settings. In this light, we explore how spike timing can represent a valid substrate on which to implement both bio-plausible characteristics. The framework of spiking neural networks is often utilised to represent and remember relevant features of specific environments, especially in dynamic contexts with sparse rewards. However, the literature offers different approaches to model both neuromodulation and memory representation, with varying degrees of cross-compatibility. Finally, we explore the challenges in implementing these bio-inspired systems, allowing computational models to aid current research, including neuromorphic hardware development, robotics, and neuroscience.

Strategyproofness and Social Choice: a New Perspective for Cognitive Modeling,
MATHEUS BOGER - LITERATURE THESIS

Social choice theory is a subfield of economics and mathematics which models the aggregation of preferences. The most typical example of its applications is in political sciences, where the aggregations modelled are votes in an election. This thesis aims to serve as a mathematically simple introduction of this theory to cognitive scientists. This is because we believe the principles behind social choice are fertile ground for new cognitive modelling techniques. Thus, we present some central concepts and results of the field while making associations to how these could be applied in brain sciences. From its main application, social choice theory adopts the voting terminology to lay down an axiomatic structure to this aggregation process. As such, 'voter's ballots' are compiled into 'winners of elections'. The compilation procedure is called a social choice function (SCF), and the whole of the ballots is called a profile. All possible profiles under an election constitute a domain. When voters are not able to gain an advantage in the election by lying about their preferences under a certain rule, this SCF is said to be strategyproof. The Gibbard-Satterthwaite Theorem gives us the main result of this field: no SCF can be strategyproof without restrictions to the domain unless it is a dictatorship (where only one voter decides the result of the election). Therefore, studies have been conducted to prove which SCFs would be strategyproof under different domain restrictions. This thesis presents three different restrictions (single-peakedness, single-crossedness and separable preferences), along with the motivation why such restrictions were thought of, the group of strategyproof SCFs found for each one and a possible applicability of these mathematical structures for cognitive modelling. In this way, we tie the ideas up until now mainly applied in social sciences to new possibilities in the field of cognition. We finalize this presentation of social choice theory to cognitive scientists by pondering what difficulties might be faced in the adaptation of these structures to cognitive modelling, specially when we take in consideration the large diversity of data types we commonly find in cognitive science, ranging from behavioral to cellular.



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