XR and Shadow Wars — the Uncanny Valley of Death

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In recent years there's been a lot of interest in eXtended Reality (XR) and its potential in military domains. The cutting-edge technology is used to influence public opinion, recruit, train the soldiers, and eventually increase combat warriors' lethality by enhancing their ability to detect, decide, and engage the enemy. The paper addresses some technological aspects of the so-called shadow wars. Deployment of Virtual Reality (VR) and Mixed Reality (MR), two basic components of XR, depends not only on technology maturity but also relies heavily on the human exposed to the completely different immersive stimulus. While accompanied by high profiling of user experience and Artificial Intelligence (AI), XR technologies can change human behaviour. The paper examines what are the possible effects of digital narratives, information embodiment, uncanny valleys, and "virtualisation" of war in the broad context of cultural and technological changes.

Keywords: virtual reality, human factors, ontology of virtual culture, body-spatial experience, quality of experience

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Introduction

After years of research, rapid technological development as well as few discouraging setbacks, extended reality (XR) appears to be on the verge of its broad adoption. The proliferation of XR continues at an amazing pace. The incorporation of XR technology into the palette of new digital media is appealing not only to game designers but is also obvious to artists, educators, and scientists — the professions involved in creating or explaining the reality. Generally, the extended reality's photorealistic quality environments are created to give the impression of "presence" in the three-dimensional sensory space. However, immersion's core experiential phenomenon is very closely related to the stimuli of sight, hearing, and touch.

To create a virtual experience in a highly captivating way, we should balance three crucial elements: cutting-edge technological solutions, psychological/sensual evaluation of the viewer (perception of presence), and the narratives.

Moreover, the extended reality is a medium of (three dimensional) space contrasting with classic "framed" image typical to cinema and games. Therefore it needs new visual language and tools. The relationship between the media and spectator has evolved, which is discussed by Elsaesser and Hagener in their book "Film Theory: an introduction through the senses" (Elsaesser & Hangener, 2015). Focusing on the "reception of the story through senses," the researchers observe increasing interactions between the screen and the spectator's mind, body, and emotions, as well as the distinctive configurations of the senses engaged in varied XR creations. They conclude that in the age of virtual technology, some media-related theories need revision and broadening of the philosophical framework in order to encompass these transformations.

The first part of this paper presents brief definitions of extended realities. Then, the uncanny valley(s) concept is presented with some discussion. The author suggests that some uncanny valley — related issues had already been discussed in the vivid Epoque of the late 19th early 20th centuries. The third part of the paper will deal with the virtualization of war, enumerating the most inspiring cases from recent years — starting from the background models, war games and ending at eye-openers for instigating warfare change, adding value, and promoting killing efficiency through XR technology. XR has been noticed by the military industries, fulfilling the temptation to decrease the number of own casualties drastically. Supporting the idea of cyber warfare has resulted in the development of military XR research and development. Concluding remarks sum up the problem of militarized exploitation of the "virtual space" defined as an emotional XR experience. The paper aims to trigger a discussion on the potential impacts of the "uncanny" marriage of XR and War.

eXtened Reality (XR)

Extended reality is a newly added term to the dictionary of technical words. XR refers to all possible real and virtual connected environments and human-machine interactions generated by computer technologies and mobile devices. Extended reality includes all its descriptive forms, such as Augmented Reality (AR), Virtual Reality (VR), Mixed Reality (MR), and Augmented Virtuality (AVR). All of them have seen significant technological advances in the last few years, but some people can easily misunderstand the underlying concepts. The purpose of this section is to explain what is behind each of these acronyms briefly. Each of these technologies comes from different research fields and is used to do slightly different things. Their common ground is a virtual-real mixture of stimulus and the first-person-perspective of user engagement in digital media. There may also be more hybrid XR solutions. For example, 3D objects and Artificial Intelligence (AI) are evenly important in all XR applications. XR can also serve as a broad virtual expansion of physical spaces, as cities, schools, or museums (Bonis et al., 2009).

Virtual reality (VR) is a fully immersive experience, also known as purely synthetic reality. It refers to computer technology that uses glasses and headsets to deliver realistic stereoscopic images, spatial sounds, and other sensations that replicate a real environment or create an imaginary world. A variation of VR is Cinematic VR, in which we watch (stereoscopic or monoscopic) 360 movies shot with special spherical cameras. Facebook Oculus Rift/Quest,

HTC Vive, and Sony PSVR brought VR to the masses. The capabilities of these technologies, however, extend far beyond creating immersive video games.

Augmented reality (AR) is a direct or indirect view of a physical, real environment enhanced with synthetic elements (computer-generated media such as audio, video, graphics, or GPS data). AR uses your existing reality and adds virtual content to it through some digital device. Smartphones and tablets are currently the most popular AR carriers. Mobile applications place a digital overlay in the image obtained from the camera. Popular examples of AR include Pokemon Go and the so-called Snapchat lenses.

Mixed reality (MR) is connecting the real and virtual worlds to create interweaved new environments and visualizations where physical and digital objects coexist and interact in real-time. Generally, it works by placing new 3D images and objects in real space in such a way that they are interacting to some extent with the physical world as we know it. An example is Vuforia View and applications based on ARKit and ARCore technologies, in which virtual objects do not "levitate" in the air but are "attached" to the surfaces we see. MagicLeap and Microsoft HoloLens add elements to the environment after recognizing not only flat surfaces of the floor or desk but also walls, windows, and any elements of our real-life environment.

Augmented virtuality (AVR). In the AVR environment, augmented virtuality implies that real objects, even the gamers themselves, can be projected into and participate in a virtual world (VR).

Uncanny valley(s)

Extended reality has enormous potential that goes beyond conventional digital media – especially in terms of human beings, our culture, and the surrounding reality. Medical and psychological applications of XR technology can improve the quality of life, bring people closer together, facilitate empathy, and influence social behaviour and interrelations (Hodges, 2001). Virtual reality gives a spectator almost perfect means to identify with the virtual environment in a pure act of perception. In his research in the field of psychoanalysis of media (Cinema), Metz concentrated on the affective dimensions of vision, trying to find an emotional tie that Freud placed at the origin of self-identification (Metz, 1986). Cinema spectators are cut off the real-life and left to themselves, having to rely on their own inner perceptions and emotions. That effect is much stronger as far as VR reception is considered. The immersive, non-framed wide field of view provides the spectator with a level of exploration freedom (s)he has never had before. Additionally, XR platforms enhance the exploration of digital content by engaging a broad palette of senses. However, at some costs, one of them is the uncanny valley.

1. Definition

Generally, the uncanny valley is a hypothesized relationship between the degree of an object's resemblance to reality (in a particular case — to the human being) and the emotional response to such an object. Aesthetics defines an uncanny valley to be "a term used in the scientific hypothesis, according to which a robot, drawing or computer animation that looks or functions similar (but not identical) to a human cause unpleasant feelings or even disgust in observers" (MacDorman & Ishiguro, 2006). The concept was defined in the 70s of the 20th century when the first humanoid robots were constructed. The more they resembled humans, the more they were accepted by humans, but only up to a point where robots with an external

appearance very similar to human beings turned out to be very discomforting or even scary because of the small details indicating their artificiality. This moment was called the uncanny valley. The uncanny valley denotes a dip in the human observer's affinity for the replica, a relation that otherwise increases with the replica's reality. Current examples of the hypothesis can be found mainly in robotics, computer graphics, and lifelike dolls. With the proliferation of extended reality and cinematic/photorealistic computer animation, the uncanny valley has been referred more and more to a reaction to the verisimilitude of the creation as it approaches indistinguishability from reality. The uncanny valley hypothesis predicts that an entity appearing almost real will risk eliciting eerie feelings in viewers.

Figure 1. illustrates this phenomenon graphically; the left axis of the plot represents the observer's psychological comfort/stimuli recognition (likeability of experience). The right axis represents the degree of stimulus realism. At the beginning of the graph, we have a valley of abstraction, where the medium is too simplified to resemble reality or, in other words, is unable to suspend disbelief (e.g., a drawing, abstract Euclidean shapes). With the increase in the level of realism, the acceptance curve also increases and reaches the first peak (for e.g., Trompe 'oeil oil paintings), then it drops drastically (when we become aware of image artificiality and of some impurities/artifacts/glitches).

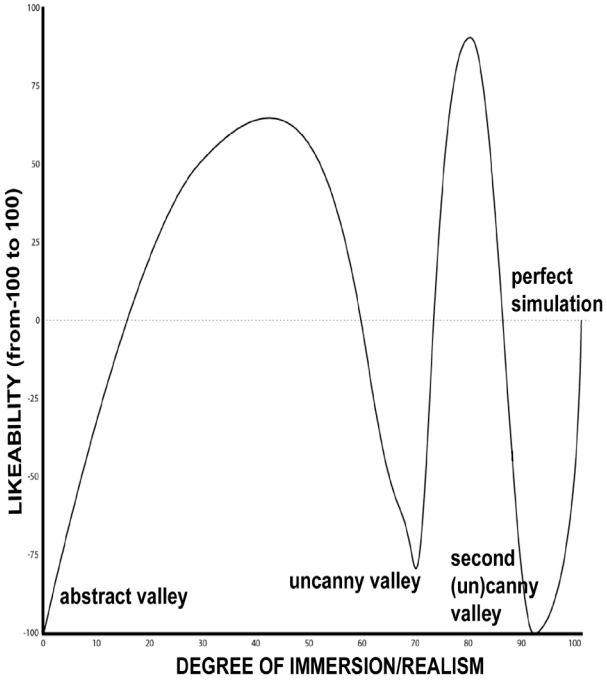

Fig. 1 The uncanny valley and its second instance

What happens next after crossing the uncanny valley, then? According to some researchers, we go straight to the ideal simulation indistinguishable from reality, but another option is assuming other scenarios. A very high level of acceptance of an almost ideal medium is followed by a drastic decline to the second valley of singularities (Mitchell, 2019). Such a situation

occurs in VR environments, e.g., when we come into contact with a "virtual" precipice. We are fully aware that we are in a simulation, but the body/subconsciousness reacts with an atavistic fear of taking a step into a "chasm." In XR, we do not watch someone else having an experience (as in the movies). We do not control the character's experience (as in computer games) neither. In extended reality, we are the medium; we are the one who experiences all sensory experience highly personalized. The second uncanny valley exists in the transitional period between the suspension of unbelief and the inability to suspend faith in the experience, which is not taken as seriously as the surrounding reality. Moving on further, we reach a perfect simulation completely indistinguishable from "real-life" reality. An example may be human faces generated by the GANN artificial intelligence. They are neither beautiful nor ugly. They are simply ordinary. Despite the fact that there are no such people physically, we are completely unable to distinguish them from photos of real people (Karras et al., 2018).

2. Some (subjective) anthropology

We have to be aware that already existing modern technologies can be referred to as century-old artistic concepts. According to Gombrich, early 20th century artists took the revolt against the illusion of the linear perspective and photo-realism of the through-the-lens pictures. Cubism is one of the most radical attempts to redefine our perception of flat pictures. While using all elements of realistic depiction: linear perspective, shading, shadows and texture, cubist artists did not make compositions in harmony but in an attempt to evoke contradictory "uncanny" evidence of perceived space (Gombrich, 1999). On the other hand, expressionists tried to present the surrounding world from a highly subjective perspective, distorting it radically for the highly emotional effect to evoke strong "uncanny" moods or ideas (Baldick, 2008). By modern experience, they strived to have their works evoke all kinds of experiential sensations, not only those visible to the spectator's eye. The Expressionists brought to the viewer sensations of the hassle, paranoia, fear, and even the smell of the metropolis. The most remarkable examples include German Expressionism. The works of Ernst Ludwig Kirchner and Hermann Warm clearly illustrate stylistic techniques and distorted visual qualities exploring paranoia, fear, and schizophrenia. Extended reality seems to perfectly fit the claims of 20th-century artists (Nikiel, 2019). Going back to an earlier epoch, the French literary movement is known as décadence "blossomed" during the nineteenth-century fin de siècle. The movement is characterized by its powerful attraction towards "artificial realities." This attraction takes center stage in the classic text of décadence: Baudelaire's "Artificial Paradises," a description of drug experiences (Baudelaire, 1996). For décadence authors, nature and reality are the archenemies, and they need to be corrected by Art. Baudelaire regards the "artificial" not as a copy (digital twin) of the reality, but as a way to overpower the terrifying chaos of organic life. In one of Baudelaire's prose poems, "Anywhere out of the world," he imagines several worlds — environments in the hope of finding the one that will soothe his hypersensitive soul unable to find a home in physical reality. Ultimately none of these potential travel destinations calms the soul. They are still too much anchored in this world… he vainly looks for "ordre et beauté, luxe, calme, et volupté" (order and beauty, luxury, calm and voluptuousness). In order to reach the worlds where his vision of patterned beauty will be fulfilled, Baudelaire turns towards the unpredictability of drug-induced hallucinations. The drug trip unfolds in three stages, but it is the second stage that truly matters in terms of his futuristic vision regarding virtual reality. In the first stage- a warm-up for the second — the drug user rediscovers ordinary reality and ordinary language through an increased acuity of the senses. In the second stage, he

does this through the enhancement of the mind power. In the third stage, the mind is overtaken by mystical feelings of peace and love. The interesting moment occurred in the second stage when senses were invaded by a "tumult" of images, loosely tying together perceptions with ideas and perceptions between themselves. The abstract becomes concrete, and the concrete elusive. Those descriptions are very similar to some experiences reported by "novice" users of VR (Barreda-Angeles et al., 2020).

Another example is Huysmans's "A Rebours " ("Against Nature"), a one-character novel about an aristocrat Des Esseintes, who literally attempts to recreate reality through Art (Huysmans, 1998). The protagonist's fish tank contains only mechanical fishes (virtual pets). The interior of his house is designed to be seen only in artificial light, and he feeds himself with pills that simulate the taste of haute cuisine. The ultimate triumph of Art is to denaturize nature itself: "After having artificial flowers that imitated real ones, he now wanted real flowers that mimicked artificial ones" (synthetic biology, sic!). From a philosophical point of view, this pursuit of the artificial is much more sophisticated than the purely consumerist obsession of the above mentioned Baudrillard's subject with the hyperreal. Extended reality seems to be the nowadays ultimate dream of Des Esseintes. Des Esseintes's living space was structured as a series of subspaces with different themes and functions (prototype of game levels!), between which he divided his days according to a rigid hourly schedule (gameplay!). Also very contemporary is Des Esseintes's fascination with new forms of nonbinary sexuality, expressing his lust for a sexual coupling of man and machine. We could say he predicted sex robots like those described by (Lee, 2017). Des Esseintes's ideal world ends up as a prison for both mind and body for a very simple reason: there is nothing to do in it. While the body loses its vitality, the mind is overwhelmed by uncanny "currents of emotions," "torrents of anguish," and "hurricanes of rage." Des Esseintes abandons his retreat and returns to the world to rekindle whatever life is left in his exhausted body. As long as he is engaged in the design of his private space, he finds respite from his inner demons, but as soon as a project is completed, he is overcome by the same boredom that drives him out of the world. Although they took opposite routes, Baudelaire's and Des Esseintes's quests for total artificial gratification led to the same state of morbid self-contemplation, the uncanny valley…

"Becoming Virtual," the English title of Pierre Lévy's "Qu'est-ce que le virtuel," is the last example to confirm décadence predictions for the "virtual" future of humanity. The virtual, defined by Lévy, has little to none relationship to all, which is false, illusory, or imaginary. The virtual is by no means the opposite of the real. On the contrary, it is a fertile and powerful mode of substance that expands the process of creation, opens up the future, injects a core of meaning beneath the platitude of immediate physical presence (Lévy, 1998). It conforms to the current ISPR definition of extended reality where XR can be defined by a psychological state or subjective perception in which, despite synthetic stimulation, the user is unable to partially or fully recognize the use of technology in contact with the environment. The environment is observable from a first-person perspective, is stochastic (randomness praised by Baudelaire!), sequential, dynamic and is by nature a continuous process (ISPR, 2020).

No other medium than extended reality can vividly encapsulate you in the space where you cannot estimate the distance. The virtual world around you is so close that you can almost touch it and cannot escape it without breaking the whole experience. The digital image breaks with the core paradigms by turning more to the concept of haptic vision, mainly due to the proximity, tactility, and sense of texture intuitively perceived in the XR.

XR and shadow wars

Shadow wars are a modern type of war were cutting edge (information) technology and plausible deniability eclipses firepower in terms of effectiveness and impact. Instead of sending tanks and soldiers, covert and secret means are used. Along with special forces, mercenaries are used while propaganda gives them plausible deniability. The fog of war is manufactured with all digital (deep fake) means, and then it is exploited for victory (McFate, 2019). This is the "front end" side of technology and military activities. Still, in the "back end," there are far more interesting things happening especially at the edge of human-computer-interaction. Modern AI-powered technologies exploit really important aspect that we are weak and mortal. We live finite lives. A lot of decision-makers are dealing with the tension that this poses to us. On the other hand, machines/computers are not alive and not conscious. Even if we do get computers to make decisions/stimuli highly affecting human life, they do not have the shared human experience, which includes pain and in the extreme situation dying as well as seeing the death of others. Computers will never truly experience painful parts of human existence; however, they can highly influence human behaviour through immersive communication channels invoking conflicts and exploiting human emotions. Conflicts in both real and virtual space are very personal and, as such, are strongly associated with extreme emotions. For instance, the presence of an opponent (including one controlled directly or indirectly by a computer) has the strongest impact on the perception of the place, giving it a new character (simplifying, it brings you to be safe or dangerous places). Developers of games simulating warfare are trying to introduce "virtual noise" in order to reduce the distance in user-enemy interaction, paradoxically offering the opposite of the natural human need to escape from the conflict area in real-life situations instinctively. This raises a number of cognitive issues from the border of culture, sociology, psychology, and computer science. This section presents the concept of an "uncanny valley of death" defined as a combination of space, people, and negative emotions in virtual environments.

1. The (psycho-) technology behind.

Computers do not have emotions nor consciousness. However, we are starting to program machines to understand human emotions (related technology is called affective computing). So far, their understanding of emotions is incredibly impoverished while compared to humans. And so we would have to give computers much richer information. The clue lies in the more intimate nature of the data collected by the additional sensors required to enable XR experiences. To enable even more immersive XR experiences, devices have sensors that not only capture information about the physical world around the user but also capture personal details about the user her/himself and (possibly) bystanders. For example, these sensors could create highly detailed 3D maps of the physical world (either by using underlying platform capabilities like the ability to intersect 3D rays with a model of the world around the user or by direct camera access, so-called Simultaneous Location and Mapping SLAM systems). XR systems can easily find and recognize nearby faces through the numerous inward, and outward cameras typically present on these devices. The infrared sensor that detects when a head-mounted device is worn could eventually disclose more detailed biometrics like perspiration and pulse rate, and some devices already incorporate eye-tracking. A user's height and gait are estimated by the precise 3D motion of their head and hands in the world, which is essential for rendering content from the correct position in a fully immersive experience. Additional

eye-tracking can support natural interaction and allow people to navigate using just their eyes. Access to camera data enables XR applications to detect and track objects in the world, like equipment being repaired or acquired target.

Immersive environments are commonly considered to have great potential to invoke feelings from empathy toward suffering people to enjoyable experiences attractive to wider audiences. Some researchers prove that the immersive presentation of XR contents impacts both empathies towards the characters and enjoyment of the experience and the interplay between these two psychological outcomes (Barreda-Angeles et al., 2020). Emotional models are used to assess and determine XR user behaviour. Examples include OCEAN (Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism), which in the context of XR experiences can be translated into: openness to stimuli, environmental awareness, assertiveness, empathy, and neuroticism (Cobb-Clark & Schurer, 2012). Even a more sophisticated 16PF model is based on a psychometric self-report personality questionnaire developed by (Cattell & Mead, 2008) and is generally used by psychologists for diagnosing mental disorders and planning therapies for individuals (as 16PF offers the ability to measure anxiety and psychological problems). Some researchers showed that the AI-based affective computing architecture could predict emotions with an accuracy of over 80%: warmth, emotional stability, liveliness, social boldness, sensitivity, vigilance, and tension (Gavrilescu & Vizireanu, 2017). Current effective computing methods can predict human behaviour at high accuracy levels and increased personality trait prediction accuracy. In military applications of XR, the emphasis is usually put on the part generally related to neuroticism. The most explored are the "uncanny valley" situations that increase the occurrence of unpleasant feelings, such as anger, anxiety, depression, and susceptibility to any emotional distortions. This may lead to unexpected reactions. There is a well-founded concern that XR designers are not taking such threats seriously. We are talking about not the common dangers of tripping and falling, the dangers of breaking a wall with a controller only about changes in the XR user's psyche.

2. War games.

According to Welsch, games cause suffering to become unreal under the influence of the media: reality "[…] loses weight, is subject to permanent procedures of giving lightness, ceases to be something binding, becomes a game" (Welsch, 1990). This, on the one hand, can shape resistance to stresses resulting from participation in combat and to practice 'dry' tactical operations (military simulators, such as "Virtual Battle Space," "Close Combat Tactical Trainer," "Delta Force: Black Hawk Down," "Full Spectrum Warrior"), and also acts as an incentive for potential recruits ("America's Army"). On the other hand, civilian versions of "The Arma" games (the equivalent of "Virtual Battle Space") or typically "entertainment" productions like "The Call of Duty" are used by terrorist groups as a gentle introduction to "real" combat in their ranks. Jihad was Westernized (Babecki, 2012). Macabre "uncanny" jihad-supporting games such as "The suicide bomber game" have emerged, in which the player's goal is to select the "place" that is most populated and detonate the Improvised Explosive Device (IED) placed on the avatar. The scoreboard rewards women and children killed, and the programmer assigned points to all injuries. The game "September 12" makes the player aware that radicalism is embedded in human life. The game is accompanied by the effects of an explosion and the crying of women and children (Babecki, 2012). The games created by jihadists are the best illustration of the definition of an "uncanny place of conflict,"

combining three elements: space (virtual or real), people (or humanoids, but with clear human features), and a large load of negative emotions combined with violence.

3. Full tactical XR.

Along with the development of new XR interfaces (Oculus, HTC VIVE, or MS Hololens and MagicLeap), intensive work is underway on the use of extended reality in the military. The US Army is currently working on research and development programs to equip its troops with new systems called Tactical Augmented Reality (or T.A.R.), where both tablets and AR glasses are used. By wirelessly connecting a tablet and a thermal sensor on the weapon, soldiers can access the point of view of their weapons so that they can observe and shoot the target while remaining hidden. What used to be SF movies' domain becomes a reality as soldiers use a range of warfare enhancements, including XR. Microsoft received a $ 479 million contract to provide HoloLens glasses for soldiers in active combat zones (Carlton, 2018). The US Army is to receive 100,000 Microsoft HoloLens 2 rugged kits, which will be used to increase the combat effectiveness of soldiers by increasing their ability to detect and destroy the enemy. In addition to the standard equipment, these glasses are likely to be T.A.R.-integrated, equipped with thermal and night vision, the ability to measure the condition of the soldier, including the ability to monitor concussion and protect hearing. The recent research in the military domain of XR includes trialing a new technology that could "fundamentally change how military canines are deployed in the future" — a pair of augmented reality goggles for dogs pairing T.A.R.- equipped soldier with the canine first responder.

The US Army has envisioned using an XR tactical helmet for some time to provide sensor imaging with 3D mapping for better performance in combat conditions and increase the soldiers' ability to move around the combat zone and improve their survival rate during dangerous operations. Virtual reality is used for the same purpose. VR perfectly suits training and tactical simulation preparing soldiers for demanding and complex operations. The two most popular simulations used in training US soldiers are "Full Spectrum Warrior" (FSW) and "America's Army." The FSW was originally intended to be a military training game, the US Army's ground forces have concluded that the FSW is not realistic enough to serve as a training tool. In the meantime, the US Army adopted other training variants using "America's Army," which was primarily developed as an entertainment game for recruiting purposes. The game is designed to convey the information that recruits will learn in basic and advanced training in the real world. In Europe, the British military commissioned a pilot program for "Virtual Reality in Land Training" (VRLT) from Bohemia Interactive Simulations (BiSim), a global manufacturer of military simulation and training software. The goal of this program is to increase the possibilities of future soldier training through the use of VR technology (VRLT, 2019). The system will be able to place soldiers in the middle of an urban shootout, intense crowd control or in a building filled with enemy soldiers. Virtual reality will allow soldiers to quickly set up, restart, and analyze training situations to demonstrate the most effective approaches to real-world challenges on the battlefield. The pilot program will investigate the potential benefits and effectiveness of using virtual reality for the British army's purposes.

The benefits of XR military training are not at all obvious (the above-mentioned case of FSW). Nobody has thoroughly examined the impact that XR can have on humans, although there are some indications (Barreda-Angeles et al., 2020). It is well known that digital environments typically do not test a soldier's ability to communicate over distance, through battle noise, through dust, flashes, and other physical and emotional distortions. Instead, XR

users communicate reliably by voice with other users (commanders) sitting in the same room or via a voice system over the Internet. Finally, digital environments do not use a full spectrum of physical and bio-sensory simulation. It's not just a question of fitness, but the ability to navigate rough terrain. For example, in a VR environment, a user can easily "instruct" to open a door, enter a room, reload a weapon and jump and turn around at the same time, all using the digital controllers. In the real world, such a combination of movement, while enemies are present and constantly prepared for a deadly threat, would look completely different or even impossible. Digital environments also inherently limit user behaviour in unrealistic ways. Deliberate constraints (such as blocked aisles, closed gates, unscaled walls) are built into the digital world to compel users to follow the scenario's linear recommendations. Of course, digital environments can be more realistic, at least at the visual level. For instance, urban combat environments are very difficult to model in the real world because of their scale and complexity; consider something as apparently innocuous as "urban clutter" — the mass of signposts, rubbish bins, rubble, wrecks of vehicles, and unidentifiable debris that litter a real urban battlefield. This urban clutter is very important for soldiers who must navigate it or use it as cover — it's also fundamental to soldiers who must train to identify IEDs, which are often hidden in unexpected places. XR environments can create visually model clutter easily. However, that does not mean that they are actually testing soldiers' abilities to interact with it in any physical or bio-locomotive way.

For some time, it has been possible to populate virtual places with synthetic avatars (Magnenant-Thalmann, 2006); however, XR environments inherently simplify human behaviour. Game design traditionally has emphasized linear scenarios and levels, including interactions with humanoid non-playable-characters (NPCs). While less true of more complex constructive simulations and turn-based games, virtual and real-time simulations tend to be highly linear, stressing fast-twitch responses over force employment. Computer-controlled NPCs offer at best some rule-based ability to interact with user-controlled avatars, interactions little more complicated than returning fire or taking cover. Still, these sorts of interactions are not normally considered "adaptive." Even moderately adaptive behaviour (such as responding to one type of tactic with the most appropriate counter-tactic) is still very burdensome to program and compute.

Conclusions

The potential of extended reality was noticed by the military decision-makers, which prompted the consideration of the use of this technology in various military domains. The underlying Information & Communication Technologies (ICT) are mature enough, but the effectiveness of their use depends very much on the human factors. The impact of virtual media is highly subjective and depends on the perceptual abilities and distinguishing between synthetic and real content. The uncanny valley and it's second, not yet fully explored, instance may cause serious problems both in training soldiers as well as in their operation on the real battlefield. Advances in Artificial Intelligence may further complicate human-computer-interaction. The temptation to hand over certain tasks to computers/machines is very high, and it's clear that this will have profound consequences. We are probably the last generation that knows how to read abstract data before we outsource that to computers: not looking at complex phenomena, not remembering things, and just relying on devices will change us. We already know that some of these processes are physically changing us: the skill of "reading"

and remembering maps increases the hippocampus's physical size, the part of the brain involved in spatial reasoning. If rely solely on GIS and GPS-based "routing" suggestions, the hippocampus is almost idle. We have to be very careful when we outsource more and more of our intellectual activities — we might be giving up something very important. Furthermore, we are not aware of the side effects of extended reality systems. Current events demonstrate the dangers of rampant data processing and misuse of personal data on extended reality devices, and the new kinds of data they generate present an opportunity to further misuse. XR with AI-driven technologies might not only help us amplify our skills, they may also change us (degrade) without our notice…

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