Empathic Predators

On the Affects and Optics of

Brain-Computer Interface Unmanned Aerial Vehicle Research

Submitted for the degree of Doctor of Philosophy in Anthropology

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Abstract

Empathic Predators is a philosophical anthropological inquiry concerning the dual use problem with relation to brain-computer interface research and technology. The thesis makes use of scientific papers as qualitative data, by taking literature on brain-computer interface unmanned aerial vehicle (BCIUAV) research as its anchor. A small number of digital interviews with BCI researchers were also conducted. The dual use problem involves research, technology, and artefacts with an ambivalent moral valence, in terms of the uses to which they can be put; crucially, where one of the uses entails weapons innovation. In BCIUAV research, the problem is represented by the juxtapositioning of the proposals for future uses of the BCIUAV as an assistive technology for people with disabilities, and as an electronic neuroweapon for combat. The conceptual and normative basis for the approach taken to dual use is found in the work of philosopher John Forge, and the cosmopolitan anthropology of Nigel Rapport. The research and technology are examined over several chapters, and special attention is eventually paid to the ways authors of some BCIUAV research papers figure bodies of future users in their texts. Speculative analyses are conducted concerning the way in which some figured bodies might function as morally persuasive optical devices, manipulating the reader's perceptions of the research and technology in question. The thesis flows towards a consideration of the Human Right to Life with relation to knowingly dual use and weapons research, but also with relation to the practice of anthropology itself. It is argued that knowingly dual use and/or weapons research constitutes an indiscriminate threat to the Right to Life of Anyone and is thus a fundamental contravention of cosmopolitan politesse; and that a justifiably moralizing anthropology, capable of critique and intervention can be founded on respect for the Human Right to Life.

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List of Acronyms[1]

ALS – amyotrophic lateral sclerosis
ARL – Army Research Laboratory
ARPA – Advanced Research Projects Agency
BCI – brain-computer interface
BCIUAV – brain-computer interface unmanned aerial vehicle
BP – Brain Painting
CLBCI – co-learning brain-computer interface
CLIS – completely locked-in state
DARPA – Defense Advanced Research Projects Agency
DRDO – Defence Research and Development Organization
ECoG – electrocorticography
EEG – electroencephalography
EOG – electrooculographic
EMG – electromyographic
fNIRS – functional near-infrared spectroscopy
HALE – high-altitude long-endurance
HMD – head mounted display
IEEE – Institute of Electrical and Electronics Engineers
ISD – idle state detection
KDU – knowingly dual use
LIS – locked-in state
LRT – likelihood ratio test
MI – motor imagery
N3 – Next Generation Nonsurgical Neurotechnology Program
NWR – neuroweapons research
OC – operant conditioning
PTK – position to know
PWD – people with disabilities
SSVEP – steady-state visually evoked potential
sUAV – small unmanned aerial vehicle
UAV – unmanned aerial vehicle
UCD – user centred design
UDHR – Universal Declaration of Human Rights
UDU – unknowingly dual use
VEP – visually evoked potential
WR – weapons research

[1] For the reader's convenience this list includes key acronyms only, and not every single acronym cited in the text.

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Thanks to the participants who gave interviews which I used in the thesis — Professor Andrea Kübler, Dr Jane Huggins and S5 (pseudonym) — but also to Marta Molinas and Ivan Villegas whose comments I did not make use of in the thesis.

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In memory of

Professor Marcus Banks (1960 – 2020)

Introduction

1: To Begin

A brain-computer interface (BCI) allows for human brains to be connected to computers. Brain signals, electrophysiological or metabolic, are detected by an electrode array implanted into cortical tissue, or non-invasively via an electrode or optode cap. The computer processes the detected signals to improve their clarity, distinguishing salient features from unwanted noise. They can then be used as inputs for an external prosthetic device for communication or control: a speller, a robotic limb, or, as it happens, an unmanned aerial vehicle (UAV) or 'drone'.

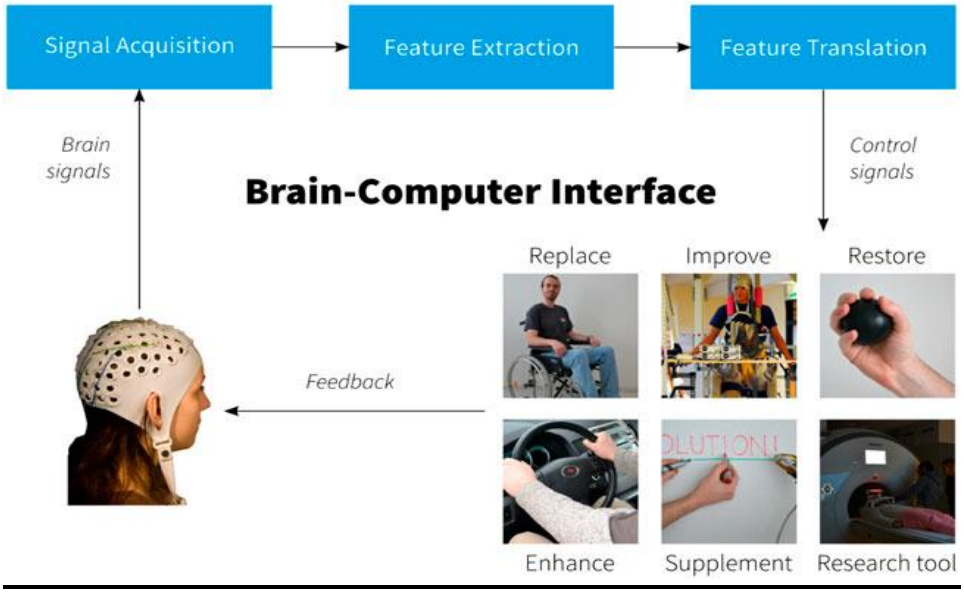


Fig 1. ' Principle of a brain-computer interface including possible application scenarios' (Brunner et al. 2015:3 https://creativecommons.org/licenses/by-nc-nd/4.0/)

This thesis concerns the research and development of (non-invasive) brain-computer interface unmanned aerial vehicle (BCIUAV) technology from 2010 to 2021, and importantly, some of its possible futures. The core materials which my research analyses are a set of 84 papers —which includes journal articles, conference papers and two

master's theses. In the thesis I focus on a subset of papers that highlight pressing issues associated with the research and technology, (a full chronological list is given in Appendix 1). Practical research involving BCIUAV technology has been done by teams based in 19 countries: Colombia, Brazil, China, Denmark, France, India, Japan, South Korea, Malaysia, Mexico, Norway, Peru, Poland, Portugal, Romania, Singapore, Taiwan, UAE and USA. Four relevant review papers dealing either solely or in part with BCIUAV technology come from teams of scholars based in the Netherlands and the USA (Nourmohammadi et al. 2018), USA (Tezza and Andujar 2019), Finland (Hekmatmanesh et al. 2021), and China (Zhang and Wang 2021). In addition, I have conducted a small number of online video interviews. Efforts were made to contact the researchers behind every paper in the BCIUAV research bibliography.[2] The response rate was very low indeed. Only three interviews conducted have been with a member of a team who worked on BCIUAV technology, and one was with a researcher who supervised a master's project on it. I also contacted some BCI researchers not involved in BCIUAV studies. Several interviews have been conducted with one eminent BCI researcher of a clinical orientation, with whom I plan to collaborate on future research.

Here I introduce the reader to the topic of BCI (which is new to anthropological research), Chapter 1 then reviews anthropological literature on drones — the military use of drones, in fact. In Chapter 2, I outline the theoretical and conceptual framework, methodology, methods, and central research aims and arguments of the thesis. Only then, at the end of Chapter 2, am I in a position to outline the rest of the chapters.

[2] With the exceptions of Martinez-Ledezma et al. (2020), Belkacem and Lakas (2021), Dumitrescu et al. (2021), Ramos et al. (2021), whose papers I found in late 2022, and thus too late to contact them within the time period of my research.

2: **BCI: An Open Question for Anthropology**

To the best of my knowledge, only two anthropologists have ever even mentioned BCI in published works. Stefan Helmreich (2013), elements of whose article I use below, mentions BCI as part of an exploration of 'the material and rhetorical power of electrical potential in cardiac and neurological medicine' (2013:139). Taking a turn of phrase from American poet Walt Whitman (1819-1892), Helmreich proposes 'the body electric' (the electrophysiological body) as an anthropological frontier of particular contemporary importance, urging others to explore 'the practices and descriptions that render (electrophysiological phenomena) knowable and visible' (2013:139). Helmreich spends less than half a page on BCI, which, is the most extensive discussion of BCI anywhere in anthropological literature before my own.

The anthropologist-cum-philosopher Fernando Vidal (2020) also mentions BCI during a discussion of the 'phenomenology of locked-in syndrome'(LIS), a paralyzing condition of the human body which I investigate with relation to BCI in Chapter 4 and to a lesser degree in Chapter 3. Vidal is also light on BCI as his focus in on LIS itself, but due to the close historical connection between the syndrome and BCI technology, he writes that '(t)he greatest hope for completely locked-in persons resides in the development of BCI' (2020:124) — pointing to the latter's crucial role (albeit still in progress) in helping patients communicate via non-muscular channels — which as I discuss later, has shown great promise for locked-in patients, but has not yet been provably achieved for *completely* locked-in patients. In sum, the state of literature suggests that at present BCI is very much an open question for anthropology.

3: Electroencephalography and the Emergence of BCI

The vast majority of studies that aim to control UAVs with BCI use a method called electroencephalography (EEG). Using electrodes positioned on the scalp, EEG is a non-invasive way of recording variations of electrical potential in brain tissue, as 'chains of ions leap from one neuron to another in an electrical current' (Helmreich 2013:143), which can occur in thousands of neurons at once across regions of neural tissue corresponding to, for instance, motor intention, sensory stimulation, or oscillations specific to a neuropathology.

It is the oldest form of neuroimaging, first appearing as an analogue graphic method which expressed the activity of the brain using an ink stylus and paper. Nowadays EEG is thoroughly digitized. German psychiatrist Hans Berger invented EEG in 1924, first publishing on it in 1929 — discovering what came to be called the 'alpha rhythm' of the brain, between 8 and 13 Hz, associated with a restful state and closed eyes in the subject. After initially being ignored by the neurophysiology community, Berger's published work was picked up several years later by E.D. Adrian at Cambridge University, who on replicating Berger's experiments and 'finding the alpha rhythm almost at once' (Adrian quoted in Borck 2008:371) confirmed a continuous electrical activity at work in the brain. A conception of the nervous system emerged that 'now reverberated literally around the concept of intrinsic electrical activity.' (Borck 2008:372).

The burgeoning array of techno-graphic methods in physiology of which EEG was a variant, contributed to an increased sense of objectivity in the life sciences in the early 20th century broadly. These methods built upon, among others, the pioneering work of inventor Jules-Etienne Marey (1830-1904), which in the 19th century had led to the development of the 'cardiograph, plesmyograph, [and] sphygmograph' (Borck 2008:368) — all ways of recording *by inscription,* physiological processes that cannot be accessed as sensitively, or

at all, by the technologically unenhanced human sensorium. In so doing, these new techno-graphic methods solved the problem of inaccessibility *and* translatability between the phenomena being observed and human language. Electroencephalography, in its 'strange and direct correlation to mental processing' (2008:367) produced a kind of 'brainscript' (Finkler quoted in Borck 2008:368). The language of nature as spoken by chattering neurons, expressed through fluctuations in electrical potential in the brain over time, was rendered in graphic inscriptions that could be interpreted by electroencephalographers. At once perceived as a natural language derived from the very impulses 'anchoring the cultural fabric of human activities in the world of the biological' (Borck 2008:370) and a powerful symbol for the future of science, technology and medicine: a potent nature-cultural straddling was performed by EEG, and indeed, what came to be called the 'brain waves' recorded by it. Here we are concerned with how, via EEG, brain waves are transformed into 'technical objects' (Helmreich 2013:140) as seen in the later development of the brain-computer interface, for *communication* and *control*.

In the 1960s, digital electronic computers reached a stage of maturity that allowed Thelma Estrin (1965) at the University of California Los Angeles (UCLA) Brain Research Institute (BRI), to work out a method of digitizing analogue EEG signals, thus developing the earliest computer system for BCI (Kübler 2020:164). However, at this time 'controlling devices with brain waves was considered pure science fiction' (Graimann et al 2010:1)

The first publication detailing the successful implementation of an EEG-based BCI system was by J.J. Vidal (1977, see also 1973) also based at the UCLA BRI. In this system, Vidal used sensory event related potentials (ERPs) — '(r)esponses … elicited by visual, auditory, somatosensory and olfactory stimuli…most prominent at short "latencies" (e.g., within 50 to 150 ms)' (1977:634). In this case electrophysiological responses to visual stimuli were used, which allowed the subjects to control a symbol on a screen, their

task being to navigate a course through a maze using the four commands available to them (up, down, left, right). The symbol in the maze demonstrates a fundamental property of all BCIs: 'the display of the brain signals of interest to the end-user in real time' (Kübler 2020:165), which is thus a form of 'neurofeedback' (ibid:167) allowing users to observe the progress of their efforts to control some kind of application.

Progress in BCI research was slow, however, and it wasn't until 1988 that Farwell and Donchin (1988) used visual ERPs called P300s (so called because the electrical positivity (P) occurs 300ms after exposure to sensory stimulation) (Kübler 2020:169)) to create a spelling device, tested with two healthy people, and with which 'characters [could] be communicated with reliability at the rate of 1 character every 26 sec, or 2.3 characters/ min.' (1988:521). In other words, very slowly.

It wasn't really until the 1990's —when there was still only 'around one publication [on BCI] per year' (Kubler 2013:2001) — that modern BCI began to emerge. A seminal moment occurred when Birbaumer et al. (1999) developed a BCI spelling system using slow cortical potentials (SCPs). These are negative and positive 'direct current (DC) shifts of the EEG' (Kübler 2020:170) seen emerging between a warning stimuli and imperative stimuli (e.g., to raise one's right hand). Significant negative DC shifts occur in the brains of epileptic patients during seizures. Neuro-feedback research with epileptic patients which involved training them to modulate their brain states by means of real-time EEG monitoring, in order to lessen seizures when they detected the warning signs, had demonstrated that SCP activity in not just one, but two distinct regions of the brain could be modulated by subjects (either inhibited or excited). BCI researchers recognised that if this control could be mastered, it afforded what could be modelled as a binary choice in a BCI system, and thus could afford yes/no communication, and further, as in Birbaumer et al's system, to control a cursor on a computer screen to select letters of the alphabet.

However, Birbaumer et al's (1999) work was ground breaking not so much due to the use of SCPs, but rather because the spelling system was developed specifically for and successfully used by two paralyzed, 'locked-in' patients with amyotrophic lateral sclerosis (ALS), demonstrating the huge potential of BCI technology for people with severe disabilities who may not be able to use normal muscular outputs (see Chapter 4). Twenty years ago, Wolpaw et al. (2002) wrote that this was 'both the impetus and the justification for current BCI research.' But this is not all BCIs can do or are said to be for. As we will see, they are also now posed as being relevant to healthy users, a 'change of focus' (Zander and Kothe 2011:2) that began around the year 2000 as more groups began working with BCI internationally.[3]

4: Fantasy to Reality

In 'Toward Direct Brain-Computer Communication'(1973) the paper that outlined the work being undertaken at the Brain-Computer Interface Project at UCLA, which led to the first published BCI study in 1977, Vidal speculated as to the possibilities afforded by BCI:

> Can these observable electrical brain signals be put to work as carriers of information in man-computer communication or for the purpose of controlling such external apparatus as prosthetic devices or spaceships? Even on the sole basis of the present states of the art of computer science and neurophysiology, one may suggest that such a feat is potentially around the corner. (1973:157)

Almost thirty years later, the theme of airborne neuroprosthetics appears again in a widely referenced introductory overview paper, 'Brain Computer Interfaces for Communication and Control' by Wolpaw et al. (2002):

[3] Wolpaw et al. (2000) wrote in their review of the first International BCI Meeting that took place in 1999, that '(i)n 1995 there were no more than six active BCI research groups, now there are more than 20.' Graimann et al. (2010:2) wrote that there were 'at least 100 BCI research groups active today', and at the Seventh International BCI Meeting in 2018, over 200 research groups were represented (Huggins and Slutsky 2019).

> the reality does not yet match the fantasy … BCIs are not yet able to fly airplanes and are not likely to be doing so anytime soon. Present independent BCIs in their best moments reach 25 bits/min. For those who have no voluntary muscle control whatsoever or in whom remaining control (e.g., eye movement) is weak, easily fatigued, or unreliable, this modest capacity may be valuable. (2002:778)

Even at their own time of writing, Wolpaw et al. temper Vidal's early optimism on the subject. But, in fact, it would be less than a decade after Wolpaw et al's remarks that this science fiction would, at least to some degree, become reality, with the international development of BCIUAV technology since 2010. In Chapter 3, I will review BCIUAV studies published between 2010-2016 and will then in subsequent chapters focus on a few special cases beyond that time period, which highlight crucial themes around which the thesis revolves. The themes in question concern firstly BCIUAV technology's own militarized trajectory, which leads onto the broader theme of the (advertent or inadvertent) creation of weapons involving BCI technology (BCI type neuroweapons), and thus also the creation of weapons in general.

5: Money Trouble

Vidal's (1973, 1977) pioneering work was funded by the National Science Foundation (NSF) the Advanced Research Project Agency (ARPA) of the US Department of Defence (DoD), and the US Air Force Office of Scientific Research (AFOSR), the latter being the basic research arm of the US Air Force Research Laboratory (AFRL). While the NSF funds a wide range of non-militarily relevant projects, it also funds those that have national defence implications. [4] ARPA was the precursor of today's Defence Advanced Projects Research Agency (DARPA). DARPA continues to fund BCI research (see Miranda et al. 2014)), as does the AFRL (Jordan 2020)[5]: both military funding sources. I consider the

[4] https://www.nsf.gov/about/glance.jsp (https://perma.cc/4BJT-85FE)
[5] https://www.afrl.af.mil/News/Article/2327617/afrl-neurotechnology-partnership-aims-to-accelerate-learning/ (https://perma.cc/BP56-S6XQ)

significance of such funding sources for scientific research in Chapter 2. In any case, it is hard to avoid the conclusion that the Brain-Computer Interface Project at UCLA was from the very beginning, militarized — and may never have come to fruition without military support. Which is not to say, however, that this kind of funding arrangement has been or is the norm in BCI research historically or today. As noted earlier, historically BCI has a very strong connection to beneficent research aimed at helping severely disabled people, who 'were until recently the main, if not exclusive target of BCI research and development.' (Kübler 2020:171)

Nevertheless, it is interesting to know that over the course of the International BCI Meeting series (now organized by the BCI Society, the major international professional organization for BCI researchers formally established in 2015) alongside a range of health-related funding sources (e.g., Eastern Paralyzed Veterans Association, National Institutes of Health) there has been US military money periodically involved. At the second and third meetings in 2002 and 2005 (Vaughn et al. 2003,Vaughn and Wolpaw 2006) DARPA was one of the financial supporters of the attendance of students and postdoctoral fellows. The US Department of Defence was one of the sponsors of the entire fourth meeting in 2010 (Vaughn and Wolpaw 2011). The event sponsors information for the sixth meeting in 2016 is no longer available online, but a workshop titled 'Understanding state change and its impact on BCI performance' was co-sponsored by the Office of the Secretary of Defence Autonomy Research Pilot Initiative, and the US Army Research Laboratory (ARL) (Huggins, Müller-Putz and Wolpaw 2017). Military money appeared to be absent from the seventh meeting, but one of the funding officers giving presentations to BCI researchers was Dr Al Emondi, head of the Next Generation Nonsurgical Neurotechnology (N3) project at DARPA (BCI Society, Program of the 7th Meeting 2018). Finally, the eighth meeting, while not sponsored by military money as a whole, saw one workshop

‘Biomimetic approaches to restore somatosensation’ part sponsored by DARPA, and another ‘Brain-Computer Interfaces for human enhancement’ sponsored by the US Department of Defence (Huggins et al. 2022). This all suggests that some members of the BCI Society are either in a *position to know*, or actually *know* about the dual use possibilities of BCI technology, also with relation to specific applications and projects (see Chapter 2). However, to my knowledge, from my readings and speaking to BCI researchers themselves, there has not yet been a serious public discussion about this kind of funding for BCI research, nor more broadly about the implications of conducting research — whether militarily funded or not — that poses known/knowable risks of weapons innovation. I discuss this further in Chapters 2, 6 and 8. In the specific case of the BCIUAV, it is really the UAV or ‘drone’ element that signals the contemporary and future weaponization of the technology, for ‘drone power… is always becoming-violence, held in the potential of the performativity of killing.’ (Fish and Richardson 2021:15). And so, in the following chapter, the anthropological literature on military drones is reviewed.

1: Anthropological Literature on Military Drones

1.1: Introduction

This chapter reviews the anthropological literature on military drone use.[6] Without exception, this literature addresses military drone use by the United States of America. While cursorily mentioning a number of other targeted countries, Afghanistan and Pakistan, (where there have been more drone strikes than anywhere else) receive most attention. The literature is thus focused on the 'war on terror' prosecuted by the US and its European allies since 2001, where 'terror' concerns the threat fundamentalist militant Islamists pose to the security of the West. The literature deals mainly with high-altitude long-endurance (HALE) drones, thousands of which have been in use by the US Air Force for over two decades, and which carry highly destructive 'precision' ordnance for aerial strikes. Some authors mention other, smaller types of drone, but only when making predictions about the future of military drone use. I conclude the chapter with a short commentary on key themes that emerge, and explain why on a number of counts, the work done in this thesis — where it relates to military drone use, and indeed, beyond — is unlike the literature reviewed and therefore innovative with relation to it.

1.2: In the Shadow of Death

In the most recent contribution at my time of writing (Oct 2022), Fish and Richardson (2021) emphasise that the drone, or unmanned aerial vehicle (UAV), has uses in policing, humanitarian and conservation efforts — although this is far from an exhaustive list. But despite their attempts to highlight the 'non-war' (2021:3) applications of drones, they

[6] Found by searching across the Oxford Library catalogue (SOLO), Scopus, and Web of Science for: ANTHROPOLOGY (AND) DRONE* (AND) MILITARY

admit that the widespread military use of drones 'colours the performative potentials of conservation, securitizing and humanitarian drones. As less developed and financed infrastructures, these drone genealogies remain in the discursive shadow of the war making drone.' (2021:15). It is the trajectory of 'militarization' (2022:13) that this chapter (and this thesis where it is entangled with drones and beyond) is concerned with. As Fish and Richardson, along with other contributors, remark, the military drone as it has appeared so far, is a continuation of air power in the interests of colonial domination. However, as we will see, drone technology is framed by neo-colonial military powers as a more humane way of killing that purportedly avoids mass civilian casualties caused by less discriminate methods of aerial bombing. Even were this claim borne out in reality, the drone 'does so only through the capacity to render anyone, anywhere, killable' (2021:13).[7]

1.3: Early Developments: World War 1 - 2001

Gusterson (2016:8-13) summarises the history of military drone development. Radio controlled bomber drones first appeared in WW1, but due to teething problems, became a way to provide British troops with a means of realistic target practice. The US military followed suit, testing bombing drones that required a pilot to achieve take-off, who would then parachute out. However, the latter were bombing drones in the sense that they were in themselves bombs, designed to explode on impact with targets, and thus precursors to contemporary loitering munition drones.[8] Radio controlled B-17 bombers were later deployed to take samples from nuclear mushroom clouds at test sites in the US where piloted aircraft were unfeasible. They emerged again in the Vietnam war for surveillance

[7] I will reconsider this phrase in Chapter 7.
[8] Iranian made loitering munitions are currently being used to destroy civilian targets in Ukraine by Russian forces.

purposes over enemy territory. Israel had used drones in the Yom Kippur War (1973) to draw the fire of Egyptian missile batteries, which then revealed the locations of the latter so they could be destroyed by manned bomber aircraft. Iran armed rudimental drone aircraft with grenade launchers against Iraqi forces in the 1980s, which Gusterson thinks was 'the first combat use of a drone (2016:11). However, it was Israeli technologist Abraham Karem who designed the now infamous MQ-1 Predator drone — a HALE-UAV — during the early 1990s while working for the American arms company General Atomics. The Predator was first used by the United States Military in 1995 in the Balkans conflict, initially only for surveillance. The first armed version was deployed by US forces in 2001 as the 'war on terror' began (see below). It is HALE drones such as the Predator and its descendent the Reaper that the literature here addresses.

US drone operations are conducted via a 'remote split' (Elish 2017:1101) (see also Elish 2018) configuration in which the operator is seated in a trailer on an airbase within the United States, while the drone itself is located in another country entirely. The remote split operation contributes to the expansion and proliferation of the sites from which war is fought and profoundly blurs the distinction between civilian and military spheres. Nevertheless, **'**the military labor [sic] of drone operations bears increasing similarity to other forms of contemporary civilian work, characterized by the language of compensation, flexibility, and in/security, and indicating a reconfiguration of the dimensions and implications of military work.' (Elish 2018:123). However, there are also up to two hundred other personnel involved in the operation, some deployed nearer the drone's flight zone, and others in the US. These personnel operate the drone's sensors, perform data analysis, aircraft maintenance, aspects of flight and weapons system control, provide legal advice and plan operations.

From a science and technology studies perspective, Elish recognizes that the remote split as described is not a necessary feature of drone technology, which begs the question as to how it became standard practice. She argues that by studying the 'networks and infrastructures that create, sustain and authorize drone operations' (2017:1103) and the distributions of labour within what is a complex *system*, we can move away from 'hardware centric'(ibid) analyses which otherwise might privilege a narrative premised on the idea that the way the technology is deployed now was an inevitability determined by the properties of the technology itself. To this aim, Elish identifies three moments in US military history where particular logics emerged that can be seen to have led to the remote split configuration becoming standard practice.

During the Vietnam War, a team of scientists devised an 'electronic barrier' (2017:1107) to cut off the Ho Chi Minh Trail used by Vietcong across neighbouring Laos. Movement sensors airdropped into the jungle would transmit information to a fleet of helicopter gunships circling above. Information was transmitted by the gunships to a covert base named 'Task Force Alpha' (TFA) in Thailand. Coordinates of suspected Vietcong activity were then passed to bomber aircraft. The statistics generated by TFA 'created the illusion of mission success' (2017:1108) for a campaign that failed in reality. Many of the assumptions upon which the project was built were flawed, not least the figure of 'an unthinking and self-contained enemy' (2017:1108) up against infallible sensing technologies — called into question when the Vietcong devised ways of fooling the sensors. Further, many sensors failed on their own due to environmental pressures. Despite these problems, this was a crucial time in terms of US military thinking that would have ramifications for future wars. Amidst the new technologies and the logics that enabled them, a 'closed world discourse' emerged, concerning 'the practical construction of central real-time military control systems on a gigantic scale…[but also] the metaphorical

understanding of world politics as a sort of system subject to technological management' (Edwards quoted in Elish 2017:1108).

In the Gulf War era, new discourses concerning the (massively exaggerated) precision of US developed munitions such as laser guided bombs, took hold. In a similar vein to the closed-world discourse that emerged with TFA and building on technological developments that followed: the US DoD's new doctrine 'Revolution in Military Affairs' involved 'sensory networks…information networks…within the joint force…and "precision weapons" [that] would allow more effective and efficient lethal effects.'(Elish 2017:1110). The idea was that along with the intelligence from sensor and information networks, precision guided weapons would allow 'a more "just" form of war' (ibid) that spared civilians and increased the acquisition of enemy targets.

The Balkans Conflict, which saw late intervention by NATO in 1995, marked the first use of the MQ-1 Predator, deployed by the US Air Force. Operated from a ground station in Kosovo, the Predator was only used for surveillance at that time, with live video feeds from the drone streamed to the USA. However, during that decade the US military had been testing armed versions of the Predator on US soil. They also began experimenting with a more extreme remote split configuration in which the ground control station with the pilot was located in Germany, while the drone itself was on another continent. In the days following the attacks on the World Trade Center by Al Qaeda on 9/11/2001, these experiments came to fruition in the context of the US military's mission to hunt and kill Osama Bin Laden. The Predator drone equipped with Hellfire missiles was put into action, and in the radical remote split configuration that would spell a new era of drone warfare, was operated by Air Force officers in plain clothes from CIA Langley, 'demonstrating a commitment not only to secrecy but also to perceptions of legal and legitimate action' (Elish 2017:1116).

1.4: Later Developments: Drones in the War on Terror — 2002 and beyond

Jeffery Sluka (2013b)[9] argues that key to understanding the presence of drones in the contemporary battlespace is the concept of 'virtual war', which 'involves the abandonment — perhaps total — of face to face combat, in favour of wars fought from safe shelters hundreds and even thousands of miles away from the "actual" battlefield.'(Mosely quoted in Sluka 2013b:172) In this definition lies a crucial assumption concerning a trajectory in the history of weapons development motivated by the desire to eliminate close proximity between combatants (cf. Gusterson 2014 below) 'which began with the first thrown implement' (Moseley quoted in Sluka ibid). Over millennia, weapons that afford combatants the ability to wound and kill their opponents from a distance have been repeatedly designed. The bow and arrow and the catapult have eventually been superseded by cannons, rifles, machine guns, intercontinental ballistic missiles, and manned bombing aircraft — all solutions to 'the age-old military problem of hitting something from a distance' (Lindsay quoted in Elish 2019:1111). Now unmanned bombing aircraft that completely eliminate physical risk to the operator dominate the battlefield.

In 2013 (Sluka's time of publication), the US counterinsurgency (COIN) campaigns in Afghanistan and subsequently (albeit unofficially and covertly) Pakistan were failing. The US was suffering heavy losses at the hands of the Taliban, who were expanding their own forces and reach — controlling seventy two percent of Afghanistan by 2008. In a replay of the failed 'hamlet strategy' (2013b:173) deployed in Vietnam, US Forces withdrew troops from rural areas of Afghanistan and refocused them in urban centres. They then increased drone strikes in the sparsely populated rural areas.[10] In 2009, the US pressured the Pakistani military to embark on a COIN campaign in the Federally Administered Tribal

[9] See also Sluka (2011, 2012, 2013a) for shorter versions of the same essay.

[10] This looks like an example of how 'pure' drone warfare can happen even in a country with whom the US are at war (see Gusterson 2016 below)

Areas (FATAs) bordering Afghanistan, where many Afghanis had fled after the war began. Simultaneously, the CIA escalated drone strikes on targets in the FATAs that had been in progress for several years already. Although the Pakistani Government was publicly protesting US drone strikes in its territories, it had given permission for them to go ahead after making a secret bargain with the CIA, in which the latter would hunt down the militant and political irritant Nek Mohammed, as the cost of allowing the US to operate drones against its own targets in Waziristan (Gusterson 2019:581), a large territory in the southerly FATAs.

From a 'top-down perspective' (Sluka 2013b:186), as well as bringing the advantage of physical protection to US operatives (and thus playing well with the American public's reluctance to see troops return home in coffins), drones have been lauded as precision weapons that spare civilian lives and only target specific individuals. Further, it is argued by proponents of drones that the presence of military lawyers in the 'kill-chain' (Gregory 2011) ensures adherence to Laws of Armed Conflict. NATO protocols enforce high-level approval for strikes that risk many civilian lives, which can therefore be halted if the cost in lives is too high. However, the 'hype is sheer fantasy, if not literally science fiction. There have been *many* mistakes…drone strikes have caused thousands of civilian casualties and have a particular affinity for hitting weddings and funerals' (Sluka 2013b:182). Thus, from a 'bottom-up perspective' (2013b:186) — that of the people being bombed — drones are the flagship weapon of a brutal state terror campaign that kills innocent people in droves. Drone strikes also contribute to wider deleterious effects on the health of populations beyond the direct killing of civilians. Drone strikes and polio eradication campaigns (PECs) are both international interventions aimed at eradication of a 'perceived threat (poliovirus or militant fighters)'(Closser and Colburn 2019:58). Thus, although they are not connected and have radically different aims and effects: in the minds

of locals, drone strikes have become entangled with internationally funded PECs. Leaders in Afghanistan and Pakistan deploy 'demand refusals' (2019:66), refusing PECs until their demand that drone strikes stop is met. This might seem unreasonable to entities funding PECs, but the fact remains that '(p)olio infects one child in a million, but hundreds of Waziri women, children and elders have been killed in these strikes' (Nasruminallah quoted in Closser and Colburn 2019:65). However, PEC officials have no power over strikes. The demand refusals do not have the desired result but unfortunately do contribute to the continued presence of polio.

The effect of drone strikes in Afghanistan and Pakistan has been to ferment anti-Americanism, recruit more militants than they ever manage to destroy, and increase resistance to occupying forces. Further, when no chance of reciprocal violence is available to those being bombed from the air, drone strikes eventually provoke terrorist attacks in the drone-using countries. By causing so many civilian deaths 'the United States has lost the battle for hearts and minds in the war on terror (Sluka 2013b:175). Sluka (2013a:94) quotes Faisal Shahzad who attempted to bomb Times Square in 2010, as saying: 'When the drones hit, they don't see children, they don't see anybody. They kill women, children, they kill everybody…I am part of the answer…I'm avenging the attack.' The effects of drone strikes appear to be counterproductive, if in a vicious circle they perpetuate the very problem they claim to be trying to solve. Here, Sluka makes a link between anthropological analyses of magical thinking in witchcraft societies and the flawed logics of US military strategy by which drone strikes are continually justified. As with the logic of witchcraft in which contradictory evidence is ignored when discerning the causation of unfortunate events, in the continuation of drone strikes we see:

> a fatally flawed military theory touted as the apex of reason but in fact based on misapplied social science and flawed thinking — that is, unreason —emerging in a context of social conflict where reason has failed. (Sluka 2013b:191)

Gusterson asks his readers to 'imagine the potentially transformative effects of drones on warfare as an arc' (2014:195-196) which is only just beginning to ascend: highlighting four ways in which HALE drones have and might change the nature of warfare. However, he avoids technological determinism that would portray the drone as 'a sort of independent force that acts upon society, forcing changes in norms and institutions. It is rather a process of the kind that Sheila Jasanoff has described as one of "co-production," in which norms, institutions, and technology interact with one another to co-produce a new military sociotechnical ensemble'(2014:196).

Referencing Homer's *Iliad*, Gusterson describes the scenario of 'archetypical combat' (2014:191) where equally matched warriors using the same low-tech weapons (swords, shields etc) fought in each other's egocentric space, face-to-face. This was symmetrical warfare, where neither party to combat had an unfair advantage. Fast-forward to the twenty-first century where HALE drones have been deployed by the US against targets in Afghanistan, Pakistan, Yemen, Somalia, Iraq, Libya, Syria and the Philippines. The relationship between combatants, who are now best described as targeter and targeted, could not be further from archetypical combat. Indeed, there is a question as to whether this relationship can even be described as 'combat', and moreover, whether the violent relation between parties can even be described as 'war'. Drone 'warfare' is 'radically asymmetric' (2014:193) in terms of the violence inflicted by targeter upon the targeted. The asymmetry extends to another crucial dimension of the operation of drones, in that the targeter can observe the target for extended periods of time from the onboard cameras before pulling the trigger, and must also watch the aftermath of the devastation they cause (see below). For the targeted, this represents a cowardly method of massacre, which they may never see coming. With the remote split operation the battlefield has become global. The drone operator's domestic life melds with the virtual war he wages on often nameless

foreigners. This poses vexing questions for military ethics, until now premised on the state of the 18th century battlefield in which fighters and civilians were easily distinguished, and where combatants 'mutually occup[ied] a distinct physical space' (Ryan quoted in Gusterson 2014:198) designated for war. Killing with drones might now be a relatively easy, dehumanized affair — morally inferior, thinks Gusterson, to the scenario of the 18th century battlefield — although 'aerial bombing, land mines, death squads, total war, and nuclear weaponry have long since dissolved' that idea of the battlefield (2014:198). However, unlike the bow and arrow, the gun and even the manned aircraft, which required their users to be in the proximity of the weapon itself, the drone has truly 'disarticulated the spatial relationship between weapon and warrior'(2014:196), marking a profound 'respatialization' (ibid) of warfare.

The 'retemporalization' (2014:199) of warfare that drones effect is found in a dynamic in which the experience of war is slowed for the drone operator, due to being able to linger and surveil a target for hours, even days, before making a strike, while simultaneously the experience of war (if we can call it that) is sped up for the victim of the strike who may know nothing of their 'condition of targeticity'(Marcus et al. 2012:4) until being hit. Drones also transform conceptions of valour. Drone operators are viewed by pilots of manned military aircraft as less courageous and skilled than the latter. In the context of military service, valour implies physical risk to the fighter's body. Without putting their own lives on the line, 'cubicle warriors' (Mayer quoted in Gusterson 2014:200) don't meet the standards of bravery that military personnel usually pride themselves on. However, Elish (2018) found that drone operators attempt to reframe their war work as a form of patriotic altruism that is crucial to military campaigns. Some articulate a sense of pride as duty by claiming they could make more money by leaving the Air Force and working for private contractors, emphasising that 'flying a drone is more than mindless, low-status

work.'(2018:144). Nevertheless, the drone fits into a colonial mould, alongside the machine gun and other weapons that aim to 'ensure that the "natives" die in an unfair fight in considerably larger numbers than colonial soldiers.' (Gusterson 2014:200), a method more akin to 'hunting than war' (ibid.) (cf. Zulaika 2020 below). This observation highlights that the unfair asymmetry of drone warfare is context dependent. Drones don't hold as much potential for fighting evenly matched adversaries with access to the same technology. They seem best suited to massacring natives of less developed countries with little or no air power and unsophisticated armouries.

The final aspect of warfare that drones alter concerns democratic public consent to war. Because HALE drones absent the bodies of the personnel doing the killing, the value of human life on one side is no longer a factor in the waging of war. The latter is key to public consent to wars, because significant and/or undue loss of life becomes an indicator of whether a war is being justly or legitimately waged in the public's eyes. Drones may risk creating both an unaccountable form of state governance if war can be waged with no human cost, and an apathetic public who may neither care nor know that war is being waged in their name.

In *Drone: Remote Control Warfare* (2016) Gusterson's overriding question is whether 'the alleged new wonder weapons are an effective tool for achieving the goals of the American national security state?' (2016:28). Gusterson (2016:14-15) makes a distinction between two kinds of drone warfare. 'Mixed' sees drone strikes deployed alongside ground forces and takes place in officially declared warzones. 'Pure' involves only drones, or predominantly drones in tandem with intelligence gathering techniques on the ground, so far only seen in/over countries with whom the US is not officially at war. In this respect, it

is the CIA rather than the US Air Force who have conducted pure drone warfare so far, for example in Pakistan and the FATAs.

Drones are appealing to militaries for several reasons. They are superlative surveillance tools with night vision and infrared optical capabilities, able to track and monitor target activity for days at a time continuously. The approximately one thousand hours of video footage they produce collectively every day (2016:36) can be archived and examined by analysts. Secondly, drones physically remove their operators from the theatre of war and thus protect their lives. The immediate reduction in casualties on the using side is also politically opportune, lessening public disquiet over the human cost of waging war. Thirdly, drones are very cheap in comparison to manned military aircraft, even when accounting for their maintenance and operation throughout the wider network of personnel. Losing a drone in the field is less costly than losing a fighter aircraft, which would also mean potentially losing a pilot, or having to attempt their rescue. Drone operators also cost far less to train than fighter pilots. The fourth reason why drones are an attractive prospect to militaries is that they promise precision attacks. Laser guided Hellfire missiles fired after extensive surveillance ought to be more discriminate than other methods of aerial bombing. However, drones are also vulnerable to adverse weather conditions, signal dropout, cyber hacking, 'ground-to-air or air-to-air missiles'(2016:26), and regularly crash 'by themselves'(2016:27)

A central feature of life in contemporary America is the ubiquitous media environment that mediates the experiences of citizens and their communications with each other. 'The emergence of drone warfare, organized around screen killing, is part of this mass emotional and perceptual migration to screen worlds.'(2016:59). Here, the boundaries between the real and its representations become increasingly blurred (see also Sluka

2013b, Robben 2016)[11]. The experiences of drone operators are characterized by '(a)n uneasy combination of physical remoteness and vivid mediated presence.'(Gusterson 2016:60) Sitting in a windowless shipping container, they control an aircraft thousands of miles away. And yet, the visual technologies that mediate their awareness of the landscape over which the drone flies immerse them in those faraway places and bring them experientially very close to the targets they hunt down. Some recognize that they wield a God-like power, staring down at people from the sky as though they are 'ants' (Martin quoted in Gusterson 2016:62), deciding whether they live or die. This may induce a feeling of pleasure in itself, which may be heightened for some when watching people die in strikes. More generally, there is a potent element of voyeurism involved, as operators spy on targets in their houses with infrared cameras, watching them going about their daily lives, having sex with their wives, and even farm animals (2016:63), but also seeing 'a lot of dudes taking shits'(Tart quoted in Gusterson 2016:64).

Drone operators with an affinity for computer games seem to be most adept at their task, which involves numerous screens and two joysticks (Gusterson 2016:34). Adding to the video game-esque-ness of their work, they use a computer simulation programme, distastefully called 'Bugsplat' to calculate the level of civilian collateral damage that would result from a strike (2016:38). Sluka (2013b) argued that the shift between killing characters in a completely virtual world and killing human beings through virtually mediated remote weapons systems 'is [only] psychological and moral; [because] the physical process of remote-controlled violence is exactly the same, regardless of whether the victims are real or simulated.'(2013b:187-188) Further, a report by the International Committee of the Red Cross (ICRC) argued that 'advanced technologies which permit

[11] Robben (2016) argues that the new anthropology of violence needs to focus on the way technology mediates the experiences of war fighters, particularly visual technologies.

killing at a distance or on the computer screen prevent the activation of neuro-psychological mechanisms which render the act of killing difficult' (ICRC in Gusterson 2016:71). However, Gusterson challenges the idea that as a video game on steroids, drone technology makes killing easier and dehumanizes the victims. While there are certainly significant crossovers, not least in the physical respect Sluka identifies, there are also differences between the on-screen environments found in video games and those encountered by drone operators, as well as experiential differences. Aesthetically, the characters in video games are often 'cartoonish' and inhabit 'stylized landscapes' (Gregory quoted in Gusterson 2016:71). Experientially, the immersion in video games (for most players) is not continuous to the extent that the drone operator would experience on shift. In terms of the distancing element of drone warfare, Gusterson cites a model by Grossman (1995) which suggested that as the distance between targeter and target increased, the easier killing became psychologically. Without the humanizing element of combat in egocentric proximity, and thus the removal of the opportunity to identify the other as also human, the barriers to slaughter collapse. However, with relation to drone operators, as opposed to, for example, pilots of bombing aircraft or missile battery personnel, Gusterson argues that there is a 'remote intimacy'(2016:72) involved. This has to do with the visuality of the technology and the extent of the operator's perceptual and thus emotional exposure to the target before and after killing. This may even provide a more intimate experience of the enemy than many ground troops have, 'who may only get a brief glimpse of, or never see at all, the people they kill.'(2016:73) Albeit only visually, drone operators often perceive the suffering of those who survive their attacks and those in the vicinity who grieve the deaths of family members and friends. They watch their victims die slowly and painfully, seeing blood spurting out of severed limbs as heat patches on infrared camera feeds, knowing that they caused that suffering and that their victims are indeed

human like them. Nevertheless, there is no guarantee that operators will experience empathy for their victims (cf. Zulaika 2020 – see below). Widely acknowledged, however, is that while they are removed from any physical risk, some operators do experience symptoms of post-traumatic stress disorder (2016:79).

Whether many or even all of the killings by drones conducted by the US are legal under international law remains uncertain. High-ranking US officials remark that even the gold standard personality strike that targets specific, named individuals (see below) amounts to a form of assassination — in other words, extra-judicial killing. Further, the ways in which the US seems to have stretched the doctrine of pre-emptive self-defence to justify drone strikes is highly suspect. The problem is that drone warfare has become normalized before the point at which neither US domestic nor international law can fully comprehend and legislate for it, complicated by confusion as to whether it is even 'war' at all. Framing this predicament, Gusterson (2016:128) quotes an ex Israeli Defence Forces lawyer, Daniel Reisner as saying 'if you do something for long enough, the world will accept it… International law progresses through violations.'

Concluding his monograph, Gusterson considers two possible futures for drone technology. In the first, 'dystopian' (2016:151) future, US drones armed with non-lethal weapons patrol the border with Mexico, and along with the traditional diet of Islamic insurgents, kill foreign organized crime bosses, bank account hackers in Africa, Central and Southern America, and Western Asia. At this point in time, other major state powers — especially the USA's main antagonists — will have acquired HALE drone fleets, alongside many 'middle-tier countries' (2016:152). Kamikaze drones of a minute size that explode on making contact with their target will be developed: later fitted with facial recognition technology and made autonomous. Non-state actors will also acquire this technology. Generally, terrorist usage of armed drones will increase. Policing uses of

drones will also expand. Mass shootings in America will become something done by drone. In the other future scenario, drones 'are well regulated by both international and domestic laws, and their civilian uses outweigh their military applications' (2016:154). Their military uses will be restricted to 'formally recognized warzones' (ibid); full automation (to the point of decisions on killing) will be banned under international law; and all footage from drone cameras must be archived and thus made available for review by independent international law experts. US police drones will not be allowed weapons, and laws will prevent citizens spying on each other with drones.

Unfortunately, Gusterson thinks the first scenario is the more likely. With relation to that future, most relevant to the subject of the present thesis is his prediction 'that scientists will produce new iterations of the technology that will make drones smaller, deadlier, and cheaper.' (2016:156). However, he thinks a ban on military drones akin to that placed upon anti-personnel landmines is 'impractical and even undesirable' (2016:156), in the latter sense, ultimately because he believes that drones do have the capacity for precision strikes that might be more ethical than other means of warfare (see below). Offering what conforms to an argumentative formula in favour of developing 'dual use' technology (see Chapters 2-8 of this thesis) Gusterson writes: 'The same drone can be used to perform a targeted killing or to verify compliance with an arms control treaty. Surely we do not want to lose the second function.' (2016:156)[12]

Gusterson (2019) argues that discourses framing drones as precision weapons that avoid civilian casualties and thus affording a form of warfare 'more consistent with human rights law and humanitarian law than the alternatives' (Koh quoted in Gusterson 2019:577), are representative of a broader discursive phenomenon called 'military humanism' (Gusterson

[12] In Chapters 6 and 7 we will see two examples of this very formula, one sincerely spoken by a BCI researcher, and another identified as a cynical ploy by a concerned neuroscientist.

ibid). American military humanism, for example, appears in the guise of an 'exceptional nation' (ibid) whose duty it is to export democracy and enforce human rights, begrudgingly engaged in war for the betterment of humanity, against forces who seek to disrupt the proper functioning of the world. Critics of American military humanism argue that the discourse functions to cover up ulterior motives, such as obtaining strategic access to foreign held natural resources and markets, and the continued expansion of military presence across the globe. Gusterson identifies a 'doubleness' constitutive of militarism and military humanism, which if we are to resist the latter's pervasive grip on public life and discourse, must be recognised as the plain hypocrisy it is:

> It is a doubleness that allows US officials to talk about human rights and morality while killing children, a doubleness that uneasily contains the optics of the drone operator and the embodied experience of his or her victim, and a doubleness in which the brutality of insurgency and counterinsurgency on the ground masks and legitimates the added brutality of drone warfare, which gets figured as its antidote rather than its supplement. (2019:585)

In connecting military humanism to drone warfare, Gusterson uses the term 'drone essentialism' (2019:579) (first appearing in Gusterson 2016:92), coined to describe the discursive phenomenon in which, despite their repeated failures to avoid civilian casualties in practice, the idea that due to inherent properties of the technology drones are precision weapons which spare civilian lives, prevails. While it is true, in principle, that drones have the capacity to be highly discriminate weapons, the question is *why do they kill so many civilians in reality*? The answer, suggests Gusterson, lies in studying the ways drones are actually used in practice. This means analysing the targeting protocols deployed by US military forces and security agencies when conducting strikes, in line with an acknowledgement that '(a) drone is a sociotechnical ensemble, not just a machine, and the same drone will be deployed to different effects in different cultural contexts.' (2016:92)

The American public was given the impression that the majority of drone strikes generally were 'personality strikes', so-called because they were supposed to be strikes on named

individuals on a Presidentially sanctioned kill-list. In principle, this would have been in keeping with the claims concerning the precision nature of drone strikes, although even with this method, mistakes can still be made. What's more, civilian collateral can legally be factored into the decision to strike (2016:97). Indeed, 'the killing of up to thirty bystanders for each combatant is taken as a rule in drone warfare' (Zulaika 2020:19). However, investigative journalists have revealed that most strikes have been 'signature strikes', so-called because the justification for a strike is based on a surveilled target exhibiting behaviours conforming to a pattern thought to distinguish terrorists from non-terrorists. This can involve well-founded assumptions, for example, when a target is seen engaging in hostile activities towards US troops — but has the tendency to become dangerously nebulous when no such definitive markers are present. When behaviours such as praying at the roadside (see also Gusterson 2016:67), digging to bury a body but which might be imagined by drone operators to be a roadside bomb, or even in many cases just being a military aged male with a beard (as all observant Muslim men have in Afghanistan), and *carrying* a gun (which is actually a cultural tradition in rural Afghanistan and what were the FATAs) become interpreted as part of the signature, mistakes are bound to occur.[13] In many such cases, what goes on in the minds of drone operators while watching the video feeds, Gusterson terms 'narrative infilling — a process where the silences inherent to grainy video footage are unthinkingly filled in' (2019:579), and in which drone operators 'craft moral narratives about the people they watch…and the reasons they deserve to live or die' (2016:77). In his monograph, Gusterson (2016:64-70) discusses numerous examples of narrative infilling that led to the accidental killing of civilians by drone operators, arguing that 'the fault lies in the interaction between the

[13] Gusterson (2016:87) quotes a CIA analyst as saying that often 'all military-age males in a strike zone [are defined] as combatants …unless there is explicit intelligence post-humously proving them innocent'.

limitations of the technology and processes of narrative infilling and remote individualization'(2016:69).

Other strikes act on intelligence from local informants on the ground to identify targets — a notoriously unreliable method of intelligence gathering, especially in a life and death situation — which has even been used by some in Afghanistan as an opportunity to have their agnatic rivals killed. Another method of identifying terrorists is to intercept cell phone signals. But again, this is not as reliable a method as it might seem, because sometimes people swap SIM cards into other phones. Without verifying who holds the phone with the SIM in question at the time of launching a strike, innocent people might be and have been killed. At the bottom of the barrel, perhaps even more depraved than the signature strike, but just as epistemologically and morally flawed, and thought rightly by many to constitute a war crime, is the so-called 'double-tap' strike. Here, having just conducted one strike (say, a signature strike), drone operators wait for first responders to attend the scene and begin trying to help survivors. The operator subsequently fires another missile at the same site, under the assumption that those helping look for survivors are terrorists or sympathisers, too. Funerals of people assumed to be terrorists killed in drone strikes have also been deliberately targeted using the same logic (2016:96).

With the constant buzzing of drones in the sky, the ever-present threat of a strike and the knowledge that many civilians are killed by them: targeted populations experience an 'anticipatory anxiety' (2019:584) comparable to the experience of people living in fear of death squads in Central America during the 1980s. In this atmosphere of helpless terror, they may develop symptoms of post-traumatic stress disorder, such as nightmares and flashbacks. Ultimately, then, the rhetoric around drones as precision weapons does not match the reality of their use, and Gusterson thinks that the main problem lies in the targeting protocols.

Recalling Sluka (2013b), Joseba Zulaika (2012) also makes a comparison between magical thinking and counterterrorist (CT) strategy, addressing the 'crisis of knowledge' (2012:52) in CT thought and how US drone strikes conform to the absurd logic he identifies as central to that crisis. With the end of the Cold War and the nuclear threat from the communist Soviet Union largely dissipated, a new enemy of the United States was needed to justify continued increases in military spending and fresh geo-political misadventures. Post 9/11, this enemy could be the 'terrorist'. Indeed, 'the phantom of terrorism has become the only justification [for war] in the nuclear era' (2012:62). The 'war on terror' initiated by George W. Bush's administration and continued by Obama's was characterized by 'the state of exception' in which 'Guantanamo, indefinite detention, rendition, torture and extra-judicial killings by drones' (2012:51) became the norm. Zulaika argues that a central but unrecognized premise of CT thought is that the terrorist is tabooed and thus communication with them is forbidden.[14] This leads to the second notable, also unrecognised feature of CT thought: its proponents must cultivate a 'wilful ignorance of the political subjectivities of the terrorists' (2012:52), and under no circumstances attribute to them a 'complex subjectivity like ours' (2012:62). On the contrary, 'their madness, suicides and killings [are framed as being] qualitatively distinct from ours' (ibid). The problem is that terrorists do have complex subjectivities like ours, and their political views are often shaped in opposition to the policies enacted by Western governments in the purported fight against terrorism. CT thus embraces a 'passion for ignorance' (2012:56), which seeps into the drone wars inflicted upon countries that harbour terrorists, in more than one way.

[14] Although, this would not seem to be the case when interrogations are used, at Guantanamo, for example.

Aligned with Gusterson's observation that '(k)illing by remote control [is] the antithesis of the dirty, intimate work of interrogation' (2016:106), and thus removes any chance to gather intelligence — Zulaika points out that drone strikes from thousands of feet in the air are perfectly suited to operating in the context of taboo. CTs deploying drones using the method of signature strikes don't even know the names of people they kill. The targets are just imagined resemblances to the figure of the terrorist. After firing missiles at nameless targets, the question arises as to how CTs can know that the mess of charred bodies caused by the strike were even terrorists at all? The targeted humans, inferred to be terrorists on the basis of their behavioural patterns, aren't asked whether they are actually terrorists (communication is forbidden), and once killed cannot speak. And so, the ignorance of CT continues. Even when personality strikes have been used, however, it has transpired that several individuals on Obama's kill list have the miraculous ability to die more than once (Zulaika 2012:54). In both kinds of strike, there is an element of 'magical realism' (Ahmad quoted in Zulaika ibid) involved in counting and identifying the dead bodies.[15] However, what *was* widely known, even at the time of Zulaika's writing, was that the drone strikes were often killing more civilians than militants. So, recalling the vicious cycle identified by Sluka in which US forces continue to pursue drone strikes even though they perpetuate terrorism by losing hearts and minds, Zulaika also recognises that counterterrorists know this to be the case. The crisis of knowledge in CT strategy is not a crisis of unknown unknowns, but one of known knowns being wilfully ignored.

The 'it is not if, but when [a terrorist attack occurs]'(2012:59) formula Zulaika identifies as the kernel of CT thought, generates 'the temporality of waiting'(ibid), in which because

[15] It is impossible to know how many people, including civilians have been killed by drone strikes. Even at Zulaika's time of writing, estimates from various sources ranged from hundreds to thousands. Several authors mention this epistemological lacuna e.g., (Sluka 2013:175-176, Zulaika 2012, 2020:14, Gusterson 2019:583, 2016:86-93). Writing this in 2022, I may as well leave it at '*probably* thousands' — and within that '*probably* thousands of civilians'.

future threats are framed as inevitable, the belief in the future reality of those threats overrides the actuality of evidence in the present that might contradict those beliefs. The perceived inevitability of the threats from terrorism leads to a paradox which can be expressed as: 'if we do nothing, terrorism will flourish; if we do something it will flourish even more' (2012:55). Zulaika draws a parallel between the 'it is not if, but when' projections of CT, and the oracular revelations documented by Evans-Pritchard with the Azande. 'If the oracle reveals that a proposed course of action is fraught with mystical dangers from witchcraft or sorcery, that course of action will not be carried out; and then the question of refutation or confirmation does not arise. We might say that the revelation has the logical status of an unfulfilled hypothetical.' (Winch quoted in Zulaika 2012:59). In the face of this predicament, CT logic concludes that it is best to use drones to pre-emptively defend against inevitable future threats anyway. The magical thinking at work when persecuting targets with signature strikes and then in identifying and counting their bodies; the passionate ignorance of known facts in the oracular revelations of CT which produces the temporality of waiting: leads Zulaika to argue that it is the 'force of fantasy that is most real' (2012:67) in counterterrorist drone culture.

Zulaika (2014) makes a similar argument, but drawing on Walter Benjamin, adds some new insights concerning the aesthetics of war. With the Italian Futurist's Manifesto in mind, Benjamin argued that fascism inevitably resulted in an aestheticization of politics in which our 'self-alienation reach[es] such a degree that [we are] capable of experiencing [our] own destruction as an aesthetic enjoyment of the highest order' (Benjamin quoted in Zulaika 2014:176). Fascism aims to alienate the populace's senses from the experience of the horrors of war as it really is, and through the distanced aestheticization of media, arts, and their combination in propaganda, transform horror into a bizarre form of (at least semi-) pleasurable consumption, engineered to serve militaristic, nationalist aims (cf. Buck

Morss 1992, Butler 2010). The 'latest development in this technological aestheticization' (Zulaika 2014:177) — the combat drone, with its capacity for remote-controlled video game-esque massacre, reduces the reality of the horrors of war inflicted on other human bodies as they would otherwise be made evident to the perpetrator's senses, to 'a mere image' (ibid). The true role of art for Benjamin was to dissolve fascistic aesthetics and reveal the 'bodily horrors' (Zulaika 2014:177) of war which they attempt to hide.[16]

Zulaika was inspired to write his monograph *Hellfire from Paradise Ranch : on the front lines of drone warfare* (2020) by testimony from ex-US Air Force drone operator Cian Westmoreland at Las Vegas Law School in 2016. Contrary to President Obama's claim that 'during his administration drone air strikes killed between 64 and 116 civilians' (Zulaika 2020:1), the drone operator had carefully researched how many he had *personally* killed and reached the figure of three hundred and fifty-nine innocent men, women and children. Zulaika was refused access to serving drone operators by the US Air Force ('a witness is the last thing a killer permits'(2020:5)), and so engaged with whistleblowing ex-personnel, and protestors against drone war at Creech Air Base in Las Vegas, where most of the US drones are controlled from today — 'where I couldn't reduce myself to be a detached anthropologist but felt required also, as part of the ethnography, to become myself a participant' (2020:6).

In comparison to the only other monograph in this review, Gusterson's *Drone* (2016), Zulaika's *Hellfire* (2020) is less straightforward, and less focused on drones themselves. Embarking on many interesting tangents, it is also a more colourful, ethnographically richer, and more theoretically ambitious venture. However, much of Zulaika's monograph — which is at once a sprawling critique of American militarism; a critical history of the Obama administration's penchant for drone strikes in Muslim countries; a critical

[16] A theme I also deal with when discussing the optics of BCIUAV research (see Chapters 2,7 and 9).

anthropological and psychoanalytic theory of CT and the war on terror broadly; a history of Las Vegas and its relationship to the US military, nuclear testing, and the development and use of unmanned aerial vehicles; and an ethnography of anti-drone protest (Zulaika himself spends a night in jail with his participants) – will have to be passed over here for reasons of expedience. Also, due to the repetitiveness of the literature broadly, other sources have already been used to illustrate many other points that Zulaika raises. The two most important aspects of *Hellfire* that I discuss below concern a more philosophical theorization of signature strikes, and the tension between the purportedly dehumanising effects of drone warfare on one hand, and the emotional experiences of drone operators on the other: a tension heightened by Zulaika's (2014) earlier comments on the aestheticization of war.

Drawing on philosopher Chamayou (2015) who theorizes asymmetrical military drone use as man hunting, and using an analogy drawn from his own ethnographic work on Basque Boar hunters, Zulaika evokes the 'paradigm of the hunt' (2020:19), which in the context of drone warfare against terrorists, is a continuation of the historical European American colonial practice of '*manhunting* for natives' (2020:25) Interestingly, the latter was also framed as a form of pre-emptive self-defence. In the paradigm of the hunt Zulaika argues that drone warfare — particularly with relation to the use of signature strikes— reduces the victim to an impersonalised target who is transformed into a 'lower *species*' (ibid). The signature strike reduces human targets to patterns of bodily activity — thus viewing them in terms of bare animal life (*zōē*) (Agamben 1998). They are thus simultaneously stripped of the dignity of a 'socially recognized life' (Rapport 2012:4) (*bios*) and their individuality; even reducing entire targeted populations to this level. This reveals the operations of a predatory human ethology, which Zulaika finds, following Mbembe (2019) to be imbued with necropower (power to kill): ' the ultimate expression of

sovereignty'(2019:66) justified not so much by racism *per se*, which ideologically settles the power to kill within Foucault's biopolitics, but by the fight against terrorism (see also Chapter 7 below).

Parallel to Gusterson's (2019, 2016) thoughts on 'narrative infilling', Zulaika (2020:18) recognises that, much like boar hunters 'whose substantive lacunae in sensory and conceptual knowledge' with relation to their animal prey' forces them to rely on 'a shaman-like "divination" of the prey's behaviour' thus precipitating a retreat into symbolic fantasies about the animal that can only be verified by a successful kill — drone operators, aided only by the sensory input of vision, and abetted by an ignorance of the target's subjectivity and identity: must also rely upon 'conjectures and intuitions'.

> Military culture is founded on the imperative to deny the brotherhood between killer and killed. The Enemy is categorically different, typically turned into some type of metaphoric animal to permit the killing. And yet, at times, the unthinkable happens and the brotherhood between killer and killed becomes so apparent that the horror of killing is revealed in all its traumatic and unforgettable real. (Zulaika 2020:133)

But there is a tension present — as seen in the quote above, and more one-sidedly in Zulaika's (2014) remarks on the supposedly fascistic aesthetics of military drone technology — between the argument about the distancing, dehumanizing effects of killing by drone, and the all too human affects the technology can produce in its operators as perpetrator-witnesses. In a chapter titled 'Trauma: The Killer as Voyeur', Zulaika considers drone operators' experiences. Like Gusterson (2016), he recognises that despite the vast distances between targeter and targeted, due to the compression of space and time that occurs via the visual mediation technologies involved, operators can feel intimately connected with the people they hunt and kill. The experiences of war that operators have may be more intimate than those had by many other military personnel. But the operator does not engage in or experience 'war' in the same ways as their targets, and so the radical asymmetry of the operation can provoke a sense of guilt about what they do — made

worse when they know children and other innocent civilians have been incinerated. Distinguishing murder from war becomes difficult. Watching the aftermath of their own strikes can be horrific, illustrated by testimonies recounting scenes of abject suffering and the traumatized responses of survivors: 'In one case a strike killed a "terrorist facilitator" but not his son, who "walked back to the pieces of his father and began to place the pieces back into a human shape." (2020:122). Seeing those kinds of scenes, and what's more, knowing they caused them, it's hardly surprising that many drone operators suffer from post-traumatic stress, and some become suicidal. Thus, even with all the methods of distancing that drone warfare involves 'space…time…weapons systems…categorical differentiations' (2020:113) that should make it easier for an operator to kill someone on the other side of the world: the opposite can occur. The operator may become traumatized and may even experience 'the breakthrough of creativity and resistance' (2020:112) against the war machine they serve. However, not every operator is prone to empathetic experiences. 'How you see the images and react to the live streaming of drone videos determines whether you are a real hunter; if you are not, then hunting will subject you to trauma.' (2020:121)

1.5: Conclusion

Drones are lauded as precision weapons, but in reality, they kill many civilians. This may be down to the way targeting protocols are deployed. Signature strikes guarantee a higher civilian kill rate, and double tap strikes double down on the depravity of drone warfare, if indeed, it can even be called 'war'. But there remains the question of how precise the effects of a 45kg Hellfire missile can be, even when conducting personality strikes. Roomy allowances in international law, however, are made for civilian collateral. Despite the unreality of the claims about precision and sparing civilian lives, as well as the subsequent

problem of losing hearts and minds in targeted countries (Sluka 2013b), the absurd logics of counterterrorist thought appear to preclude an internal re-examination of the use of drones to combat terrorism (Zulaika 2012).

While on one hand, the remote split as described by Elish (2017) is a historical contingency (and thus could have been otherwise); on the other hand, the profound 'respatialization' (Gusterson 2014) of war that drones effect appears to be the current zenith of a technological trajectory that has been in motion for millennia, providing yet another solution to that 'age old military problem of hitting something from a distance' (Lindsay quoted in Elish 2019:1111). The pre-existing drive to kill from afar is embodied by the contemporary preference for drone warfare, and to some degree by the intrinsic nature of the technology itself.

This form of killing — ridiculed by traditional airmen for its cowardice— appeals to military officials for a number of strategic reasons, but also because it is comparatively cheap. The lives of the populations hunted down by it are likewise made cheap, even animal-like (Zulaika 2020), especially when the signature and double tap strikes are involved. It is agreed, however, that despite the dehumanizing effects of drone warfare on those targeted, some operators can be traumatized by what they do and see, and break through the techno-aesthetic framing of the target as a blip on a screen to see another human, suffering and dying (Zulaika 2014, 2020). Intense visual mediation in combination with jarring time-space compression, makes operating drone technology in the remote split configuration a uniquely confusing phenomenology. The ways drones have been used in US COIN/CT campaigns is both morally and legally suspect, and their deleterious effects go beyond the mass killing of innocents to the further destabilization of war torn areas and the health of their populations (Closser and Colburn 2019)

We will be leaving most of this literature behind since although in part an 'anthropology of drones' (Gusterson 2014), this thesis is actually more an anthropology of brain-computer interface research culture, where it *intersects* with drone technology in the 'brain-computer interface unmanned aerial vehicle' (BCIUAV). Moreover, by examining the research into BCIUAV technology, the thesis also reaches for deeper issues that the intersection represents via a microcosmic synecdoche. By this I mean the issue of *neuroweapons*, which leads in turn to a consideration of weapons in general. In the main, this thesis does not involve HALE drones. Rather, following Gusterson's (2016:156) predictions, it concerns scientists producing plans for 'new iterations of the technology' involving 'smaller… cheaper' drones. We cannot say (yet) whether they are *more* deadly than HALE drones, but from the angle I address the topic, this is not really relevant because from a philosophical anthropological perspective I am interested in what makes *any* weapon a weapon at all — which is that it is potentially lethal (see Chapter 7). Further, combat BCIUAV technology does not necessarily imply deeply asymmetrical violence as HALE drones seem to, nor the involvement of a network of over a hundred personnel including lawyers (see Chapter 5). Unlike the literature reviewed in this chapter, this thesis is not about drone or weapon use in past or present wars. Rather, it concerns the potentiality of BCIUAV technology (but also) neuroweapon technology more broadly, to be used in *future wars*. In terms of human beings, because BCIUAV technology is still in development, I am primarily concerned with the researchers who design it — although I have not spoken to many of them and found my way into their practices via their publications. Where that research involves the demonstration of knowledge of the harmful and lethal uses of the technology (see Chapter 2), I am tasked with theorizing the kind of power that these researchers wield. Zulaika's (2020) argument concerning necropolitics and bare life is made with relation to both drone warfare using signature strikes and the

target category of ‘terrorist’. In Chapter 7, I will put forward a connected but more general argument that relies on no specific categorization of human beings, nor made with relation to a specific kind of weapon. My argument involves a diagnosis of the power that scientists and engineers wield through their work with relation to any weapon and the effects of that power with relation to ‘Anyone’ (Rapport 2012).[17]

[17] Who in my argument overall does appear more in the guise of *zōē* than *bios* — but according to Rapport (2012:4) these two aspects are collapsed into the figure of Anyone, who I discuss first in Chapter 2, and in subsequent chapters.

2: Theory, Concepts Argument

2.1: Introduction

In this chapter I outline the general theoretical framework used in the thesis, along with relevant themes in anthropology, philosophy, and sometimes beyond. I begin with remarks on method, and sources of data. The philosopher John Forge's account of 'dual use', which is central to this thesis, is introduced in detail. A short section follows on the nature of the weapons innovation germane to the case of BCIUAV research and technology. I then introduce the idea of a cosmopolitan anthropology with particular relation to the concept of dual use and set out two moral imperatives which guide my analysis in line with the proposed moral vision of human conservation for anthropology. Subsequently, I discuss the criteria by which I diagnose 'red flag' cases of BCIUAV research. The final sections introduce the theme of 'optics' with relation to BCIUAV research and define what is meant by 'the moral vision of BCI research'. At the end of the chapter, I outline the chapters which follow.

2.2: Methods Talk and Scientific Papers as Qualitative Data

A century has passed since the publication of Malinowski's *Argonauts*; a flagship work seen by many as marking the inauguration of the era of "intensive" work' (Stocking 1992:28) or as it came to be called, 'ethnographic fieldwork', and thus the completion of a movement away from the speculative armchair surveys that characterised earlier anthropological studies. In the intervening years, much in anthropology has changed. But there remains discomfort with the idea that fieldwork might not be lauded as the only truly

legitimate way to proceed with anthropological inquiry. However, in the mid-1990s, faced with the march of information technology (IT), Zeitlyn and Houtman speculated that this might not remain the case forever:

> It is likely that IT will have us reexamine familiar concepts. By collapsing geographical divide between home and field-site, hitherto an assumed element in anthropology's self-definition, the concept of fieldwork is changing from the Malinowskian model. Indeed, with time, it may yet 'plunge us back into the armchair' by affording such rich data set in addition to personal fieldnotes, including remotely accessed data-channels, permitting new forms of interactive fieldwork off-site. (Zeitlyn and Houtman 1996:2).

The approach taken here is essentially the opposite of the Malinowskian one which came to dominate anthropology in the twentieth century (and which continues); and a far more minimal, much less 'interactive' vision than that anticipated by Zeitlyn and Houtman. The approach taken here involved no fieldwork, was largely concerned with documents and other secondary sources both textual and visual, academic and non-academic, heavy on theory and concepts, and in relative, scholarly terms, massively multi-disciplinary in its range. Although not by choice, hardly any interviews were conducted and those that were, were done digitally across vast geographical distances using IT. In this respect, it may be called 'computer-chair anthropology'.

Imagine yourself at home for several years, conducting computer-chair anthropology in the era of the internet, with near unlimited access to textual and non-textual, scholarly and non-scholarly materials at the push of a button. Moreover, during these years, since you have been confined to your home on several occasions for months on end without being allowed to meet anyone in person, owing to lockdowns to stop the spread of a pandemic disease, you have become embroiled in your studies in a way that fieldworking anthropologists would hardly recognise. More akin to that of the stereotyped philosopher

— solitary to the extreme, walking on the edges of fields, both literal and academic. But unlike the ethnographic fieldworker, whose work may have screeched to a halt until travel privileges and social contact can be reinstated: you study a highly literate scientific research culture, which means that your central sources of data, *are* 'embodied in fixed material documents'(cf. Malinowski 1922/2014:3), and thus allow for self-sufficient remote work to be conducted.

The main 'data' considered in this thesis are scientific papers from BCI research. However, alongside these I have conducted a small number of semi-structured interviews with BCI researchers (see below). I also use visual materials — video advertisements for small combat drones — as the basis for discussion and theorization of future combat BCIUAV research and technology (see below). Relatedly, a famous work by German artist Otto Dix helps me think through both BCIUAV research and anthropological theory. Temporally, I look not only to the near past and present but also to the future, which the subject matter demands. As a non-fieldworking anthropologist I have tried to develop my own approach to the subject matter by means of radical synthesis of anthropological and non-anthropological materials, all brought together by an idiosyncratic writing style and creative modes of analysis (cf. Hannerz 2003). It is not grand theory that interests me, but rather theoretical and conceptual *dappledness* (Zeitlyn 2022), meaning an eclectic but pragmatic synthesis of ideas. Along similar lines in terms of 'method', Rapport (1997:9) writes:

> my understanding of a broadly 'literary anthropology' is of a social science which deliberately maintains a conversation with whatever ideas and texts appear provocatively to elucidate the subject under review.

In agreement with Rapport, I also follow Rabinow (2008:7) in that much of the time:

> I am trying to appropriate conceptual tools that had been forged for certain problems, and to refashion them in the hope they will provide analytic purchase for different problems.

Nevertheless, the use of scientific papers, not least as *qualitative* data, raises several theoretical and methodological issues. First, by taking scientific papers as the central form of data (which are usually 'secondary' sources, but for me are really primary) I am conducting research into other research — a form of *meta*-research. The papers are largely quantitative in nature, given the characteristics of the science involved, but my main focus is on their qualities, and the qualities of the technology discussed in them. I therefore conduct *qualitative meta-research*. Meta-research usually implies re-analysis of data derived from multiple sources, and usually in quantitative terms. I do not consider what I am doing to be a *re*-analysis, because the *qualities* were never really addressed up-front in the original materials. However, due to the use of other methods (see below) there are elements of both 'research' (i.e., interviews etc) and meta-research involved in the thesis.

As opposed to doing fieldwork and adopting a micro-level perspective; by adopting a computer-chair approach and taking BCIUAV research papers as my central data, I am *in a sense* taking a macro-level perspective on the phenomena in question, perhaps better phrased as a 'bird's-eye perspective' (Knorr Cetina 1982:116), or, indeed, a 'drone's-eye perspective'. But the macro/micro level distinction isn't quite right in my case, as at times I do *zoom in* and deal with, for example, minute distances between bodies and technologies that are only realised at the micro-level of individual BCI studies, in the systems themselves (e.g., Chapter 4). I might not *be there*, but sometimes my analysis operates within the smallest measurable spaces of BCI systems. The emic/etic distinction is, I think, appropriate here. So, I do not get the emic 'being there' perspective afforded by, for instance, Knorr-Cetina's fieldwork-based 'ethnography of knowledge approach'

(1982:129n32) but unlike her, I do not equate etic/emic with macro/micro. Rather, I argue that from a drone's eye view, different levels of zoom can be applied for varying effect.

Another question concerns units of analysis. The papers themselves are grouped together by what they share in common. They all represent attempts to develop BCI control strategies for UAVs. Here, with 'BCIUAV research', I define a 'taxonomic collective', which is perhaps in part an etic 'outsider's similarity classification' (Knorr-Cetina 1982:115). Although a simple, reasonable form of classification, taxonomic collectives such as BCIUAV research sometimes have 'no empirical referent… no real interrelations, and the similarities invoked … to characterise their members may have no significance for participants themselves' (ibid). However, this logical operation is also performed by some scholars of BCI research themselves, for example, when they author review articles of BCIUAV research (although they do not use precisely that term - e.g., Nourmohammadi et al. 2018), demonstrating the at least partially emic nature of the category. 'BCIUAV research' represents the formation of an 'isolate' entailing '(t)he perception of phenomena as classifiable into types…[and]…the theoretical abstraction of their relevant qualities from a mass of empirical material' (Firth 1958:3).

Similar issues arise in defining a BCIUAV researcher and subsequently BCIUAV researchers, another taxonomic collective term, membership of which is afforded by the shared activity of engaging in BCIUAV research. Specialty communities, units found in the sociology of science since the structural-functionalist approach of Robert Merton, 'are seen as small social systems with fuzzy borders and internal mechanisms of integration… frequently circumscribed by a speciality area represented in the scientific literature' (Knorr-Cetina 1982:102). I do not go so far as to claim that BCIUAV researchers are a specialty community in empirical terms, but analytically I do, at some level, treat them as

such.[18] However, the notion of a specialist community is not without empirical referent when it points to, for example, 'professional associations' (1982:115) whose existence are unambiguously recognised by members. One such association is the BCI Society discussed below in section 2.7. As Knorr-Cetina observes, even where specialist communities can be empirically located, they are never bounded entities beholden only to internal factors. The research practices and rationales of science and even the content of scientific knowledge, are affected not only by factors internal to science itself as inquiry, but also by outside actors such as funding bodies or industry players. Science is comprised of 'transepistemic arenas' (1982:103).

2.3: Online Video Interviews

A small number of online video interviews using Skype and Zoom were conducted with BCI researchers. This method of interview has several advantages as discussed by Lo Iancono et al. (2016). The researcher is not limited by geography or national boundaries, and the potential sample of participants is thus widened immensely. For my own research, this was always the preferred method because BCI researchers and research groups are internationally distributed. I conducted interviews with researchers located in China, Colombia, Germany, Japan, and USA. Because the COVID-19 pandemic hit just as I was beginning my research, Skype and Zoom were being widely used by many people for all sorts of communication, and so the interviews fitted perfectly into this context. Contrary to the ecologically destructive methods of (often air) travel deployed by many fieldworking anthropologists, I was able to keep the carbon footprint of my research to the bare

[18] Likewise, BCI researchers more broadly

minimum as well as being cheap (financially and in terms of time since there was no travel).This method of interview is, in comparison to in-person fieldwork, unintrusive — and thus is beneficial for participants who are busy professionals. Using this method, I found that rapport was perfectly achievable, even in the case of single interviews, but especially with the researcher I conducted multiple interviews with. Body language/non-verbal cues were present enough — especially when I was able to watch interviews back afterwards: because another major advantage of this method is that interviews can be recorded.[19]

2.4: Video Advertisements as Visual Data

In Chapter 5, I use video advertisements for small combat drones as data to theorize possible futures of combat BCIUAV technology. Visual advertisements are 'commercial action(s) designed to influence others' (Banks and Zeitlyn 2015:11), and in this respect are examples of the 'technology of enchantment' (Gell 1992), a concept which I discuss in another context below (see section 2.12.2). Their demonstration of various properties required for membership in the category of small combat unmanned aerial vehicle systems, helped me establish that category as the focus of my inquiry in that chapter and beyond, and their subsequent curation and analysis was largely an intuitive matter. However, due to my training in visual anthropology, when analysing them, I was in part following Banks and Zeitlyn's (2015) advice on visual methods, with relation to the 'internal' and 'external' narratives of images:

[19] All interviewees gave written consent to being interviewed and recorded and were notified when recordings began. All data was managed according to the University of Oxford's Central University Research Ethics Committee's guidelines. **Central University Research Ethics Committee (CUREC) Approval Reference: SAME_C1A_19_082**

> The content of an image we refer to as its internal narrative — the story, if you will, that the image communicates (see Barthes 1981:40). This is not necessarily the same as the narrative the image-maker wished to communicate, indeed it can be markedly different. This is linked to, but analytically separable from, what we call the external narrative. By this we mean the social context that produced the image, and the social relations within which the image is embedded at any moment of viewing. (Banks and Zeitlyn 2015:11)

In Chapter 5, I pay attention to the possible internal and external narratives that the images convey and are embedded in (in terms of both making and viewing), while — most importantly — in a forward-looking manner, attuning to the possible futures of BCIUAV technology that those videos suggest are 'on the way to being given' (Ingold 2014:389).

2.5: Introducing Dual Use

The concept of 'dual use' is central to the thesis. In general terms, it means that an item has the potential to be used in both beneficial and harmful ways (i.e., civilian and military uses). The potential for and possibility of dual use is seen as a 'problem' for researchers. Ironically, the only work in anthropology that deals explicitly with the concept of dual use, is directed internally at anthropology itself. David Price (2012) discusses the 'dual use legacy' of anthropological research in the context of the M-VICO project which in turn built upon the controversial use of the ethnographic 'Human Relations Area Files' (HRAF) database by the US military to conduct cultural engineering and counterinsurgencies abroad. He addresses the wider dual use nature of anthropology in a subsequent book length publication *Cold War anthropology: the CIA, the Pentagon, and the growth of dual use anthropology* (2016).

To my knowledge there is no anthropological literature on dual use research, technology and artefacts in ('hard') science. In this respect the present thesis makes an innovative contribution to anthropology. I look outside anthropology for resources to help think

about/with ‘dual use’. There is a large literature on the subject, and a full review would take us far away from anthropology. Edwards et al. (2014:573) note that ‘(t)here are essentially three types of academic discussion … currently evident within the dual-use literature.’ Some discuss dual use at the level of policy, and some discuss it at the level of the need for education within the scientific community about the issue. However, others discuss it by ‘conceptualizing the dual-use issue as an ethical question; this involves a philosophical and normative evaluation of the responsibilities of those involved in scientific research to prevent the misuse of research and emerging technologies.’ (ibid.). The first two kinds of discussion are relevant for future research. The third kind is most relevant for introducing an anthropological audience to the concept, and also most fruitful for a self-consciously *philosophical* and *moral* anthropology to build upon when addressing scientific research and technology that may be dual use. Philosopher John Forge puts forward an authoritative conceptual but also normative articulation of dual use in general terms that I will review in detail below, and which is part of my analytic framework throughout.

2.6: Learning to See Dual Use with John Forge

‘(W)e always knew that scissors could be used to stab people and that things designed for one purpose could be used for another.’ (Forge 2010:114) Likewise, in the sciences — although in a more complex manner — research, technologies and artefacts with a neutral or beneficent purpose can sometimes also become the means to harm. Indeed, the dual use issue is ‘as old as design and engineering’ (Van Der Bruggen 2012:742). However, the theoretical possibility that nearly any research, technology or artefact ‘*could* have some

bad use' (Forge 2010:116), cannot be sufficient to motivate inclusion in the dual use category. We must somehow narrow down the conditions for membership. Forge responds to the challenge of Resnik (2009) to design 'a definition of dual use that is not so narrow as to exclude matters of real concern and not too wide as to make exercise of control unmanageable.' (Forge 2010:112). The suggested approach to is to judge '*contextual* factors' (2010:116) *risks* and *threats*, that influence the likelihood of an item being repurposed for 'weapons innovation' (2010:117). In this respect, dual use is posed as a *problem*, not just a statement of fact, as will be discussed in due course.

To begin with, research and development are activities. These can produce technologies (knowledge, skills, techniques, methodologies, designs etc). Technologies provide the means by which artefacts can come into being. It is important to distinguish weapons research/ technology/ artefacts from dual use research/ technology/ artefacts. For brevity's sake, in this section, I will use the term 'technology' as implying the research preceding it and artefacts following. A dual use technology has a 'primary purpose' that makes possible both a 'good' 'derivative purpose' intended by the designer, and a 'bad' 'derivative purpose' which *is not* (Forge 2019). Although appearing somewhat naïve, this lack of malign intentionality on the part of the designer with regard to the 'bad' derivative purpose is essential to Forge's account of dual use more broadly. Instead, the 'bad' derivative purpose is intended by 'secondary users' (Miller and Selgelid 2008:526) who exploit the work of the designer to their own maleficent ends. Weapon technology, however, has only one purpose, which is to instantiate a violent relation with other bodies that can be harmful and/or lethal. Forge's position is that 'all instances of weapons innovation are classed as bad uses — this is an unargued assumption — even those done in the name of national defence by friendly states.' (Forge 2010:117) (see discussion of 'values' below). There is no 'dual use' discussion to be had concerning this kind of

technology because it only has a 'bad' purpose, which its designers *intend* to begin with.[20] It is not uncommon, however, for 'reverse dual use' (2010:117) to occur: a technology with at first just one 'bad' (e.g., military) purpose being repurposed for 'good' or indeed neutral (civilian) uses.[21] Still, Forge wants us to think of the dual use *problem* as beginning with a 'good' use, presumably because it is not really problematic when harmful technologies are repurposed to beneficent aims, although harmful technologies remain problematic in themselves.

All this talk of 'bad' and 'good' demands that we recognise another contextual factor, 'values' (2010:117) (2013a:129), which underpins the entire discussion:

> No person in her right mind wants to be harmed: *everyone,* wherever they come from, can agree with that. Thus, everyone can accept a moral code that proscribes harming, and agree that everyone would be better off with less harming. (2013a:127)

Without the 'values' that allow the analyst to normatively identify something 'wrong' in principle with harming, there would be no dual use *problem*. So, despite the importance at one level of distinguishing between weapons technology and dual use technology — the existence of the dual use *problem* (which entails weapons innovation) is premised on the same value system that finds weapons to be 'bad'. In terms of values, then, the difference between weapons and dual use, is that the problem of dual use signifies the identification of an item with *ambivalent* moral valence, by and for a morally positioned subject.[22]

The contextual factors of 'risk' and 'threat' act as heuristic poles, each situationally specific, imagined as being on either end of a 'spectrum' (2010:116). Here risks are

[20] Neither would there be a discussion to be had concerning 'dual use' if, say, a technology had dual derivative purposes that were neutral and/or 'good'.
[21] Which actually applies to drone technology. Van Der Bruggen talks of the 'spin off effect' (2012: 742) which equates to 'reverse dual use' in Forge's terms.
[22] The normative element of identifying a dual use problem might be considered by some to be potentially problematic for anthropology. I discuss this below after further summarizing Forge's argument.

associated with state actors and concern the likelihood of an item's possible future involvement in the development and functioning of 'weapons systems' (2010:116), particularly those which are 'new or improved' (2013a:122). Threats, on the other hand, are associated with 'sub-state actors' (ibid.) and concern an item's likelihood of being assimilated into an 'improvised weapon' (2010:117). For Forge, a threat requires evidence of the 'intention' (2013a:122) to *use* the item to harm. Items will pass in and out of the dual use category based on the risks they pose and the likelihood of threats to use them at a given time. The threat to use the harmful artefacts is not usually made by the scientists who research, develop and design them. Rather, scientists pose risks by providing 'the *means* to harm' (2008:155). It can be said that given their causal responsibility with relation to the outcome of their research, and its consequences in use, that they are harming *indirectly:* 'aiding others in doing *future harm*' (ibid my emphasis). And so, given my primary concern with the activities of scientists, rather than the activities of soldiers, even though it is the latter who, as it were, 'actually' do the harming with the resultant artefacts: the proscription of providing the means to harm emerges as Forge's 'means principle' (ibid.).

Importantly, however, an item can pose both risks and threats at the same time. Often it is the case that a state-sized or state-funded actor poses a risk by developing (or aiding the development of) a technology, which can then become involved in weaponry via the improvisations of, say, a terrorist cell: resulting in the 'threat' of its use. But there needn't be a 'terrorist' cell involved. States themselves intend and threaten to use weapons they themselves develop. Beginning from the 'risk' pole — where usually the most advanced, powerful, potentially destructive technologies first appear — it is the primacy of risk over threat, the former as a condition of possibility of the latter, that helps identify the dual use

problem within the scope of this discussion.[23] This also helps us locate the optimum level at which to implement *regulative* controls: 'the "higher up" the knowledge spectrum…the better off we will be' (2010:117).[24] Forge's 2010 definition is:

> An item (knowledge, technology, artefact) is dual use if there is a (sufficiently high) risk that it can be used to design or produce a weapon, or if there is a (sufficiently great) threat that it can be used in an improvised weapon, where in neither case is weapons development the intended or primary purpose. (ibid)[25]

Forge's later definition (2019) (see below) brings increased conceptual clarity by reaching a more incisive *terminological* solution. Originally Forge talked about dual use in terms of 'primary' ('good') intended and ('secondary') 'bad' unintended purposes. The 2019 definition instead involves talk of a 'primary purpose' and 'derivative purposes':

> (A)n instance of dual use comprises two functional elements that derive from the same primary element, which is to say that each 'dual use' is a derivative purpose. Research can be said to be dual use as a consequence of the primary purpose of its outcome, which in turn enables the derivative, dual use, purposes. (2019:41-42)

To demonstrate the importance of this terminological shift, we must consider the example Forge (2010) gives of a dual use *technology*: an aerosolization technique for bacteria that produces particles 'of the order of a few microns' (2010:113). The 'primary purpose' of this technology, says Forge, is pest control aimed at gypsy moths. However, this very same technique can be put to use (perhaps with minor modifications) in the aerosolization of

[23] Therefore, we aren't interested in the contents of the cutlery draw, where artefacts like scissors could pose a threat in rare circumstances but pose no significant risk in the first place.
[24] Nevertheless, Forge believes the buck stops with the individual scientist who actually creates harmful technologies, and it is to them that his work is primarily addressed. Clearly, there would be less need to implement regulatory controls higher up the knowledge spectrum if no one created harmful technologies in the first place.
[25] Building in part on Forge for his own definition, Koos van Der Bruggen writes: 'an artefact, a technology or a natural product will become ''dual use'' only by a combination of (technical) properties and intentions.' (2012:746). van Der Bruggen thinks his own definition is 'wider', but I think it just places a useful re-emphasis on the fundamental interplay of contextual factors.

particles of a similar enough size, but of a different bacterium: anthrax, which can be deployed as a biological weapon — this being the 'bad' secondary purpose:

> We have here one and the same technology processing different organisms: the technology is the same, the inputs and outputs are different—one good, we assume, and the other bad (2010:114).

Considering the aerosolization using his 2019 terms: no longer does the primary purpose describe the 'good' use (intended by the researchers), standing in moral opposition to the 'bad' secondary purpose (unintended). Instead, 'primary purpose' now describes the specific qualitative substrate, as it were, of a technology or artefact which in turn affords the *derivative* 'good' and 'bad' purposes to which it can be put.[26] That the purposes are now spoken of as *derivative*, indicates that they are supervenient in relation to the specific properties of X — which the talk of primary and secondary purposes did not quite capture. Here Forge arrives at the *terminological* solution which captures with most clarity the crucial conceptual insight of dual use technology.

In 2013a, drawing upon the moral philosophical position originally described in *The Responsible Scientist* (Forge 2008), *responsibility* is taken to be the guiding concept in relation to dual use. The focus is dual use 'research', given its primacy in the hierarchical taxonomy of research, technology and artefacts, and in the movement across the spectrum from 'risk' to 'threat'. Fellow philosopher Bernard Gert's (1998) account of 'common morality' for which 'the value of not harming' takes precedence (Forge 2013a:129), is revealed as the foundation for Forge's own 'non-consequentialist' (ibid:126) position concerning 'forward looking' (ibid:123) responsibility. The idea that the bad use of their

[26] Importantly, the idea that the scientists don't intend the bad use but do intend the good, remains constant. And of course, in moral terms, the good and the bad use are still diametrically opposed.

work is unintended by the scientist remains central to Forge's definition of dual use research.

To begin with, scientists should accept that 'science affects people (SAP)' (ibid:124). Subsequently, they must recognise a complex '*role responsibility*' (ibid:123) specific to their position, which, given their intimate knowledge of its functions and their broader knowledge of the world around them, involves being aware of their own work's possible future uses. Compounding this is the 'changed context of science' (ibid:125) since the coming to fruition of the Manhattan project — which was based on the work of theoretical physicists — and the subsequent decimation of Hiroshima and Nagasaki, after which it became difficult to claim that there is any such thing as 'pure' research. Instructive in this regard is a letter published in *Atlantic Monthly*, written by mathematician and founding figure of cybernetics Norbert Weiner replying (indignantly), to an anonymised fellow scientist who had written to him privately. The scientist in question, was, in the newly forged peacetime, inquiring after the work Weiner had done during WW2 (a supreme emergency) on guided missile systems for the US military. The following quote from Weiner's reply captures the changed context in which the division between pure and applied science was irremissibly blurred.

> (T)o provide scientific information is not necessarily an innocent act, and may entail the gravest consequences. One therefore cannot escape reconsidering the established custom of the scientist to give information to every person who may enquire of him. The interchange of ideas which is one of the great traditions of science must of course receive certain limitations when the scientist becomes an arbiter of life and death. (Weiner 1947).

The first tier of Forge's account of the future oriented moral responsibility of the scientist, emerges in a prohibitive principle or *rule* 'demanding' that the scientist look ahead and 'avoid doing research that can have harmful outcomes' (2013a:127). The second tier is an *ideal* aspect which 'encourages' rather than obliges them to 'do research that prevents

harm' (ibid.), with emphasis placed on the first tier for the simple reason that it is much easier to refrain from harming than to 'do good'.[27] But the rule of tier one is not absolute. If they conduct harmful research, they must be able to morally justify it somehow. If they knowingly work on a weapons system, then very often this will be done in the name of *defence*, and thus with reference to specific contexts and circumstances. Nevertheless, the capacity to defend with a weapon supervenes on its capacity to harm, which is why there is technically no such thing as a defensive weapon. 'All the derivative purposes of an artefact presuppose that it fulfils the primary purpose, and this is true of weapons as well as every other artefact.' (2019:34). Ultimately, this makes weapons research (WR) very difficult, if not impossible to justify in the long run, something which will be further discussed in Chapter 7.

With dual use research — which on Forge's account isn't WR, but does involve weapons in the second degree — then the (intended) good use must be such as to balance the checks with the (unintended but foreseen) bad use.[28] Forge thinks that the prevention of harm counts as a good use.[29] Importantly, any such 'justification [for a bad use] needs to take the form as if it were the bad use that is the main object of the investigation' (2013a:130). Today scientists should find it easier to anticipate possible future uses of their work, because it is increasingly standard practice in both publications and funding proposals to cite future applications, stating their work's usefulness in ways that satisfy funding bodies and so on. However, despite all this, Forge wryly observes that scientists would rarely be expected to cite possible harmful or dangerous uses in their grant proposals or published articles.

[27] These two interlinked kinds of future oriented responsibility that the scientist should consider at all times, map onto Gert's distinction between 'moral principles' and 'moral ideals'.
[28] Here a neutral use isn't sufficient in place of a good use.
[29] To my mind this is too narrow a summary of 'good' uses.

Moving on to the 'wide view of backward-looking moral responsibility' (2013a:128) Forge asks whether a scientist can be responsible for something they do not intend, but (within reason) could have foreseen or did foresee?[30] The orthodox philosophical position or 'standard-view' (ibid.) holds that they cannot, because intention is taken to be the essential factor in voluntary action, and thus the attribution of responsibility. And yet, the following is 'simply a commonplace' (ibid.): S does R, which brings about A which they intend, in the knowledge that by doing R, B could also occur, which they do not intend. If B occurs, we turn round and say to S: "well, you *knew* that upon doing R with the intention of producing A but not B, that B might also occur. Thus, even though you did not intend it, you are held responsible for B."[31] The criteria of intention for the attribution of responsibility on the standard view is too narrow, and so Forge takes this commonplace as the basis of the wide view of backward-looking moral responsibility.

But what about the possibility that a scientist really might not foresee the likely uses of their work? Because science is nowadays recognised as a 'a social institution and not something engaged in by disinterested seekers after the truth' (Forge 2000:348) claiming ignorance of contextual factors beyond the act of research itself is not an acceptable way to deflect responsibility. '(E)ven the pure researcher…who only seeks to publish papers, ought to know SAP. This is a general item — a "universal" (2000:347). Forge considers responsibility with regard to dual use research to be 'cashed out' (2013a:132). It traces back foreseen and unforeseen, intended and unintended, bad and good effects of dual use technology and artefacts to the scientists. Taking a 'conservative' (ibid:131) position, and

[30] Clearly, if they could not reasonably be expected to foresee a bad use at all then they cannot be held responsible for it.

[31] However, this is hardly a 'convincing philosophical rationale' (2013:128 n20). Forge (2008, 2013b, 2019) discusses the intricacies at length elsewhere. From a bootstrapping perspective (Zeitlyn and Just 2014), at this time, I will leave this to philosophy, and settle if only provisionally, for a practical understanding such as Forge's 'commonplace'.

on top of all of the above, Forge calls for censorship of any findings that pose a risk, and possibly a threat.

In conclusion: to design a weapon whose primary (and really *only*) purpose is to harm, and, importantly, to *provide* that design to others who will subsequently use it to harm – following the means principle, is morally wrong. So, as long as we agree with the basic value system proscribing harm and providing the means to harm: certainly to *knowingly* conduct dual use research, that, in one of its futures leads to innovation in weapons or weapon systems, is morally wrong for the same reasons as it is to conduct straight-up weapons research (2019:43). As noted earlier, in order to meet the minimal standards of moral rectitude prescribed by the first tier of Forge's position, scientists need not *do* anything. They are required only to *refrain* from creating and providing the means to harm. Having learned something about dual use, we must now briefly consider the general variety of weapons innovation at stake in the present case.

2.7: Weapons Innovation

> A weapon is defined as "a means of contending against another" and "…something used to injure, defeat, or destroy". Both definitions apply to neurotechnologies used as weapons in intelligence and/or defence scenarios. (Giordano and Wurzman 2011:56)

'The Neuroweapons Threat' (Giordano 2016) concerns the dual use potential of a wide range of neuroscience research, neurotechnologies and artefacts, none of which are weapons of mass destruction (Giordano 2017:14), and most of which are non-kinetic. Neuroweapons span both lethal and non-lethal categorizations, and the menu of possible and actual examples is especially diverse. Moreno and Evans (2016) write that '(i)nternational law strongly proscribes the use of neuroweapons, which target the brain and central nervous system and can be chemical, biological, or toxin-producing in nature.' And yet, there are no extant conventions international or otherwise, on neuroweapons *per*

se (Giordano 2016). In principle though, drug type neuroweapons would seem to fall under the chemical weapons convention, and at least some of the other neuro-nasties under the biological.

However, there is another variety of neuroweapon little discussed, neither chemical nor biological, but *electronic*. Neurotechnologies developed to help paralyzed patients communicate or control prosthetics are now being considered for the control of combat equipped robots. In this case, we are concerned with the 'brain-machine interface' (DeFranco et al. 2020:50) type of electronic neuroweapon, which, importantly, works in the inverse manner to chemical and biological varieties, by exploiting certain neural mechanisms *in the user* as an output to operate the machinery of war. In the absence of a convention on neuroweapons *per se*, a convention on *electronic* weapons (Requarth 2015) might be relevant. But no such convention exists (yet). In short, this is the *general sense* in which BCIUAV research and technology can be said to be dual use. I discuss this in more detail in later chapters.

DeFranco et al. (2020:59) call for '(i)nternational surveillance and research' of and into neuroweapons and the conditions of their emergence, with a view to eventual regulation:

> Towards these ends, assessing the scientific literature is an important step, as it could depict present and future research trends and afford means to monitor researchers who are knowledgeable, skilled, and able to exercise methods of creating neuroweapons. (2020:60)[32]

Starting from the published literature, this thesis contributes to the study of 'knowledgeable, skilled' individuals capable of designing the system frameworks for at least one type of neuroweapon. On the one hand, despite concerning neuroweapons development, this enacts the 'spying eye' surveillance (Grimshaw 1999:39) that usually characterises anthropology's way of seeing into societies and the lives of human beings.

[32] See DeFranco et al (2020:60) for a wider range of surveillance priorities.

On the other hand, granted the subject matter, it is similar to the monitoring/ surveillance that DeFranco et al. mention. For DeFranco et al. surveillance is associated with efforts by nation states to gain intelligence about the military activities of other nation states, particularly those regarded as actual or potential antagonists. Indeed, DeFranco et al. are officially associated with the United States security and military complex — as far as I can tell, displaying no explicit concern with *their own* state's efforts to develop neuroweapons. However, in my usage, surveillance is not beholden to or operating for any nationalist, militarized agenda, and instead is voluntarily undertaken, conducted in the interests of Anyone and powered by a cosmopolitan love (see below).

2.8: The Responsible Anthropologist: Cosmopolitan Confessions and Human Figures

In anthropology a traditional view with a conservative bias exists — represented by, for example, D'Andrade (1995), Zigon (2007), Fassin (2008), and most importantly in the context of this thesis Nicolas Langlitz (2020a) (see Chapter 8). Alongside an envy for the disinterested gaze of the 'hard' sciences, this perspective is characterized by relativistic thinking and a worry about the subsequent difficulty, especially in *moral* terms, of claiming one worldview to be superior to another, and the attendant dangers of presuming the righteousness of intervention in the worlds we study on moral grounds. These are legitimate concerns. It is true that where possible, '(p)art of the point of academic anthropology is the aspiration to neutrality, to a projection that is as even-handed as we can achieve granted our inevitable and recognisable biases' (Zeitlyn 2022:25). But we must also remember that even a purportedly neutral position is a political one (ibid:105). The aspiration to neutrality is easier to achieve where nothing of great importance is at stake, or, more questionably, where we actively, methodologically choose not to pass

judgement on troublesome issues in order to avoid having our pretence of neutrality challenged (e.g., Langlitz 2020a).

Where the stakes are higher, and where our attention is drawn to issues of great concern, a forced adherence to relativistic neutrality is potentially inappropriate, and not necessarily humane. Nigel Rapport (2002:156) writes that relativism 'has morally nihilistic, politically conservative and quietist consequences; the noble goal of understanding others in their own terms slips into a legitimation of inegalitarian and repressive political regimes and facilitates acquiescence to state repression.' Tim Ingold (2021:269) advocates for anthropologists to become scholar-activists in the interests of 'pointing the way to a different relation to the environment from the one we have now, a relation that would allow us to live more sustainably, and to pass on a habitable world to coming generations.' In line with Rapport's and Ingold's reasoning, I argue that as professional anthropologists, dual use and weapons research are not issues we can afford to be neutral on. Addressing them from a perspective of concern, if and where we find them, is part of the task of anthropologists as scholar-activists.

In the interests of transparency concerning my own 'philosophical and political biases' (AAA Ethical Code in Fassin and Lézé 2014:369) as a morally positioned person, and as an anthropologist (cf. Stade 2018) I agree that 'everyone would be better off with less harming' (Forge 2013a:127), and therefore that to design weapons, and to *knowingly* engage in dual use research which entails weapons innovation, is morally wrong. I believe it is the very 'right to life' — *the* Human Right that precedes all others, found in Article 3 of the Universal Declaration of Human Rights (UDHR) (1948/2021) — that is trampled upon by knowingly dual use (KDU) and weapons research (WR) (see Chapter 8). Building on Rapport, whose thinking is central to my own project, these are acts that from a *cosmopolitan* perspective, indiscriminately threaten the 'safe passage' (2019:6) of

'Anyone' (2012). In a nutshell, '(t)he cosmopolitan project is to provide space for the flourishing of individual-human capabilities and to offer succour for its potential liabilities.' (2012:6)[33]. But who is Anyone, this 'cosmopolitan figure of anthropology' that Rapport conjures? The human as at once precious, unique, ultimately inscrutable *individual* existing within yet stretching beyond the impositions of cultural categorizations and symbolic interaction; *and* representative member of the human *species* at large. Anyone has certain inalienable rights that must be recognised and protected — human rights. But from Rapport's own cosmopolitan anthropological stance, influenced by key figures of political and philosophical liberalism such as J.S. Mill (see also Rapport 2010a) a key tenet is the right to be left to one's own devices and to design one's own life projects as far as this can be taken without infringing upon that right of anyone else (2012:131-132). Also, and in line with the latter, the right to 'futurity' (2012:4), 'to become someone else, anyone else (2012:185), and thus be free from the impositions of fundamentalist religious education or other authoritarian cultural and societal influences that might oppress the flourishing of individuality.

However, as mentioned above — we must here include the right to life itself — and in this respect, the right to 'futurity' includes continuing to exist. Without this there is nothing else. A truly meaningful articulation of 'cosmopolitan politesse' … 'that virtuous social state where Anyone is recognized as an end in themselves — and where norms of social interaction are in place such that a balance is achieved between space and care' (2012:174) must be explicit about this right's centrality. Human life and thus the Human Right to life is threatened by the technology I study, in its maleficent guise. In a minority of cases of

[33] 'Cosmopolitanism' here is not meant to refer to the contrast between 'cosmopolitan' urban centres and rural peripheries, a distinction that confused some early readers. It is instead a philosophical anthropological term, concerning the unity of humankind, contrasted with a communitarian, culturalist perspective that divides humanity according to various socially constructed categorizations. My use of the term is therefore more related to the contrast between global and local, than between centres and peripheries.

BCIUAV research, rather than the 'good manners' (2012:195) of an idealized cosmopolitan politesse, we find striking examples of *bad manners* that in cosmopolitan and ecological terms, pollute the public space we all share and stalk the right to futurity — in the most literal sense — of Anyone. '(T)olerance and generosity' (Malinowski 1922/2014:535), although perhaps not love (see below) may reach their limits here.

Rather, then, as might be the case in a culturalist paradigm of anthropology, some cultural or ethnic group immediately set against others in a simultaneous fragmentation of the species and a lumping together of individuals into groups, being the focus of attention: Anyone is the figure of the human with which this thesis, is ultimately concerned. And, indeed, concerned *for*, because as I will discuss in the final chapter with reference to Rapport's recent work, *love* is key to the approach taken, and the proposed moral vision for anthropology. Love, as Rapport details it from a cosmopolitan anthropological perspective, and being very much connected to human rights discourse (see also Rapport 2002), is a civic virtue (2018) and is meant here in the sense of *agape* (2019). Love transcends identity politics and the communitarian infatuation of relativistically inclined anthropology. Instead, incorporating love, cosmopolitan anthropology takes the individual as its ontological priority, respects individuality and acknowledges the conditions under which Anyone can flourish. Love 'might be the motivational force by which cosmopolitan politesse is *understood* as virtuous, and *welcomed* as an ethos and interactional code' (2019:45). Following from this, both in alignment with and in the hope of building on Rapport's work, I too believe love can also be a motivational force, specifically in contemporary anthropology with relation to the approaches we take and the subject matters we address (see Chapter 8). It is perhaps reminders of death that provoke the most potent 'loving recognition' of Anyone, on a potentially cosmic scale (2019:200-213). Such revelations, which concern both BCI research *and* anthropology, support the moral vision

of *human conservation* (see below). To illustrate this, in the final chapter, I discuss the famous print by WW1 artist Otto Dix, '*Wounded Man* (*Autumn 1916, Bapaume*)' (1924). Indeed, something we mustn't forget about Anyone, about us, and what the issue of both WR and certainly KDU research and technology — especially in the context of BCI research — forcefully reminds us, is that our condition is also encapsulated by the figure of the human that Christopher Davis conjures, and which forms part of the title of the present thesis. We are 'empathic predators' (2012:509). A mixture of care and lethality define our nature:

> We know things will kill and we know torture hurts because we're empathic, but because we're predacious we do them anyway. In the doing, we attempt to protect our capacity for empathy by defining our "victims" as those deserving of the treatment we inflict on them. (Davis 2012:510)

In addressing the issue of dual use and weapons innovation in BCI research, albeit initially only with relation to one fringe application:

> we are dealing here with the problematic relations of *anthropos*, *logos* and *ethos* — and their saturation with diverse forms and figures of *pathos*. The multiple relations that have obtained, do obtain, and might obtain between these terms is the terrain to which the anthropologist of the contemporary is drawn. (Rabinow 2008:100)

In an important sense, like Rabinow, in the final analysis I am asking:

> (W)hat *logos* is appropriate for *anthropos*? And how should that *logos* be practiced so as to increase our capacities, without intensifying the myriad relations of brutalization that are so pervasive unto our times? (ibid:14)

2.9: The Conversational Imperative

Science itself is a cosmopolitan phenomenon bringing together individuals of numerous nationalities, ethnicities, and other forms of collective identity together in the search for knowledges. *Dual use* scientific research is a cosmopolitan issue specifically because it entails weapons innovation and thus cuts through the illusory separations of culture.

Weapons are not confined in their deleterious effects to one group or another. Anyone can be harmed or even killed by the artefacts that result from (knowingly and unknowingly) dual use research and WR. As I discuss in Chapter 7, the power to design weapons and conduct KDU research is a *cosmopolitan power*, albeit one reserved for a relatively quiet, highly educated elite (Bourke 2017). The sad fact is that despite all the wonderful work they otherwise do, and without which the world would be a worse place in many respects: it is nevertheless also scientists and engineers who bring new weapons into the world, and who ultimately make other human beings suffer and die in ways they otherwise would not. Anyone as KDU or weapons researcher — and thus as predator — inflicts upon Anyone else, as victim, the 'condition of targeticity' (Marcus et al. 2012:4). In BCIUAV research, a majority of seemingly completely beneficent or neutrally positioned researchers appear to conduct dual use research *unknowingly*. However, amidst the mass of unknowingly dual use (UDU) research, there are a few teams who are open about the dual use possibilities of the technology they develop and thus conduct KDU, as well as a few who do not explicitly mention any harmful purposes of their work but do declare military funding, and also a very few conducting straight-up neuroweapon research (NWR)(see section 2.11). One imagines that the wider 'BCI community' (a term used by some of my informants, and by which I mean all researchers who work with BCI and may or may not belong to the BCI Society (see below)) has researchers in all these categories too. I would think that only a *minority* of BCI researchers engage knowingly in harmful projects. However, my research shows that while many other ethical issues are discussed by the BCI Society (see Chapter 6) the issue of dual use and weapons research is not yet on their conversational agenda. So, this thesis is underpinned by a common-sense rule I call the *conversational imperative* that asserts the importance of at the very least talking, openly, publicly, about the issue of dual

use and WR from an ethical perspective. It may be stated more formally, and in general terms, thus:

> *in any situation in which the activities conducted by some or all members of a professional community have the (knowable and/or known) possibility of leading to weapons innovation, then this ought to be at the very top of the conversational agenda.*

Conversation and debate may reveal that attitudes to KDU or straight-up NWR, are, on the whole *laissez-faire* (or worse, encouraged). But conversation may alternatively reveal that a majority of practitioners are unhappy with the prospect, do not want it to be an accepted element of their milieu, and do not accept association with practices that contribute to the harm and killing of human beings. This all concerns what lawyer and systems theorist Sir Geoffrey Vickers termed an 'appreciative system', 'a set of readinesses to distinguish some aspects of the situation rather than others and to classify and value these in this way rather than that' (1965:67). Novossiolova et al. (2018) consider this concept crucial when thinking about how to understand and raise awareness of the dual use problem in science:

> Every culture includes an appreciative system which must be at least sufficiently shared to guide collective action, to mediate communication, and to give the society which generates it enough self-confidence to survive. And this interpersonal artefact is sustained and changed by transmission through the series of personal appreciative systems it develops and supports in succeeding generations… it is only if the appreciative system classifies a situation as one that should be changed will a problem be seen to exist, and it is only if a problem is seen to exist will a solution be possible. (Vickers in Novossiolova et al. 2019:55)

My intention is to eventually engage with the stakeholder community in question, with reference to the appreciative system that presently exists among them, but this goal is beyond the scope of the thesis. The BCI Society is the major international professional organization for BCI researchers, 'with 300+ members located in over 24 countries', and whose aim is to 'foster research leading to technologies that enable people to interact with

the world through brain signals.'[34] While not every BCI researcher belongs to it, the BCI Society is an actually identifiable entity or 'unit' in the real world, a 'professional association(s)' (Knorr-Cetina 1982:115) with an empirical referent and not just a theoretical object. The BCI Society is a stakeholder, perhaps the most important one, when it comes down to the future of BCI research and technology. However, this means that they are not only stakeholders in the beneficent, or just neutral, and sometimes financially profitable outcomes of BCI research and technology — but also in the potential development and proliferation of the next generation of brain-computer interface type electronic neuroweaponry. This responsibility has not been openly acknowledged by the Society. To assume that the BCIUAV is the only problematic technology or neuroweapon involving BCI would be naïve. But what we learn from the case study of BCIUAV (for which, I must unfortunately state, it is *too late*) might help in our understanding for the future. In any case, the BCI Society's existence is fortuitous because as a cosmopolitan society in itself it brings together many individuals across the world, facilitating issue specific communication between members, and presents the most hopeful route for activist research in future. Only time will tell whether or not the BCI Society take kindly to an intervention that seeks to prod them into having a conversation, and whether or not the appreciative system of the BCI Society can eventually classify the situation concerning dual use and neuroweapons research as morally problematic. But the responsibility will still always fall at the feet of individual scientists, as it does now, *not to* engage in projects that they know might or will harm and kill.

[34] https://bcisociety.org/about/ (https://perma.cc/WR5A-ASMH)

2.10: The Conservational Imperative

What I am calling the *conversational imperative* to discuss pressing ethical issues, coexists with, and is grounded by another general precept: the *conservational imperative*. As discussed in Chapter 8, this imperative follows from the proposed moral vision of *human conservation* for anthropology, by which I mean that anthropologists ought to be keeping an eye on the human community at large and delving into issues such as dual use and weapons innovation that potentially threaten the existence of Anyone. As scholar-activists, they might effect modest social transformation that can help make the world a more liveable place. This takes a cosmopolitan approach to anthropology from a well-meaning stance to a *loving* but *critical* engagement. In order to even entertain the possibility of conversation in the interests of conservation, however, a great deal of work must be done.

2.11: 'Red Flag' Cases

As noted previously, in my view the majority of BCIUAV researchers, are conducting dual use research, but unknowingly (UDU) and may not even be in a position to know this. However, a small number of papers can be designated as 'red flag' cases, meaning that I take them to represent research in which the researchers are either *in a position to know* (PTK) that their work is dual use; or are *knowingly* conducting dual use (KDU) or just neuroweapon research (NWR). Given the seriousness of this matter, concerns have been raised by early readers about the 'danger of painting an overly Machiavellian account of scientists strategizing and calculating', which could be potentially libellous. Libel refers to a defamatory statement that is in a permanent form, such as an academic publication. In UK law, the 2013 Defamation Act states that 'a statement is not defamatory unless its publication has caused or is likely to cause serious harm to the reputation of the claimant.'

[35] Several defences against libel claims listed by the act are relevant here. I include only the most relevant clauses of those defences below:

2) Truth

(1) It is a defence to an action for defamation for the defendant to show that the imputation conveyed by the statement complained of is substantially true.

3) Honest opinion

(1) It is a defence to an action for defamation for the defendant to show that the following conditions are met.

(2) The first condition is that the statement complained of was a statement of opinion.

(3) The second condition is that the statement complained of indicated, whether in general or specific terms, the basis of the opinion.

(4) The third condition is that an honest person could have held the opinion on the basis of—

(a) Any fact which existed at the time that the statement complained of was published

4) Publication on matter of public interest

(1) It is a defence to an action for defamation for the defendant to show that—

(a) the statement complained of was, or formed part of, a statement on a matter of public interest; and

(b) the defendant reasonably believed that publishing the statement complained of was in the public interest.

6) Peer reviewed statement in scientific or academic journal :

[35] https://www.legislation.gov.uk/ukpga/2013/26/crossheading/defences (**https://perma.cc/DU6C-5M5Q**)

(1) The publication of a statement in a scientific or academic journal (whether published in electronic form or otherwise) is privileged if the following conditions are met.

(2) the statement relates to a scientific or academic matter

(3) before the statement was published in the journal an independent review of the statement's scientific or academic merit was carried out by —

(a) the editor of the journal, and

(b) one or more persons with expertise in the scientific or academic matter concerned

With relation to the defence of truth, any reasonable person can see that the facts from which my speculative hypotheses are formulated *do* support the *possible* truth of those hypotheses (see criteria A and B below). To prove that they are without doubt *untrue* would be beyond the realms of plausibility. But to prove that they are certainly true is beyond my own epistemological reach — and this must be acknowledged. Whether this would meet the standard of 'substantially true' (which, in legalese, as far as I understand does not mean the same thing as 'true') is unclear and could only be established through litigation, which must be avoided if possible. The hypotheses in question are technically *honest opinions* based on available facts and are proposed in the spirit of adequacy (Zeitlyn 2009). I take this to be the most important defence at my time of writing. However, with relation to the defence of 'publication on a matter of public interest', I do believe that it is in the public's interest to be aware of the risks and threats posed by research and development that could or will lead to electronic neuroweapons innovation. The public I will reach is obviously very small at this time and will consist entirely of academic readers. Finally, at publication stage, I am confident that **6** (1, 2, 3, a, b) would

be met. And this is why it is necessary to set out my reasoning on the matter of red flag cases.

My early readers counselled that I needed to be careful about claims concerning what scientists 'intend' and pointed me to literature in science and technology studies discussing 'interests'. The latter are 'social and/or cognitive' (Woolgar 1981:367) factors which motivate and inform the course of action taken by an individual (reaching an outcome in accordance with those interests). Knorr-Cetina's (1982:129n32) concise summary of the difficulties involved in the analyst's attributing interests to scientists, and explaining their actions in terms of those interests, is useful here:

> …such explanations must come to grips with the problem (a) that these interests are not generally obvious to agents themselves; (b) that interests, like other phenomena, appear to be negotiated and accomplished in social action rather than to simply 'exist'; (c) that 'objectively' attributed and 'subjectively' perceived interests do not always coincide; which means (d) that there is a question as to who may or may not legitimately identify somebody's interests, and on what grounds.

I have tried to avoid this angle of inquiry entirely. Along with interests comes the question of 'intentions'. These are not the same things, although they can and do overlap (i.e., where intentions flow from interests, and perhaps even where it is possible to infer interests from intentions). However, to reduce legal exposure, as well as for epistemological reasons, I am not speculating about intentions or interests and will concentrate on published statements. Recalling Forge on dual use, intention is taken to be too narrow a category when it comes to attributing responsibility to scientists for the outcomes of their work. Rather, it is awareness and thus knowledge that matters. Indeed, Forge (perhaps naively) assumes that scientists conducting dual use research *do not* intend the harmful derivative purpose, although this does not imply that they are not responsible for it. For Forge, intention only appears in the case of straight-up weapons research.

> I understand "weapons research" to refer to research conducted with the *intention* of designing or improving weapons systems or the means for carrying out activities associated with the use of weapons, such as command, control, and communication. (2008:153)

I disagree with Forge about weapons research. I argue that weapons research, just like dual use research, can be done *unintentionally, but knowingly*.[36] This strange sounding argument is a product of my attempt to reduce legal exposure by avoiding attributing intentions, but also an acknowledgement that it is usually impossible to discern intent from scientific articles alone. Here, in the case of both dual use research and weapons research, I think it is *awareness* and *action* that matters: not intention.

The diagnosis of 'red flag' cases is based upon two criteria:

A: *military funding*

B: *explicit mention of harmful derivative purposes (e.g., battlefield / combat uses)*

In my honest opinion a paper that meets criteria A or B, can be fairly called a 'red flag' case as I now discuss in more detail. It seems reasonable to infer from **Criteria A** that researchers declaring military funding sources were *aware* of the possible harmful implications of their work; and from **Criteria B** that the authors of a paper who explicitly mentioned combat uses of BCIUAV technology, were *aware* of the possible combat uses of their research. From this perspective, researchers satisfying *both* criteria A and/or B would be engaging in KDU research. However, as I will discuss below, using criteria A it is not possible to assume knowledge in the same way as with criteria B.

[36] Although, clearly, weapons research can be done intentionally, too.

It might seem commonsensical to assume that if scientists took military money to conduct their research (satisfying criteria A) then whether they intend it or not, they must be aware, and thus know that their work is understood and appreciated by military entities (valuing it according to military interests). However, this is not necessarily the case. There is an epistemological disjuncture between what the analyst can know about a piece of research, and what the analyst can know about what the scientists know about that research. From the perspective of the external analyst, I use Latour's (2013) concept of 'pre-positions' to help justify criteria A. In a conceptual complex that has multiple uses in the present thesis (see also section 2.12.6), I find that Latour provides a powerful way to grasp the significance of military funding in the diagnosis of 'red flag' cases. Latour builds upon the radical empiricism of William James in the interests of preserving a plurality of interacting yet distinct modes of existence each rational in its own way, as opposed to making the assumption that there is fundamental objective knowledge that trumps all the others and by which all other values can be judged. Instead, we should find *pre-positions*[37] at the heart of every distinct but nevertheless interlinked mode of existence, whether that be law, religion, politics, science or fiction — a positioning that gives us a sense of the 'tonality' or 'interpretive key' (2013:57) in which the propositions following it should be taken. They may subsequently be judged as to the conditions of their felicity and infelicity, happiness and/or unhappiness, terms taken from J.L. Austin (1979a), which signal mode-specific *veridiction* rather than the absolutism of truth and falsity (see also Chapter 4). This is a matter of following experience through the 'lines of force' (2013:237) of the mode in which it persists and is set upon a trajectory, having a certain sense. In fact, we should take

[37] Due a translational quirk from the French to the English version, the term which I have modified with a hyphen to be 'pre-position', appears in Latour (2013) as 'preposition'. It is clear enough that the term as it appears in the original is not meant to refer to little words in English that connect nouns to other words. Nevertheless, a trace of the grammatical logic of the former is present in the philosophical anthropological terms in which it should be taken here. 'Pre-position', then, as it is meant here (and hopefully clarified by the hyphen) coming before a corresponding set of *propositions*, sets the tone for the latter's sense.

as synonymous ‘trajectory, being, and direction, sense or meaning’ (ibid.) Applying this seemingly abstract set of concepts to the present case, I take military funding to be a pre-position, and the research and technology underpinned by it to be propositions or, indeed, utterances (Austin 1979a) whose sense, or direction is given by that pre-position (and so here we are thinking about utterances in a more-than linguistic way, too (Ogborn 2020)). Given our reliable contextual knowledge of military interests and intentions, it is natural infer from the declaration of military funding to the possibility that the research in question *may* lead to weapons innovation. Militaries, like any serious investor, rarely fund research that is not perceived by them as being in potential or definite alignment with their own interests and intentions.

Despite using philosophical anthropological concepts to frame this here, no such conceptual work need be done by scientists. In common sense terms, and following Forge, it is incumbent upon scientists to possess a minimal level of awareness about their own work’s protendings. It is hard to imagine a *real* scientist so ignorant as to have missed this. And yet, in a similar way to the discernment of scientists’ intentions, it is impossible to know from a research paper alone that the authors know about the implications of military funding. What we can say in the case of criteria A (in the absence of criteria B) is that on top of their own basic knowledge of the world around them and the specialist knowledge of the scientific fields in which they operate:

> *Someone in this position is uniquely qualified to understand the possible military applications of their own work, not least because of their role in making applications to funding bodies and the relationships that they must forge with those bodies in order to navigate the research process.*

The researchers/authors whose papers meet criteria A, are therefore in *a position to know* (PTK) that their research is dual use, and is valued by military entities according to military interests. For Forge, I think this would be a clear example of weapons innovation

being a foreseeable outcome, and thus good reason to suggest that the researchers in question should know, have a responsibility to know, have a future-looking responsibility not to do that research, and a backward-looking responsibility for its harmful outcomes if they continue with it. However, in the present thesis I afford researchers whose papers meet criteria A (without meeting criteria B) a degree of (barely) plausible deniability of knowledge concerning the possible weaponization of their work. Ultimately, then, meeting criteria A, the scientists in question may not intend to be designing the next generation of neuroweapons, and they may not actually know that they are doing this: but they are at the very least, in a PTK that they very likely are.

Criteria B is much more straightforward. If scientists openly write about military uses of the technology in question, they clearly *know* of the dual use nature of their own work. They conduct KDU research. Independent of whether the work is funded by a military source or not; the explicit linguistic utterances (concerning e.g., combat uses) although in one sense literal propositions — could be taken in turn to be pre-positions, framing the research and technology in a particular manner, sending it out into the world on a certain trajectory. On meeting criteria B, it is perfectly reasonable to infer that the researchers are *aware*, that they *know* about the dual use and thus possible weaponization of their work.

In sum, I believe that my reasoning as set out here is adequate; that to diagnose papers as red flag cases via criteria A and B is well within the bounds of free academic speech; and that this at the least comes under the legal defence of 'honest opinion', because any 'honest person could have held the opinion on the basis of…any fact which existed at the time that the statement complained of was published' (Defamation Act 2013: 4, a). We are interested in what the scientists are in a position to know (criteria A), what they demonstrate that they know (criteria B) and in both cases what the external analyst can

assume they *are doing/have done*: all of which can be inferred in the absence of knowledge concerning their intentions or, indeed, their own interests.

2.12: The Optics of BCIUAV Research: Defining a Visual System

2.12.1: The Art of Science

Sociologist Joseph Gusfield made the innovative move of employing the metaphors of literature and literary criticism to analyse the discourse of scientific papers, focusing on one paper in particular, 'Identification of problem-drinkers among drunken drivers' (Waller 1967). Gusfield took this paper to be synechdochic in relation to a larger body of work in policy-oriented drink-driving research (1976:18). It is commonly understood that the operations of scientists diverge radically from those of artists. Moreover, science discourse is taken to be scientific precisely because of the oppositional distance it traditionally enforces from the artistic. Science aims to reveal the world 'as it is' (1976:17), objectively reporting as though observing through a 'windowpane' (1976:16); whereas art creates, embellishes, fabulates, deals in subjectivity and affectivity, and as in the art of rhetoric, centrally incorporates *persuasion* into its forms. Science doesn't need to engage in persuasion, we might assume, because 'the author attests to a world of real properties' (1976:20). The implicit message of a scientific article is that the reader 'as a rational person, cannot but reach the same conclusion as I' (1976:22). In order to understand the literary rhetoric of science Gusfield concentrated on the rhetorical, persuasive devices employed by scientists in their discourses to produce a transparency effect and ensure that their arguments are received as authoritative by audiences.

There are a couple of salient points in Gusfield's analysis that connect to my own work, which partly also concerns the literary rhetoric of science. Gusfield identifies two agents in Waller's paper, set up as psychological and moral opposites: the social drinker and the problem-drinker. Gusfield's notes that the figure of the 'drunken' driver (repeatedly mentioned in Waller's paper), doesn't accurately reflect that fact that all the people under study (whether classified as social or problem-drinkers), were those who had failed a 'chemo-mechanical test which measures the blood alcohol count', in a US state where 'the maximum count considered "legal" [for driving] is 0.10 milligrams per millilitre of blood.' (Gusfield 1976:23) not whether a road accident had occurred or they had been observed driving erratically. Those included in the study might therefore have been at 0.11, or 0.12, for example, although some may also have been way over. But as Gusfield observes, a BAC of 0.10 and just above, while registering a considerable level of intoxication, is hardly reminiscent of Hogarth's 'Gin Lane' (1751), which makes Waller's choice of words all the more curious:

> A drunken driver is not only a more opprobrious figure [than someone who has failed a chemo-mechanical test to establish that their BAC is at or above 0.10%], it is also a more *visual image* joined to the common-sense experience and imagination of the audience with drunkenness. It may, as it does to me, convey the sense of a reeling, incoherent, unreasonable and thus unpredictable and dangerous person. (Gusfield 1976:23 my emphasis)

Contrary to the emotionless scientific literary style, Gusfield notices that Waller chooses the highly evocative (and in this case hyperbolic) word 'drunken' to describe this figure. In Chapter 7, when analysing one particular figure found in a BCIUAV research paper (Nourmohammadi et al. 2018), we will see a similar move involving the placement of an affectively charged word, for different reasons, and in a different context entirely: but still, I will argue, in the interests of persuasion.

More broadly applicable, providing a launching off point into my own theorizations concerning *optics* (see below), in the quote above we observe Gusfield making an explicit link to the *imaginative visuality* of the choice of words in Waller's article. Gusfield recognises that Waller conjures a figure in the mind's eyes of his readers. The artistic, rhetorical elements I focus on in BCIUAV research papers involve this phenomenon, and concern what is written about the future uses of the technology in question.

2.12.2: Technology and Enchantment

For Gell, '(t)echnical means are a roundabout way of securing some desired result' (1988:6). After designating two fundamental categories of technology, technical systems that involve combinations of the body, tools, and specific procedures — the productive (subsistence, communication and problem solving) and the reproductive (kinship systems, material culture of child rearing etc) —– Gell introduces, 'the technology of enchantment' (1988:7). Defined by their functioning as 'psychological weapons' (1988:7) technologies of enchantment are deployed in the interests of bending the minds of others to one's own plans. It could be said that this concerns processes of domestication, the fundamentals of which are found in our 'exploit(ation) (of) natural psychological biases in horse and dog psychology' (ibid). However, the enchantment is reciprocal between humans to a degree not seen with domestic animals, and the level of complexity required in the strategies to affect humans far surpasses those used to domesticate animals. The technology of enchantment plays its part evolutionarily in the (ongoing) self-selection of the 'more "domesticable" human being' (ibid.).

Gell (1992) expands the concept of the technology of enchantment by focusing on the agentic, visual, psychological aspects of artefacts, introducing 'the enchantment of

technology' — a species of cognitive effect achieved in the spectator after having had their attention drawn. They become transfixed or 'trapped'[38]: overwhelmed by the technical complexity of an object's construction and/or its patterned surface designs, resulting in the inability to trace the causal chain of making that birthed it. It seems to the spectator that the effect has been achieved by a powerful magic attributable to the maker, which the spectator does not possess. In a way, this species of effect is as common to 'primitive' art as it is to 'fine' art (cf. 1992:62 n1). This effect of 'cognitive stickiness' (1998:86) caused by various instances of the technology of enchantment,[39] is expanded in the first half of Gell's *Art and Agency* (1998). Elaborating different kinds of agentic relationality between people mediated by things, Gell comes to the formula Index-A---Recipient-P, in which the human spectator is patient to the force of the 'agency inherent in the index' which may be 'physical, spiritual, political, etc. as well as "aesthetic"' (1998:31). Gell's discussion of this relation concerns cognitive stickiness to a degree, but emphasises the '*physiognomic aspect of visual worlds*' (Benjamin quoted in Taussig 1993:19):

> Reconsider for a moment the Azmat shield which terrifies the opposing warrior. It is surely noteworthy that these designs produce terror by making terror manifest — these designs seem to have been composed in a mood of terror, and we are terrified by them…because submitting to their fascination , we are obliged to share in the emotion which they objectify……the shield terrifies us by persuading us that *we are what it shows*'…The same 'false mirror' effect is observable in myriad other contexts, and may, according to Benjamin (see Taussig 1993; Benjamin 1933), constitute the very secret of mimesis; that is to perceive (to internalize) is to imitate, and thus we become (and produce) what we perceive … the primary means through which the index affects the recipient is by subverting the recipients sense of *self-possession* in some way. (Gell 1998:31)

The relationship Index-A---Recipient-P is integral to the technology of enchantment and the many possible enchantment(s) of technology. Enchantment as effect and experience is not simply about the psychological or cognitive, as in the highly specific mind boggling

[38] Something he addresses again in 'Vogel's Net' (1996)
[39] Objects belonging to that category being couched as Peircean indexes within an 'art-nexus'.

(over technical virtuosity) effect Gell spends most time on. It also concerns the affective, visceral (and thus moral) grip that a work can exert, often due to 'the very secret of mimesis…we become (and produce) what we perceive'. (ibid.)

Part of the task of the anthropologist is to elucidate the varieties and specificities of enchantment in particular social configurations as mediated by bodies, images, artefacts, and imaginaries (see below). We do not sway like seagrass in the encounter with the technology of enchantment but resist by following the method of 'dissolution' (Gell 1992:41): perhaps the *sine qua non* of anthropological theorization.

2.12.3: Our Garden Magic

> "The dolphin plays!
> About my *kaysalu*, my branching support, the dolphin plays.
> About my *kaybudi*, my training-stick that leans, the dolphin plays.
> About my *kamtuya*, my stem saved from the cutting, the dolphin plays.
> About my *tula*, my partition-stick, the dolphin plays."
> (Malinowski 1966:169)

Intertwined with preceding discussion, now we must turn our attention to the 'ideal technology' (Gell 1988:9), considered here from an anthropological perspective, and in relation to the others: 'magic' itself. Here we see the influence of Malinowski's *Coral Gardens and their Magic* (1966/1935) on the development of Gell's thought on technology. As for the evolutionary significance of 'magic', all the other technologies present some 'opportunity cost' (1988:9), whereas magical thought is unencumbered in this regard, save perhaps for the shared cost of occupying a duration of time in mental space.

That magic is the daughter of play is demonstrated by its innovativeness and creativity. The child pretending to be some non-human entity provides a 'symbolic commentary' (1988:8) on technical procedures facilitating the successive stages of his transformation, thereby 'inserting the ideal into the real'(ibid.).[40] Although some readers might think it a distasteful comparison, the symbolic commentary of the child in play is taken to be analogous to the incantations of the Trobriand garden magician documented by Malinowski.[41] The latter 'consist of a prolonged series of descriptions of an ideal garden, the garden to end all gardens' (Gell 1988:9).[42] In this way, both play and magic are haunted by the unrealizability of their ideal point.

Gell takes as his theoretical trope the *okwala,* the penultimate inaugural ceremony conducted by the Trobriand [43] garden magician (*towosi)* before the harvesting of a yam garden, concerned with 'the magic of growth' (Malinowski 1966:168), a key passage from which is quoted above.[44] With the poeticism of the magician at the forefront of his mind Gell asserts: '(i)t is clear that not only is this hymn to superabundant foliage animated by the poetic devices of metaphor, antithesis, arcane words, and so on … but that it is also tightly integrated with the catalogue of sticks and poles made use of in the garden, and the ritually important constructions, the magical prisms and boundary triangles.' (1992:61). The garden magician's 'art is exercised through speech' (1992:60): but on my reading it is nevertheless *images* of dolphins playing in the waves he conjures, that trigger multiple, *visual* similes with the 'winding and weavings of the vine…present in the minds of all native hearers' (Malinowski 1966:170) evoking the ideal garden. Despite their apparent

[40] When speaking about how play, and thus magic can be understood on its own terms, in ways that make it intelligible, Gell (1988) makes remarks that chime with Latour's understanding of the modes of existence and their 'interpretive key(s)' (2013:57).
[41] However, the seriousness of play is not under dispute.
[42] The ideal garden resonates to a degree with the 'prototype' term in Gell's (1998) art-nexus.
[43] Specifically, in the village of Omarakana on Kiriwana, also known as Boyowa Island.
[44] '"(T)he *okwala* is made so that the taytu may truly, really grow, so that it may ripen."' (1966:168).

nebulousness these ideal technologies of 'prospective magic' (Tambiah 1968:200) become intertwined with the activities of gardening, the functioning of an actual technical system, guiding growth and shaping the perceptions of all those who look on and concern themselves with the production of yams.

In 'Technology and Magic' (1988), Gell also mentions the role of technologies in industrialized societies where modern magic is found. The technology of enchantment is found in media and advertisements, where marketers cast their spells (some relevant examples of which I will discuss in Chapter 5), but his remarks on science fiction stand out.[45] As with the relationship between the actual garden and the ideal garden, in a functionalist mood, Gell thinks science fiction, as part of '(t)he imagination of technological culture' (1988:9) is an element of our own garden magic: a symbolic commentary that creates future imaginaries for and with technology. The reason that science fictions can be so enthralling, and can make so much sense, is that they revolve around a technical domain that demonstrates the possibilities already available to us, which in turn charges technology with new potentiality. Thinking across cases, and despite the element of unrealizability ultimately involved: magic, conceived of broadly as ideal (imaginative, representational) technology,[46] is used to drive technological innovation and development, by the insertion of the ideal into the material. This happens via *ekphrasis* (see below) in the classical sense of the evocation of the image of an absent or imaginary object but also in the more modern sense (Webb 1999) of translation across media (Zeitlyn 2014) and vice versa, iteratively (cf. Irving 2013).

Although concerning a radically different situation to that described in the Trobriand islands by Malinowski, and taken up by Gell; BCI researchers, use essentially the same

[45] See also (Haraway 1997:13-14) (Rabinow 2008:46)

[46] This is probably a very reductive definition of 'magic', but it serves a purpose here.

means as the garden magician, when in the symbolic commentary to their articles, they figure human bodies with relation to the futures of their technical systems. These figured bodies are at a fundamental level, realist prospections which play a pivotal role in the *optics* of the BCIUAV as a *visual system* (Banks and Morphy 1999) (see below) conceived as stretching beyond the material into the imaginary.[47] For like the mental images of dolphins at play tied to the garden and gardening tools by the magician's spell; these bodies are tightly integrated with the research, technologies and artefacts in question. Not mere decoration, if there were such a thing (Gell 1998:74): but functioning to (hopefully) trigger certain associations in the minds of native readers, geared at producing certain responses. It is in this sense that the figured bodies are in themselves *ideal* technologies of enchantment, albeit some more concertedly than others. Particularly with these latter sorts of cases, optical 'dissolution' (Gell 1992:41) is the only way to break their spell (see Chapter 7).

2.12.4: The Persuasive Power of Mental Images: A Metalogue on Symbolic Commentary

I will now further develop aspects of the preceding section. In particular, I attend to the reasoning behind the comparison between cases by expanding upon my interpretation of the gardening spell, which hinges on the trope of 'ekphrasis', signalling the importance of the visual imagination in all of this. This will set the scene for elucidating the concept of 'optics' with relation to BCIUAV research, and subsequently afford a brief contextualization of the approach being taken within contemporary science and technology studies discourse.

[47] I recognise there is a deeper discussion to be had about the imagination in anthropology and STS e.g., Sneath et al (2009), McNeil et al (2017) but alas, am charting a very specific course.

S.J. Tambiah takes Malinowski's analysis of Trobriand garden spells as one example with which to think through theories of the 'primitive's magical attitude to words' (Tambiah 1968:186). Malinowski's pragmatic theory, in line with his own perhaps mistaken view of the way infants acquire language, led him to hold the position that from a magical thinker's perspective, to say a word enough times in the right way 'can materialize the thing.' (ibid.). This magical worldview in which words have the power to conjure into reality the thing they refer to, is termed the 'denotive fallacy' (1968:187), and which for anthropologists historically resonates with Frazerian theories of sympathetic magic, concerning perceived relations of contiguity and similarity. However, as Tambiah notes, there is hardly a good reason to impute such beliefs to 'primitives' if we do not ourselves hold such beliefs in the power of words.

I am not entering into that debate. My own thinking is rather *adjacent* (Rabinow 2008:33-50). Essentially, I use the same aspect of gardening ritual that both Tambiah (1968) and Gell (1992) refer to, in a comparison with aspects of BCIUAV research papers. In terms of Tambiah's analysis, I see an analogy between the cases with relation to the 'outer frame' of Trobriand garden magic:

> Here the ritual complex as a whole is regarded as an activity engaged in by individuals or groups in pursuit of their institutional aims. This perspective we may call 'pragmatics', and it corresponds in some ways to what Malinowski called the 'context of situation'. It investigates how ritual relates to other activities, in what contexts and situations it is practiced and what consequences it may produce for various segments of society. (Tambiah 1968:189)

My starting point is the visual aspects of the rhetoric in the gardening spell, briefly touched upon but not followed up by Tambiah (1968:187), when he refers to Izutsu's work on 'the 'magical' effects of language' (1956:60) (see below). Tambiah, like Gell, largely overlooks this element in favour of a logocentric analysis. As indicated in the previous section, there are not just words at work in the passage of the gardening spell quoted

earlier, but *images* being evoked. They are not images like paintings or photographs but nevertheless, 'the idea of the visual underpins this mode of speech which rivals the effects of painting or sculpture, creating virtual images in the listener's mind' (Webb 2009:9). This indicates the importance of *ekphrasis* to the gardening spell. Ekphrasis, specifically according to its ancient definition is intimately connected to the art of rhetoric. In this way, rhetoric is taken to be a supremely visual affair taking effect in the mind's eye of the listener. It concerns how the hearer is made into a seer, as it were, and moreover that by absorbing the words and thus entertaining the images evoked, they might be persuaded as to the nature of affairs according to the speaker (or writer). In my view, 'ekphrasis' is the missing but implied term in both Tambiah's and Gell's utilization of the same piece of ethnographic evidence.[48] In fact, ekphrasis is the term missing from but implied by the following quote from Izutsu, that sets up his discussion of connotative meaning in magical language:

> (A)ll words…as symbols are capable of conjuring up something in our minds. The spoken word evokes in the mental system of the hearer the picture, the image, the concept (simple or complex), the emotion, the reasoning, or whatever else it may be, which is occupying the mind of the speaker. This process of mental evocation, then, we can safely take as the most fundamental act of verbal magic, though from the ordinary man's point of view it may perhaps be too fundamental or commonplace to be called 'magic' at all…many, if not all of the 'magical' effects of language…can be explained as simple variations or intensifications of this fundamental act of connotative meaning. (1956:60)[49]

According to this view, the power to conjure images in the mind's eye is key to the workings of (many) words in themselves, as they are connotatively enmeshed with the social worlds of speakers and hearers. On my reading, Ruth Webb (2009), who writes on

[48] It is also missing from Malinowski's account.

[49] Despite the requirement that it be contextualized historically in Western terms via a discussion of rhetorical arts. As Izutsu rightly intimates, ekphrasis as effect is 'commonplace'; perhaps so commonplace that it can escape our attention as a phenomenological feature of the everyday – which in turn can lead us to overlook its presence in a variety of cases, familiar or strange.

the ancient definition of ekphrasis, just about allows for Izutsu's position that potentially even *single* words, as symbols in themselves, can have this visually evocative power. That is, if 'ekphrasis can be of any length, of any subject matter, composed in verse or prose, using any verbal techniques, as long as it "brings its subject before the eyes"' (Webb 2009:8). Ekphrasis as it is primarily meant here, then, is intimately connected to the *visual imagination*, involves 'inner vision' (Irving 2013:86) (Squire 2015:2). In fact, the Cambridge dictionary definition of 'imagination' is 'the ability to form pictures in the mind'.[50] I include within 'the visual', the publicly invisible,[51] but privately visible imaginary images evoked in the mind's eye via ekphrasis.[52] Technically, then, one might think that to see 'only words' at work here would be an error stemming from a failure of imagination.

In Roman era discourse on rhetoric, key writers such as Quintilian regarded it a sign of intellectual vapidity for one not to be able to see and even feel the vividness (*energeia*) of mental images evoked by rhetorical speech or text. They spoke of this lack of visualisation almost as a pathology, one so rare as to be *almost* inconceivable. Nevertheless, early writers on the subject do acknowledge this variation, evidenced in their stating of what they took to be the normal and abnormal response to ekphrasis (Webb 2009:21-25). Today we do not necessarily expect this response, nor regard its absence as a sign of vapidity.

[50] IMAGINATION | meaning in the Cambridge English Dictionary

[51] Cf. Hacking (1983:132-133) who disbars from the category of 'representations' in science, those internal, private images, 'Kantian vorstellung', or 'ideas' which are endogenously viewed, and not therefore *public*. Although it is not possible to interrogate this here, the optics of BCIUAV research may present a partial challenge to Hacking's exclusion – perhaps along with motor imagery BCI itself.

[52] Irving (2013) also includes private mental images within the visual. However, Zeitlyn's (2014) usage of the term ekphrasis as a (partial) metaphor for anthropological representation, on the whole anyway, resonates most clearly with the modern definition in which one work of art represents another with particular emphasis on poetic descriptions of visual art (Webb 2009:33)) and therefore is concerned with *translation* across media. While emphasising the visual imagination, Irving also makes use of this modern definition of ekphrasis. I too, and by necessity,also mean ekphrasis in the sense of translation across media. Because, if these images are evoked by (written) language, the apprehension of them as images through inner vision in the media of the mind's eye makes them ekphrastic as translations, or perhaps rather *transpositions* (Webb 2009:29).

Indeed, as Webb writes, in our own time and culture, in a sort of reversal of the classical perspective, often 'the attitude to visualization is sceptical and the activity considered as an intensely individual matter' (2009:25). One cannot simply expect readers to see (at least not consistently), let alone emotionally respond to, images in the mind's eye evoked by text, or even understand reading in this way.[53]

The images of the dolphin at play evoked by the garden magician, as well as and in virtue of the rhetorical speech that carries them, are examples of *visual rhetoric.* Contemplating the imaginal, imagistic aspects of Trobriand garden magic, we can appreciate that the images of dolphins constitute outward facing components of the socio-technical system,[54] aimed at manipulating the perceptions of onlookers. Indeed, in my own analysis of BCIUAV research papers,[55] just as with the Trobriand gardening spell, the words and the mental images evoked are 'addressed to the human participants and use(s) a technique which attempts to restructure and integrate the minds and emotions of the actors' (Tambiah 1968:202). In this sense I take the rhetoric of Trobriand gardening — and subsequently the rhetoric of BCIUAV research — to be *optical.* Here is an example of minimalistic ekphrasis constituting what I call the optics of BCIUAV research:

> In future, these integrated systems could serve more practical purposes—some conceivable applications are as follows: in hospitals where patients with severe disabilities could use them for transporting objects; in battle fields where wounded soldiers could use them to proceed with the combat; and in space where they could assist astronauts to accomplish multitask missions outside the spacecraft. (Nourmohammadi et al. 2018:338)

The mental images evoked via ekphrasis in either case (Trobriand gardening and BCIUAV research papers) are optical components of an extended technical system. I argue that their

[53] At least not without exegesis that might, in lieu of helping strengthen powers of visualisation, afford a conceptualization with which to operate.
[54] Interiorized in the minds of hearers via ekphrasis.
[55] As already indicated, bolstering the Gellian perspective concerning *ideal technologies of enchantment*.

ekphrastic visuality invites us to define that technical system as extended via speech or text (i.e., as a research paper) and into the imagination as a 'visual system':

> We use the term 'visual systems' to convey a very general concept: the processes that result in humans producing visible objects, reflexively constructing their visual environment and communicating by visual means. (Banks and Morphy 1999:21)

> One agenda of visual anthropology is to analyse the properties of visual systems, to determine the properties of particular visual systems and the conditions of their interpretation and to relate the particular systems to the complexities of the social and political processes of which they are a part. (Banks and Morphy 1999:2)

Consequently, we must attempt to analyse the social and political entanglements of the nebulous imagery of this visual system, to understand its functioning within the system and elucidate its effects and affects in the relevant context.

2.12.5: Ekphrastic Futures

> …Trobriand magic is a testimony to the creativity of thought that its logic is an anticipatory effect. I am not merely stating that the magic provides incentives to work — though that is a part of the matter. More importantly, it is a blue-print and a self-fulfilling prophecy and embodies for the Trobriander an understanding of the technical, aesthetic and evaluative properties of his activities, in a manner denied to us in our segmented civilization. (Tambiah 1968:200)

As indicated earlier, the analogy between Trobriand gardening and BCIUAV research also lies in the prospective function that these words, and importantly the mental images that they evoke serve, as parts of the outer frames of each socio-technical system. Resembling the relation between the Trobriand garden magician and his audience: when figuring bodies of likely users in their texts, BCIUAV researchers, along with their readers, anticipate the future stages of the system's growth in ways that are not absurd but 'in accordance with reality' (Tambiah 1968:200). The bodies figured by BCIUAV researchers

all play a future framing function in relation to BCIUAV technology. The futural optical function is primary and generalizable. In the vast majority of ordinary cases I am inclined to assume that the bodies represent straightforward and *sincere* accounting by researchers. There is an element of persuasion involved, the sort of baseline level of persuasion present in nearly any communicative statement, not least statements concerning the nature of futures about which we can only be asked to *believe* (Zeitlyn 2020). However, not all of the figured bodies could be viewed as concerted attempts to persuade readers in not simply a futural, but also perhaps, a *moral* sense: and which along with this latter sense, *may* well also involve an element of *dissemblance*. My main focus in this regard is on the wounded soldier evoked by Nourmohammadi et al. (2018) shown above, and the ALS patient figured by Meriño et al. (2017) (see Chapters 4 and 7). However, it should be emphasised that the analysis conducted in this vein in Chapter 7 comes from a speculative perspective that embraces the artfulness of anthropology (see Firth 1958; Leach 1982:52). At the same time, it concerns the art-like productions of science. A degree of artistic licence is therefore demonstrated in my analysis. Further, in addressing 'optics', it is restricted to an analysis of the way things look, and so on this basis I acknowledge that appearances can be deceiving, and that the conclusions reached are necessarily partial. Nevertheless, as I remark in Chapter 7, other scholars have recognized the same species of phenomenon which I point to in their own assessment of discourse around dual use research in neuroscience (Bell 2014).

Even when done in a sincere manner, the futural function of figuring a particular type of body as a user of BCIUAV technology (for example, that of a disabled patient) can have moral connotations in itself. Drawing on the passage from Tambiah quoted above, all the bodies figured in BCIUAV papers function to help both researchers and readers understand the possible future uses of the technology and therefore help evaluate and

justify the research in question. I suggest that we are more inclined to evaluate the research and technology positively if a vulnerable body is given as beneficiary. This blending of the futural and moral (whether intended or not by the researchers) is perhaps a simple consequence of the inherent altruistic tendencies of humans to interpret X which alleviates A's suffering in some way as a 'good' thing. I am particularly interested in the operation of figuring bodies via ekphrasis with moral persuasion in mind.[56]

The next chapter discusses endogenous, 'mental' images that play a role in the internal workings of some BCI systems, variously referred to as 'motor images' or 'motor imaginations'. In these cases, the user is required to imagine ("image") the movement of a body part, and this imagining produces signals in the region of the brain associated with ordinary, organic limb movement. The researchers describe the motor images as functional components within the human-machine system, essentially being the commands for BCI control. But the imaginary images evoked by researchers in text when describing future uses of BCIUAV technology, are created by the researchers themselves without being explicitly discussed. They might seem somehow more nebulous than the motor imaginations involved in BCI control. And yet, from an anthropological perspective, the images of future users evoked by ekphrasis in the texts written by BCIUAV researchers, are just more instances (albeit distinct in several ways)[57] of the same species of imagery as the motor images in the same extended technical, or rather, *visual* system. It's just that now, rather than coming from the perspective of the user of a motor imagery BCI system, we are positioned at the other end of the (admittedly, diffuse) system, where the reader

[56] And here, aside from the obvious, is where the comparison between Trobriand gardening spells and little sentences in BCI research papers seems to diverge most potently. The magicians, I assume, act sincerely.

[57] For example: the motor images are actively generated by the BCI user. The images evoked by the texts are at first passively (but reactively - see Chapters 3 and 4) apprehended in the mind's eye of the reader. But here I more actively engage with them and so in soliciting them, drawing them out, examining and interpreting them, they become much more vivid and actively generated, albeit still being carried initially by text. Context and content wise they are also very different.

remotely encounters the individual systems, the research and technology, as well as the figured bodies of future users, through the scientific articles. From this vantage point the reader encounters an imaginary dimension of the technology as communicated to them by the researchers.

The present work aligns with techno-anthropologist Lucy Suchman's methodological trope of 'configuration', which can be taken to mean a way of ordering or arranging things *and* the resulting arrangement itself. It attends to the manner 'in which technologies materialize cultural imaginaries, just as imaginaries narrate the significance of technical artefacts' (2012:48). Suchman's focus on the imaginary in the constitution of technologies in a more holistic sense is clearly germane to the present discussion. 'Configuration' is a useful gloss for 'visual system' — although I prefer the latter, in the recognition that not all configurations are visual systems, while all visual systems, as I have described them, are configurations. Once we acknowledge that the images carried by words in the articles and evoked via ekphrasis in the imagination of readers are there, we can appreciate that they are not only included within the technology's boundaries but play a crucial role in defining its identity in the perceptions of readers.

2.12.6: Ekphrastic Science Fictions

Finally, I also take these figured bodies to be *fictions*. The objectivity — a matter of primary qualities reserved for the hard sciences — of the beings of fiction has long been denied by the moderns, who relegated them to the quite separate, subjectively interpreted and projected '(symbolic) reality' (Latour 2013:236) (cf. Gell 1988): in other words, fictions are relegated to *interiority*. Latour challenges 'the moderns' on this, (whom, it should be noted, he has in part invented, so are partial beings of fiction themselves) (2013:246). He argues contrary to the modern's view, that the beings of fiction have their

own kind of *exteriority*, in the way that the fabulated figures found in works of art make us 'more like [their] constituents than creators' (2013:240). In the process of learning to be affected by, make sense of and with the beings of fiction in the requisite ways, we find that they need our 'solicitude' (Souriau quoted in Latour 2013:242) to persevere in their mode of existence.[58] At the same time they afford us a capacity for imagination that we would otherwise be lacking. Without the materials through which they are allowed to reproduce and be taken up by the next person, beings of fiction cannot persevere; and yet they cannot be reduced to those materials or we lose them. On the one hand, moderns have often imprisoned the beings of fiction within art worlds on account of disbelief in their exteriority. And yet, on the other: '(e)very scientific article, every story of an expedition, every investigation is populated with stories experienced by these beings' (2013:250). The 'little emissaries' (2013:251), characters that populate the scientific imaginary[59] who undergo tests and that make science possible at all, are beings of fiction as much as those conjured from the pages of a fantasy novel. It's just that the fictions put to work in scientific practice have been domesticated, and are, like gun dogs, expected to '*bring something back*' (ibid.). '(D)elicate procedure(s)' (2013:252) must be developed to ensure their return with reference after having been launched out. The beings of fiction evoked by the novel's text and sustained by the reader, or appearing in a painting or a film, are usually left to drift with no such expectation.[60] We ask scientists to provide proof of their workings to substantiate the claims they make (cf. Spüler 2019), but we do not go searching for the golden fleece (cf. Firth 1958:15). Still, the beings of fiction, are at once 'fabricated, consistent, real' (2013:238).

[58] 'If *Homo Faber* and *Homo Fabulator* actually derive from the same source they differentiate themselves at once.' (Latour 2013:244). Material technology persists without our solicitude, whereas the being of fiction depends upon it.
[59] E.g., 'remote galaxies, particles of matter, upheavals of mountains, valleys viruses, DNA, or ribosomes (2013:250))
[60] Or so it seems.

The bodies of future users figured via ekphrasis in BCIUAV papers, are realist fictions, not fantastical fabulations. They are not as free and wild as the figures attributable to the 'pure' arts, but domesticated. Unlike the motor images utilized in BCI control paradigms: they are not sent out to return with reference, as part of the *internal* representative acts of scientific practice (e.g., within the immediate technical apparatus of the system to achieve its primary purpose of flight control). Rather, as part of the 'outer frame' (Tambiah 1968:189) of the visual system, these 'little emissaries' (Latour 2013:251) are tied to and *put out in front* of a BCI system and/or research pertaining to it: simultaneously guiding growth towards virtual points and shaping the perceptions of those who concern themselves with the production of BCIUAV technology.

2.13: The Moral Vision of BCI research

Finally, I am also concerned with the moral vision of BCI research itself. Examples of this include the 'user-centred design' (Eddy et al. 2019:20) perspective (see Chapter 4), which aims to ensure that BCI systems are designed and implemented in appropriate ways for disabled users, and more generally that the potential benefits of BCI research and technology are increasingly translated to those users. But by the moral vision of BCI research, I also mean the existing, explicitly 'ethical' discourse in BCI literature, discussed, albeit briefly, in Chapter 6, which concerns what BCI researchers talk about when they talk about 'ethics'. This also includes what they are *not* talking about and might not be able to see. I argue that the moral vision of anthropology adopted here, and in partial alignment with the moral vision of BCI research, could help change the appreciative system of the latter, via the BCI Society, in order to expand and nuance its view of ethical concerns: with reference to electronic neuroweapons.

2.15: Conclusion

Following the general introduction and the review of drone literature, Chapter 2 has introduced the general theoretical and conceptual framework used in the thesis overall as well as key arguments. I am now in a position to give an outline of the chapters to come.

2.16: Outline of Remaining Chapters

Chapter 3: 'A High-Flying Idea': BCIUAV Research 2010-2016

The aim of this chapter is to review BCIUAV research from 2010-2016, in terms of both the technicalities of the BCI systems (as far as I can manage from my non-specialist perspective), how work is carried out, and what the researchers write that they are meant to be for. Citations between papers are also considered. Here we begin see BCIUAV research in approximately its own terms. At the same time, using elements of Forge's conceptual framework, we can see how the technology is framed by researchers over this time period, in terms of the kinds of future uses and users they figure. The chapter ends by summarizing findings and remarking on a significant moment when one paper, for the first time, triggers criteria B. Finally, the 'red flag' papers across the entire selection of BCIUAV research are listed.

Chapter 4: Ophthalmoplegia

Malinowski 'passed on to his students an invaluable awareness of the tension which is always there between what people say and what they do' (Kuper 1996:34) (Beatty 2014:546-547), which is still regarded as a vital sensibility for the anthropologist and ethnographer. This sensibility is at work in this chapter's analysis of Meriño et al's. (2017) paper. Also informing my analysis is an insight derived from material-semiotic approaches in science and technology studies: 'agency is…not locatable in either humans or

nonhumans… [and] is rather an effect or outcome, generated through specific configurations of human and nonhuman entities' (Suchman 2007:261). This insight has implications for assessing the intimate relations established between the users of BCI systems and the individual systems themselves. As part of the moral vision of BCI research, the 'user centred design' (Eddy et al. 2019:20) (UCD) perspective aims to ensure that design principles appropriate to the target users of BCI systems, who are often individuals with severely paralyzing neurodegenerative conditions such as amyotrophic lateral sclerosis (ALS), are applied at every stage of the research process. Inspired by UCD, and in order to eventually conduct an analytical review of Merino et al's BCI system, I collect information about the relationship between ALS and BCI research and technology, with emphasis on the visual problem space summoned by the extremes of ALS in which paralysis can extend to the eyes. This is done because Meriño et al. figure the body of an ALS patient who they claim would be a beneficiary of their work, the latter being a visual BCI system. An essay by John Austin (1979a) points to the tension between what people say and what they do, when assessing whether, how and to what degree Meriño et al's remarks are happy or unhappy, with relation to the question of whether agency can emerge for the patient they figure, through the individual BCI they present. The chapter ends by considering Meriño et al's funding source, which triggers criteria A.

Chapter 5: 'Model Airplanes that Can Blow People Up': A Contextual Montage

What kind of '*model airplanes that can blow people up*', to borrow a phrase from David Graeber, may we be dealing with when thinking about future *combat* BCIUAVs? To help think forwards, promotional videos for *small* unmanned aerial vehicle (sUAV) systems designed for combat are treated as data providing contextual information in relation to the militarized tendencies of BCIUAV technology. The aesthetics in two of the videos are

discussed with reference to anthropologists Willerslev's and Suhr's (2013) work on montage and invisibility, which in turn leads to an observation about the optics of BCIUAV research and the moral vision of BCI research further discussed in Chapter 6. Subsequently, theoretical reflections on the integration of BCI control into combat sUAV systems are offered. I argue in the end that *flight control* is the most important aspect of the BCIUAV in any guise, but specifically as a future weapons system (whether armed itself or not).

Chapter 6: Knitting with Dr Huggins

This chapter is based on an interview with BCI researcher, Dr Jane Huggins. I focus on our discussion of dual use and weapons research with relation to BCI. Following Huggins's comments on what BCI researchers are interested in when they talk about ethics, I identify the importance of defining BCI type electronic neuroweapons research/ technology/ artefacts as a problem that *is* 'unique to BCI'. I then consider a small selection of BCI ethics literature originating from within the BCI Society, which allows me to identify a near blind spot in the Society's moral vision (i.e., that it is predominantly user focused and tends to ignore the non-user) and subsequently to identify the incipient 'Principle of Social Impact'. This principle 'emphasizes the importance of recognizing that BCI technologies can have broad social effects' (Pham et al. 2018:107). It is this principle, cast in the existing ethical language of BCI research, that may allow for the window of concern to be further opened and for conversation about dual use and weapons research to proceed in future.

Chapter 7: Optical Dissolution

This chapter expands upon the more critical side of the optical theory introduced in Chapter 2, in first addressing the figure of the 'wounded solider(s)' posed as 'conceivable' future user of the BCUAV by Nourmohammadi et al's (2018). Drawing particularly on the work of human geographer Leila Dawney (2019, 2020), and in alignment with Gell's (1992) 'dissolution', I dissolve the optics that the wounded soldier projects into the imagination of the reader, first in social, and then political terms. A philosophical anthropological account of the power that KDU and weapon researchers wield is offered. I diagnose their power as a *transversal, cosmopolitan necropower* to kill *anyone, anywhere*. Subsequently, it is proposed that Nourmohammadi et al's wounded soldier is 'necro-optical', in that it attempts to morally persuade the reader, and to some extent distract from the broader reality of combat uses. I then take what is learned from the wounded solider and loop back to the figure of the ALS patient figured by Meriño et al. (2017) discussed first in Chapter 4, showing how the wounded solider and the ALS patient — although very different kinds of body — share notable characteristics. With reference to the work of philosopher John Austin (1979b) on *pretending*, I engage in a thought experiment, finding that the ALS patient is potentially playing the very same role as the wounded solider. Through a comparative analysis of the optics at work across the three BCIUAV research cases of Meriño et al. (2017), Vishwanath et al. (2018) and Nourmohammadi et al. (2018): on the surface, I liken the role of the wounded solider and the ALS patient to *human shields*, which here I imagine to involve dissemblance. I then speculate, via Davis (2012) as to the underlying logic common to both bodies in their optical roles as human shields, despite their radical difference.

Chapter 8: Human Conservation: A Moral Vision

In the first part of this chapter, I critically address the proposal for an 'amoral anthropology' put forward by Nicolas Langlitz (2020a), by exposing it to the extremes of human practices that threaten human life. In the face of these extreme cases, I diagnose amoral anthropology as an ethological, rather than anthropological perspective. The alternative moral vision of 'human conservation', is introduced for later discussion. Then, drawing upon the work of Ted Stolze on Spinoza's political philosophy, contrary to Langlitz's position, I argue for the value of indignation in anthropological work. The 'affective transition' (Stolze 2019:117) germane to my own moral position on BCIUAV research is analysed through the work of Phillip Fisher (2002). A *fear for* others leads to experiencing *pity* for those others, which in turn provokes the passion of anger as found in *indignation* directed toward the oppressor, who in this case are KDU and weapon researchers. This indignation must be transformed into, and through *love.* In this case, while definitely passionate, love is not divorced from reason. The second part of the chapter discusses the work of Nigel Rapport on the possible role of love in anthropology. With love, we reach the moral vision of 'human conservation' for anthropology — which takes the Human Right to Life to be paramount. To this end I use Rapport's thoughts on how reminders of death provoke a potent form of 'loving recognition'(2018, 2019), to address Otto Dix's famous 'Wounded Man' – a memento mori whose presence is directly inspired by Nourmohammadi et al's (2018) 'wounded soldier(s)' encountered in Chapter 7. Having established the moral vision of human conservation on a general level as a Regulative Ideal and the conservational imperative as a Regulative Principle (Emmet 1994), I finish the chapter with suggestions for future, applied anthropological work with the BCI Society.

3: A High-Flying Idea: BCIUAV 2010-2016

3.1: Introduction

In this chapter, I review all attempts from 2010 to 2016 to develop the means to control unmanned aerial vehicles (UAVs) by brain-computer interface (BCI), in chronological order. The analytic decision to treat papers within this time period in this way is discussed below. The aims of the chapter are:

- to come to a basic understanding of BCIUAV research and technology, with an emphasis on the BCI component.
- to establish the point at which the research and technology is openly revealed as being dual use, even though none of the research ever uses the latter term.

So, alongside the technological learning curve, my review seeks to chart how the researchers *talk* about the future uses of the technology. With a paper by Zhang and Jackson (2015) that triggers criteria B: I argue that we reach a point at which we and the authors in question know that the research and technology is dual use, but importantly, that other researchers working on the same technology also have that knowledge available to them. Finally, I list the 'red flag' papers identifiable in the remaining body of research, which meet either criteria A or B. The full bibliography of BCIUAV research (2010-2021) is provided in Appendix 1**.**

3.2: Introduction to Synoptic Review of Literature 2010-2016

I have taken the analytic decision to cover papers from this time period (2010-2016) in detail for several reasons. First, chronologically, 2016 marks about halfway between the year the first paper appeared (2010) and the point at which the period of BCIUAV research covered during my own period of research, ends (2021), which seems an appropriate

division given the constraints of space and time. This time period, given the number of papers in it, happens to comprise a manageable chunk to deal with in detail across one, admittedly lengthy chapter. Second, by 2016, all the kinds of BCI and nearly all the different ways of using them will have been seen in some form. This will put the reader in good stead for what follows and in fact removes the need to address the entire body of BCIUAV research in the same way. Third, the first paper published in the following year (Meriño et al. 2017), and the focus of Chapter 4 (see also Chapter 7), is something of an event in terms of my analysis. As such this requires special attention and invites a departure from the literature review format.

Across three databases (Oxford SOLO library catalogue, Scopus and Web of Science) the search terms deployed to ensure an exhaustive bibliography of BCIUAV research and relevant review papers were:[61]

(brain-computer interface) AND (unmanned aerial vehicle)
(brain-computer interface) AND (drone*)
(brain-computer interface) AND (quadcopter)
(brain-computer interface) AND (unmanned aerial system)

During the review, I asked *what* was done, *how* it was done, *where* it was done, and *who* cites *whom*. I also asked what the authors say the BCIUAV is *for*. Although not all papers under review follow suit, it is common for literature in self-consciously 'applied' science, when presenting an innovative design to remark upon possible future uses. Deploying the technical vocabulary of Forge introduced in the previous chapter, the 'primary purpose' of BCIUAV technology is *control*. Granted this we want to know according to the teams working on it what uses this control of the BCIUAV might be put and in what contexts?

[61] Literature that appeared from more recent years using these searches dealing with the BCI control of swarms of drones (some of which directly builds upon the work covered in the present thesis) was collected for future research but not included in the present remit (cf. Taylor-Green 2021).

Proposed future uses are ‘derivative purposes’ in Forge’s terms. However, the literature reveals that this is actually quite a blunt term, so I make some minor modifications, in order to account for more or less specific descriptions. As a further note on terminology, although I have made my moral position and its resonance with Forge’s own clear, I also believe that the conceptual structures of his account can aid anthropological inquiry whether we subscribe to the moral kernel or not. Forge’s work is analytically useful. However, instead of using value-laden terms such as ‘good’ and ‘bad’ to refer to derivative purposes, as Forge does, throughout this thesis, I deploy more descriptive alternatives such as ‘beneficent’, ‘neutral’ or ‘harmful’. The real advantage of doing so is that such terms are particularly relevant to the research and technology that I address and describe valences relative to bodies (users and non-users) encountering machines. Once all the papers in the specified time period have been reviewed, a summary of findings is given. Reflections are then made on the paper by Zhang and Jackson (2015), who are the first authors to speak of possibile harmful uses of the BCIUAV *alongside* beneficent and neutral ones. Finally, I will list the ‘red flag’ cases identifiable in the remaining body of research, which meet either criteria A or B.

3.3: A Word on Partiality

As Royer et al. (2010:588) write,

> BCIs are intrinsically multidisciplinary. Neuroscience, engineering, and computer science combine to create a complex system. The future of BCIs lies in leveraging the potential of all disciplines involved.

I do not have a technical background and cannot claim to understand most technical BCI talk. I follow basic explanations of some aspects of the science(s) at hand, but in a largely *non*-scientific way. For the most part, the ‘actual’ science remains black boxed. For example, I will not consider the computer science central to each study. In this spirit, I do

not evaluate the metrics used to measure performance of BCI systems. The finer points are the professional preserve of the scientists writing the papers, and interested readers should refer to the originals. But while my own competencies as a qualitative thinker fall outside of those possessed by the scientists of various stripes involved, I hope to bring a different expertise to bear on the same material. Anthropological knowledge is always partial. As long as we are honest about our epistemological partiality; that we cannot know all, that what we do know and present is reductive and selective, and that there is always more work to be done: this knowing incompleteness is something to positively acknowledge (Zeitlyn 2009).

3.4: BCIUAV Research 2010-2016 (full refs in Appendix 1)

Akce, A., Johnson, M. & Bretl, T. 2010, "Remote Teleoperation of an Unmanned Aircraft with a Brain-Machine Interface: Theory and Preliminary Results"

Institution: University of Illinois at Urbana-Champaign, Urbana, USA; Department of Computer Science and Department of Aerospace Engineering.

Funding: 'This research was supported by awards NSF-CNS-0931871 and NSFCMMI-0956362-EAGER and by a NASA-ISGC Seed Grant.' (2010:5327)

Akce, Johnson and Bretl (based at the University of Illinois at Urbana-Champaign) achieved the first BCI controlled unmanned aerial vehicle flight. Using 'motor imagery' (2010:5323) (MI) paradigm electroencephalography (EEG)-based BCI, Akce et al. (2010) managed, albeit only with one test subject, to control an actual fixed-wing glider (Multiplex Cularis) on an airfield several miles away, with two dimensions of control (left/right). In this control paradigm the user imagines moving a body part, producing motor imagery in the mind's eye. The EEG signals corresponding to these motor imaginations are recorded via electrodes positioned on the scalp over the sensorimotor cortex. These signals are then processed and mapped to commands in the device being

controlled. Because the commands are endogenously generated by the user this variety of BCI is categorized as 'active' (Zander and Kothe 2011:3). In this case, the user imagined either left- or right-hand movement.

Akce et al. construe the task as a communication problem according to information theory. They construct a 'lexicographic[ally] ordered' (Akce et al. 2010:5323) symbolic language, in which each symbol expresses a smooth curve. The glider was at a fixed altitude, travelled at a constant speed, and was 'equipped with a custom autopilot, GPS-aided inertial sensor, and wireless video camera' (2010:5326). The role of the autopilot is 'to regulate altitude, airspeed, and bank angle' (ibid.). The camera feeds back live footage to the graphical user interface. Throughout the flight, the user, who they refer to as 'the "encoder" (ibid.) is presented with two desired paths for the aircraft, given in the symbolic language. Depending on the way the glider needs to travel to keep to the path specified for it on the screen, the user selects from the path options presented to them via the graphical user interface using the two left/right MI commands, corresponding to either left or right direction in flight. '(T)he user only has to decide if the desired curve appears lexicographically to the left…or to the right…of the candidate' (ibid.) path, the latter being the path that the aircraft is presently on, which is also expressed by a symbol.

Acke et al's (2010) paper may be the first recorded achievement of BCI control of an unmanned aerial vehicle. However, for two reasons their study was something of an outlier with relation to subsequent BCIUAV studies. Their approach to the task of control was not one deployed by any other team, although Akce et al. (2013) themselves use it again in a subsequent simulation study. Nor would subsequent attempts by other teams use fixed-wing drones excepting one done in India eight years later (Vishwanath et al. 2018). Instead, the vast majority of studies work with small drones, usually quadcopters. Aside from three relevant review papers that cite Akce et al's (2010) work (Nourmohammadi et

al. 2018, Zhang and Wang 2021, Hekmatmanesh et al. 2021) and excluding Akce et al's (2013) subsequent self-citation: only four BCIUAV papers (Meriño et al. 2017, Tezza, Garcia, Hossain, Andujar 2019, Tezza et al. 2020, Belkacem and Lakas 2021) cite Akce et al's (2010) work. So, even though Akce et al's (2010) study is the first of its kind, it sinks into relative obscurity.

Future Uses?

Akce et al. are circumspective about future applications of the work, stating that they 'do not believe an EEG is necessarily a practical input device for flying an aircraft, although we do think it serves as a useful demonstration of what can be done…possibly opening doors to new and more practical applications that have yet to be defined.' (2010:5323). No derivative purposes are posed.

Royer, A.S., Doud, A.J., Rose, M.L. & He, B. 2010, "EEG Control of a Virtual Helicopter in 3-Dimensional Space Using Intelligent Control Strategies"

Institution: University of Minnesota, Minneapolis, USA

Funding: 'This work was supported in part by the National Science Foundation (NSF) under Grant CBET-0933067, and in part by the National Institutes of Health under Grant NIH RO1EB007920 and Grant NIH T32EB008389.' (2010:581)

This simulation study is the first of three related attempts at the University of Minnesota which culminate in the first *actual quadcopter* flight controlled by BCI (LaFleur et al. 2013), and which importantly achieve control in three dimensions, rather than two. It is these three Minnesota experiments that lay the ground and become key reference points for, as well as setting the standard for subsequent attempts to develop BCI control strategies.

Royer et al. explain that the futuristic imaginings of BCI prosthetic applications in science fiction films such as 'Firefox, Surrogates and Avatar' are being fast approached by '(r)eal

world' (2010:581) science. Previously, using invasive BCI, monkeys have controlled computer cursors, and prosthetic arms for self-feeding. Humans with limited physical mobility have also controlled computer cursors and spellers via these means. However, the emergence of non-invasive BCIs and their growing purchase on the capabilities of their invasive counterparts in terms of performance, has opened up a new range of potential users within and beyond clinical settings. Now the BCI user can just wear an EEG cap. Non-invasive EEG-based BCI control applications, say Royer et al., have been achieved with some success in two dimensions, allowing the control of human-like robots and wheelchairs using what seems to all intents and purposes to be 'only thought'. The challenge remains to achieve 'full and continuous exploration of 3D space for non-invasive systems' (ibid.). In order to make advances in this regard, Royer et al push towards 'complex BCIs capable of doing more than we ever imagined.' (ibid.).

They achieve non-invasive EEG-based BCI control of a virtual helicopter in a 3D environment viewed by the user on a computer screen. Four human participants were involved. Control of the virtual helicopter via BCI was done using a motor-imagery (MI) paradigm.

> The left/right control signal was the subtraction of the electrodes and frequencies of the left hemisphere from the electrodes and frequencies of the right hemisphere. The up/down control signal was the inverted addition of left and right. Using this scheme, subjects imagined moving their right hand to go right, their left hand to go left, both hands for up, and rest for down to create a four class system. (2010:582)

Although I don't quite grasp the meaning of 'inverted addition' here: in this way they achieved depth control (up/down) in the ('quasi' (Doud et al. 2011:2)) 3D virtual environment via modification of the motor-imagery techniques required for 2D control (left and right). They call this their 'reductionist method' (2010:586). The virtual helicopter was set to move forwards at a constant speed automatically, and so this aspect was not controlled by EEG signals. However, continuous concentration on MI was

required to keep the helicopter airborne.[62] The virtual helicopter was viewed from third person perspective, in a 3D environment[63] designed to resemble a place familiar to the four participants called Northrop Mall. Subjects completed a number of trials ('7-13 5 min runs' (2010:582)) in which they navigated to and through a number of ring-shaped targets. Royer et al. deployed a software generated tool called 'the cone of guidance' (ibid.) to help the pilots achieve in-flight goals. The cone is invisible to the user. Its point projects out toward the entry side of the target, acting as a 'needle threader' (2010:583). It helps draw the virtual helicopter through the ring targets representing flight path goals and reduces the frustration of performing a task the authors compare to 'finding a needle in a haystack, and then threading it.' (2010:583). The cone of guidance improves the flight performance of the pilot, but overall, a human-machine system emerges 'more powerful than either individually.' (ibid.). All four subjects managed successful continuous control of the virtual helicopter.

Future Uses?

What stands out in this article is that while there are no 'actual' future uses suggested, science fictions are cited instead, as found in three popular films. Science fiction offers us an opportunity to 'explor(e) what it means to be embodied in high-tech worlds' (Haraway 1987:28) (cf. Gell 1988). Let's look briefly at each of the films they mentioned to see how the neuroprosthetic is figured in them.

1: Firefox (1982) is a film based on the novel by Craig Thomas (1977) about cold war era British-American military espionage, involving a secret agent, played by Clint Eastwood

[62] Allison, Faller and Neuper (2012:246) diagnose Royer et al's system as 'slow cortical potential' (SCP) based: a method no longer favoured due to its being 'inherently slow, allows only one dimension of control, requires extensive training and is prone to error.'

[63] Custom made in a VR program called Blender.

(also the director), sent to capture a Soviet prototype weapon. The weapon in question is a manned hypersonic fighter jet with BCI controlled weapons systems.[64]

2: Surrogates (2009), set in 2017, portrays a world where most people no longer allow their fleshy bodies out of the safety of their homes, instead using advanced remote-controlled humanoid robots called 'surrogates' which they operate from pods. People do all sort of debauched things with their own and each other's surrogates because no one can feel pain through them.

3: Avatar (2009) is a science fiction fantasy film set in the next century and is worth expanding on briefly in several respects. In the film humans are expanding into the habitable planets of the nearest star system. They are in an asymmetrical xeno-colonial struggle for control over territory with the indigenous inhabitants of the moon Pandora. The Earthlings want access to the rare element unobtanium, which happens to be abundant on Pandora. The atmosphere on Pandora is toxic for humans and so their bodily presence outside of specially constructed environments, or mechatronic suits is impossible. However, a group of scientists studying the planet's ecosystems operate BCI controlled avatars. The avatars are bio-synthetically produced electronically networked bodies, part derived from the genetic material of the native Na'vi and visually almost indistinguishable from them, whilst also being genetically matched to their human users. The users remotely operate the avatars from within static pods, fully immersed in their prosthetic body's experience. For the film's protagonist, Jake, an ex-marine who was wounded in combat on Earth and is now paraplegic: the liberating effects of being able to walk and run when in

[64] Notably, Wolpaw et al (2002) also mention Firefox but seem to put less emphasis on the control of weaponry by BCI, and rather focus on flight.

control of his avatar, makes for stark comparison to his ordinary state. This has a profound effect on him. The neuroprosthetic in/as *Avatar* is an enhancement technology for disabled and able bodies alike. But as the film progresses, and with particular reference to Jake, it becomes caught in the midst of overlapping purposes and futures that seem to negatively interfere with each other, particularly in moral terms (cf. Zeitlyn 2020; Law 2000).

Leaving Surrogates aside (because it adds little to the discussion technologically nor narratively), two distinct themes emerge from *Firefox* and *Avatar*. One concerns a 'neuroweapon' (cf. DeFranco et al. 2020) that could obliterate other human bodies; the other holds the promise of assistive technology, ameliorative and life transforming for individuals with a range of physical disabilities, but nevertheless also has other, more sinister uses.

To the anthropologist-pedant (cf Malinowski 2014:11) sifting through the imaginal reality of this technology (Suchman 2012): something stands out in the way things have been written by Royer et al. (2010:581). The abstract (a) differs significantly from the first lines of the introduction (b):

a) Films like Firefox, Surrogates and Avatar have explored the possibilities of using brain-computer interfaces (BCIs) to control machines and replacement bodies with only thought.

b) In the 1982 movie Firefox, a fighter jet's weapons were controlled by thought. Although the movie was science fiction, brain-computer interfaces (BCIs) are approaching such capabilities.

In the abstract, the three films posited are meant to stand for a range of imagined uses, all in their own way expressing the general premise of the technology in question as affording remotely controlled, real-time neuroprosthetic embodiment. But in the introduction, only the science fiction of *Firefox* is mentioned. This is a film about purely military uses of BCI, and within that category a highly specific use is named: the control (targeting and triggering) of high-powered weapons mounted on a manned, high-speed combat aircraft.

Anyway, these are just fictions, aren't they, so they don't really mean much? In reality, Royer et al's reductionist methodology could be used to do almost anything. In fairness, it is hard to think of real-world precedents to ground the thinking of such a thing in, at least at this early stage. Science fiction is an obvious choice in this respect. Although Royer et al. do not pose any actual derivative purposes of the technology they developed, they indicate possible applications via fictions. In very general terms, and with relation to the system framework, they say that the research 'provides a platform for the development of 3-D noninvasive BCIs that are open to a wide subject population. The 3-D world we live in demands such functionality from BCI systems. Here we demonstrate the potential of noninvasive systems to meet that demand.' (2010:588).

Doud, A.J., Lucas, J.P., Pisansky, M.T. & He, B. 2011, "Continuous Three-Dimensional Control of a Virtual Helicopter Using a Motor Imagery Based Brain-Computer Interface (Continuous 3D Control Using EEG Based BCI)"

Institution: University of Minnesota, Minneapolis, USA.

Funding: 'This work was supported in part by National Science Foundation CBET-0933067,[65] National Institutes of Health RO1EB006433,[66] and RO1EB007920'[67] (2011:1)

This paper is an affirmation, more than anything, of the work conducted by Royer et al. (2010) and follows a conference paper in the interim by Doud, Lucas and He (2011) which was essentially a report on the research published in detail as Doud, Lucas, Pisansky and He (2011; henceforth Doud et al. 2011) Only three subjects participated, two of whom were involved in the previous year's study. Again, the virtual environment resembling Northrop Mall, dotted with ring targets, was produced in Blender. A series of trials were conducted. While no major changes were made, there was one curious adjustment. A third

[65] NSF Award Search: Award # 0933067 - Neuroimaging of Motor Imagery for Brain Computer Interface Applications (same as Royer et al. 2010))
[66] Same as Royer et al. (2010)
[67] This is a new injection of funding. As far as I can tell, the NIH search database does not list the present study (or any study) under this grant number.

differential was added to the MI selection, which resulted in 'the incorporation of both force and displacement actuation' (Doud et al. 2011:9) in the EEG-based BCI commands mapped to the virtual helicopter. Recall that in Royer et al. (2010) there were only two control signals actuated via EEG output: left and right arm MI, achieving 3D control in a 2-D medium (or as Doud et al. refer to it, 'quasi-3D (2011:2) environment). In Royer et al. (2010), resting one's motor imagination caused the virtual helicopter to descend, whilst imagining moving both hands upwards caused the virtual helicopter to ascend. In Doud et al. (2011), however, as well as the MI of arms and hands mapping to flight actuations for rotational (left/right) control, a *tongue/foot* MI differential formed the control signals for the virtual helicopter's altitude. Subjects were able to reverse by imagining resting both hands,[68] or go forward by imagining moving both hands (2010:3). Here too, the subjects viewed the virtual helicopter from a third person perspective.

Up/down control via tongue/foot MI was achieved through less finely grained, lower resolution control analogous to the 'gross movements' of the arm toward an object. But left/ right rotation control mapped to EEG signals associated with left/right hand MI is afforded a higher resolution, allowing for more finely grained control: analogous, say Doud et al., to the grasping of fingers. This means that the system mirrors the nervous system's own modes of movement control (2011:9).[69]

Of note, is that Subject 1 (who was also involved in Royer et al. (2010)) reported an increasing correspondence between their performance of the MI commands mapped to control actuations in the virtual helicopter, and in turn their general sense of embodiment as inclusive of the latter. What Doud et al. take this to mean is that although it is built into the training and initial operation, eventually their system eliminates the need to 'perform

[68] What Doud et al. call a 'volitional "rest" state' (2011:2).
[69] Here, the virtual helicopter is set to continue moving in the direction last input via EEG even after the command has been made.

multiple motor imageries simultaneously, a task often complicated for the inexperienced user' (2011:9). From the sparse insight given by Doud et al. into the experience of the particularly expert user, Subject 1: it seems they stopped actively visualising the relevant MI almost altogether. It was rather 'awareness' being shifted to the relevant parts of the body that had their MI and thus sensorimotor rhythms mapped to a command, rather than any foregrounded, explicit visualization. Consistent, then, with theories of prosthetic incorporation (Leder 1990, Clark 2003) the system allows for a shift from novice 'representational', to expert 'abstract and intuitive control' (Doud et al. 2011:8). An embodied knowledge was expressed in fluid movements of the virtual helicopter.

Out of the blue during a discussion of 'average ring acquisition velocity' (ARAV)… a metric that allows for the characterization of the speed of pursuit of randomly positioned targets presented sequentially' (2011:7) Doud et al. briefly attempt

> (t)o give the reader a sense of real world equivalent values… [by scaling the ARAV from their experiment up] … to the standard length of an AH-64 Apache military helicopter, [in which case] Subjects 1, 2 and 3 would effectively be pursuing the presented targets at an average velocity of 25.5 mph, 14.0 mph, and 3.82 mph, respectively. (ibid.).

Future Uses?

What actual future uses are cited? Again, no specifics, just hints at *areas* of potential application (see below). On top of 'biological navigation' (which may just be another way of describing the EEG-based BCI control of a remote prosthetic in 3D space) and 'other applications' in the abstract, they conclude the paper:

> By placing emphasis on the interplay between the methodologies used to train the user and the functionality of this novel system, the possibilities for non-invasive BCIs for potential applications to neuroprosthetics, rehabilitative medicine or other fields will continue to expand. (2011:9)

Although we do catch wind of a beneficent future with mention of 'rehabilitative medicine', they may as well have left it at 'neuroprosthetics': a blanket term describing

BCI controlled *anything*. However, on close inspection, these comments refer to the system itself, without specific reference to the application they have been working with, albeit in the virtual realm; nor, for that matter, with reference to any specific application at all. Moreover, the team have avoided saying anything about their system in future being used to fly an actual drone, which seems the most logical progression. We can frame this by saying that Doud et al. have given **derivative purpose *areas*** for their *system framework*, a modification to Forge's terminology that will have utility for describing what later teams write about future uses of the BCIUAV. So, although this remains something of an 'open project' (Gell 2013:109), clearly the research lends itself to a particular species of neuroprosthetic — airborne, remotely controlled — whether in 'rehabilitative medicine' or 'other applications'… in 'other fields'.

Yu, Y., He, D., Hua, W., Li, S., Qi, Y., Wang, Y., Pan, G., 2012, "Flyingbuddy2: A brain-controlled assistant for the handicapped,"

Institution: Zhejiang University, China

Funding: Qianjiang Talent Program of Zhejiang

Chinese team Yu et al's (2012) conference poster presents their 'FlyingBuddy2', a MI paradigm EEG-based BCI quadcopter system.[70] No references are made to any of the studies reviewed so far. They use a low-cost EMOTIV EPOC headset with 14 electrodes as opposed to a full 64 found in higher-cost EEG caps used by better funded teams (see Nuwer et al. (1998) for the internationally standardized scalp EEG electrode placement map according to the 10-10 system) to control a quadrotor Parrot AR. Drone. It is unclear exactly what the team did in terms of testing the system, but it is reasonable to assume that they tried to actualise each of the commands proposed with a healthy user. To make the

[70] FlyingBuddy1 is presented in a 2011 conference paper that is no longer available.

quadcopter take off and land the user had to "think left hard" (2012:670). A weaker signal from the same command when performed as "think left lightly" (ibid) was used to turn left in flight. For the quadcopter to travel forward, the user had to "think right" (ibid). Ascension during flight was achieved by "think push" (ibid), while the command for descent was "clench" (ibid). The drone was set to hover when no BCI output occurred. However, as we will see later (Chapter 4), this is not an active recognition of an idle brain state. It is simply an automated response to no EEG output signal. Finally, although Yu et al. have only included a command in the drone for turn left, and not one for right, and a command for forwards but not for backwards, technically (although not entirely practically) they achieved three-dimensional control.

Future Uses?

Yu et al. give a ***specific*** **derivative purpose** for BCIUAV technology. They write that FlyingBuddy 2 'can augment mobility and perceptibility of the handicapped.'[sic] (2012:669), going on to discuss three different scenarios of use. The first is a 'boxing game', in which the BCI user in a wheelchair could control the quadcopter in order to try to take down an opponent's drone which they imagine being operated by handheld controls by a healthy user. This scenario is supposed to illustrate how the technology can allow for the inclusion of disabled people in recreational activities with non-disabled people. The second scenario of use imagines that the user could extend their visual perception by directing the quadcopter to 'inaccessible building or scenery' [sic] (2012:670). The third scenario builds upon the previous one. Here the user could take still images from the video feed from the drone's onboard video camera. Another, non-flight related command — blinking four times — is suggested to perform this function. This is more of an early proof of concept than a fully-fledged study. Nevertheless, Yu et al's thoughts concerning

disabled users are clear. ‘Maybe one day in the future, the handicapped can use brain [sic] to drive a mini plane in which they were seated, and go anywhere they want to go.’ (ibid)

Akce, A., Johnson, M., Dantsker, O. & Bretl, T. 2013, "A Brain-Machine Interface to Navigate a Mobile Robot in a Planar Workspace: Enabling Humans to Fly Simulated Aircraft With EEG"

Institution: University of Illinois at Urbana-Champaign, USA.

Funding: NSF CNS-0931871, NSF CMMI-0955088.

As discussed earlier, Akce, Johnson, Dantsker and Bretl (2010) were the first team to achieve (two-dimensional) BCI control of a (fixed-wing) UAV. In their 2013 study, they conducted a simulation experiment with twenty subjects, rather than implementing actual drone hardware. The study builds on the methodology used in Akce et al. (2010). Akce et al. (2013) aren’t particularly interested in BCI itself, or in ‘advanc(ing) the state-of-the-art in EEG signal processing’ (2013:307), and by their own admission treat EEG processing ‘as a black box’ (2013:308). Nevertheless, their main point of comparison in terms of performance is an early BCI wheelchair system designed by Iturrate, Antelis, Kübler and Minguez (2009), which they claim to have outperformed (Akce et al. 2013:307).

> (W)e make system design choices that allow us to cast interface design as a communication problem. Our first choice is to model desired paths as strings in an ordered symbolic language for representing smooth planar curves. Our second choice is to model the neural sensor as a communication channel – in particular, to model EEG with left- and right-hand motor imagery as a binary symmetric channel. Our third choice is to use a graphical display for providing feedback to the user. (2013:307)

During the experiments there were two main tasks given to the twenty subjects: the ‘tracking task’ and the ‘high-level task’ (Akce et al. 2013:312). The former entailed flying the simulated aircraft around a predetermined three-kilometre-long path made visible to them on the screen as a red line. During the tracking task, just as in their previous study, Akce et al’s approach is to present the estimated best choice of flight path to the user via

the graphical display in a symbolic language which is arranged according to 'lexicographic ordering' (2013:308) and overlaid onto the computer graphic of the aircraft in flight. In their 2010 study, in which they achieved two-dimensional control of an actual fixed-wing UAV traveling at a fixed speed, Akce et al. used this method alone. However, in 2013, the 'high-level' task did not require the user to follow a pre-set path, but rather freely navigate the aircraft 'over a given list of terrain structures' (ibid.). In this mode the user was not presented with the symbolic language prompts. The symbolic language element in terms of user experience is used only in an intermediary or training stage (2013:314). The high-level task, then, represents a more intuitive and realistic user experience with reference to possible future actualizations of the simulation.

While the results appear promising, unlike the two simulation studies from Royer et al. (2010) and Doud et al. (2011), Akce et al. (2013) have still only provided two-dimensional control. They do, however, make suggestions as to improvements for future work in which three-dimensional control might be achieved by extending their symbolic language method, amongst other possible additions such as the utilization of a head-mounted display (HMD).

Future Uses?

In terms of what this might be for, aside from the obvious (control of an aircraft), just as with their 2010 offering no indication of derivative purposes is given.

LaFleur, K., Cassady, K., Doud, A., Shades, K., Rogin, E. & He, B. 2013, "Quadcopter control in three-dimensional space using a noninvasive motor imagery-based brain–computer interface"

Institution: University of Minnesota, Minneapolis, USA.

Funding: 'This work was supported in part by NSF CBET-0933067,[71] NSF-DGE-1069104, the Multidisciplinary University Research Initiative (MURI) through ONR (N000141110690), NIH

[71] Common denominator throughout Royer et al (2010), Doud et al (2011) and LaFleur et al (2013).

EB006433, and in part by the Institute for Engineering in Medicine of the University of Minnesota.'

> We demonstrate for the first time the ability to control a flying robot in 3D physical space using noninvasive scalp recorded EEG in humans. (LaFleur et al 2013:1)

LaFleur et al. (2013) reference only their own team's work (Royer et al. 2010, Doud, Lucas and He 2011, Doud et al. 2011). More broadly, rather than Akce et al's (2010) pioneering study being the major internal citation node of BCIUAV research, LaFleur et al. take on this mantle because they achieve 3D control of an actual quadcopter drone (Parrot 2.0) for the first time. Including review papers, LaFleur et al's paper is cited in 39 of the 78 subsequent papers in the bibliography of BCIUAV research collected here spanning from 2010-2021 (see Appendix 1), and thus in 39 of 84 papers overall: making it the most internally referenced paper at my time of writing.

The previous two studies at the University of Minnesota (Royer et al. 2010, Doud et al. 2011) laid the ground for LaFleur et al. (2013). Indeed, LaFleur et al. write that the work is intended as part of an escalating dialectic between simulation and actualization. The simulations with the virtual helicopter allowed them to actualise BCI quadcopter flight, and in turn, the actual quadcopter experiment will feed back into more sophisticated simulations, which may in turn give rise to more fruitful actualizations.

This is still a closed-loop BCI with the three steps of 'sensing, processing and actuation' (LaFleur et al. 2013:2) combined with visual feedback given to the user. Like all the systems reviewed so far, because the commands for control are actively generated by the user endogenously without any preceding exogenous stimuli, the BCI system can be categorized as 'active' (Zander and Koethe 2011). It is also categorizable as simple/conventional BCI (Pfurtscheller et al. 2010). Using only EEG, it records the fluctuations in electrical potential in the sensory-motor cortex corresponding to the motor-imaginations of the user, processes and then translates them into commands in the

prosthetic. The MI command selection has returned to that of the 'reductionist method' (Royer et al. 2010). The tongue/foot differential seen in Doud et al. (2011) is not present.[72] Take off is controlled by the moderator, left- and right-hand MI is mapped to respective rotational control in the quadcopter, and double handed MI is used for increase in altitude. Resting (no MI) results in the quadcopter's descent. The gross and fine control developed in Doud et al. (2011) is preserved via processing of the EEG signals (La Fleur et al. 2013:7). WiFi is used to transmit control signals to the drone in flight, and to relay video data from the onboard camera to the user.

Before being allowed to progress to control of the quadcopter, human subjects undertook screen-based tasks involving 1D control for right and left, the same for up and down, then moved onto 2D control training which combined the previous two. Subjects who passed the criteria of 70% success then trained for around five hours over three months on the virtual helicopter simulator. During the experiments with the actual quadcopter, which took place in a gymnasium dotted with ring targets, the five subjects sat facing a wall and observed a screen displaying the video feed from a first-person view camera attached to the quadcopter. This is in contrast to the third-person view afforded by the virtual helicopter experiments.

A test for the user involving two goals of any successful flight, 'target acquisition' and 'obstacle avoidance', is built into the experiment as an 'exciting game' (2013:13): the same game played in the simulations of Northrop Mall. Although now, in the gymnasium, they deploy an actual quadcopter which may crash, causing the flight to be restarted. Thus, unlike the virtual helicopter experiments, there is a real (albeit innocuous) element of risk motivating a sustained, well controlled flight. Central to the gamified conditions of the

[72] Cf. Kosmyna et al. (2015b) who say that 'both imagined feet movement' (2015:513) is present in LaFleur et al.

experiment is the goal-directed task of passing through the ring targets. To pass through a target (to acquire it) requires obstacle avoidant behaviour, in other words, avoiding the outsides and the inner edges of the rings. While 'intrinsic limitations' (2013:12) included restrictions on peripheral view and minor time lags throughout the system in both command transmission and video feedback, the overall results suggest that subjects were able to complete the flight tasks with relative ease.

Future Uses?

LaFleur et al. write that the 'significance' of their work concerns those suffering from 'neurodegenerative disease(s)' (2013:1) such as muscular dystrophy and spinal muscular dystrophy, although 'amyotrophic lateral sclerosis' (2011:2) (ALS) is given prominence. In later stage cases, individuals with ALS may have little to no motor function, yet still be able produce motor imagery, and thus sensorimotor rhythms (SMRs) accessible through EEG, subsequently available for involvement within a BCI system. LaFleur et al's system allows for the accurate, continuous, higher speed control[73] required for the autonomous exploration of space (via neuroprosthesis[74]) willed only by thought.[75]

In clinical settings, a well-known advantage of noninvasive BCI is the elimination of the need for surgery, but LaFleur et al. think that their system might also act as a transitional technology for patients 'paralyzed by brain stem lesions' (2013:13) to allow for training before having an invasive BCI component surgically implanted. However, the authors are

[73] Some of the criteria for BCI systems desired by ALS patients, identified in Huggins et al. (2011). The patients contacted revealed their needs as being pretty basic, however: operating wheelchairs, robotic arms for self-feeding, 'communicating' and 'use the bathroom' (2011:320) are cited.
[74] But not necessarily a UAV.
[75] They also tell us that the interface (and the gamified experiment) is intuitive and thus inviting, responding to the perceived problem of low uptake of BCI systems by ALS patients.

insistent that BCIs, although having been developed for therapeutic or restorative purposes initially, can be useful for healthy individuals too.[76] In their own words:

> The ability to interact with the environment through exploration of the 3D world is an important component of the autonomy that is lost when one suffers a paralyzing neurodegenerative disorder and is one that can have a dramatic impact on quality of life. Whether it is with a flying quadcopter or via some other implementation of telepresence robotics, the framework of this study allows for expansion and assessment of control from remote distances with fast and accurate actuation, all qualities that will be valuable in restoring the autonomy of world exploration to paralyzed individuals and expand that capacity in healthy users. (2013:14)

So, in this quote, while emphasis is put on 'the [system] framework': they do not exclude the possibility, and have certainly foreseen it, that a paralyzed patient could benefit from using a BCIUAV. In this respect, the narrative shifts slightly in a video made about the project by the University of Minnesota (2013), hosted on the international weekly journal of science *Nature*'s YouTube channel, *Nature Newsteam* (O'Brien and Walton 2014) geared at school age science students or perhaps just the general public:[77]

> This BCI technology is all about helping people with disability or various neurodegenerative diseases to help them regain mobility, independence and enhance performance. We envision the use of this technology to help control wheelchair, artificial limb, or other devices. (Bin He)

The narrative shifts slightly again in another video made by the funders of the study, National Science Foundation (NSF), found on their YouTube Channel, aimed at similar audiences:[78]

[76] Obviously, the capacity for 'world exploration' (2013:14) is not something germane only to those living with paralyzing and/or neurodegenerative conditions.
[77] https://www.youtube.com/watch?v=VSTLHBrTgD4 **(https://perma.cc/5BQP-SB2C)**
[78] https://www.youtube.com/watch?v=lsraC04Mm8w (https://perma.cc/FCN6-YUNE**)**. In the text description for the NSF video, it says: 'The research in this episode was supported by NSF award #0933067, Neuroimaging of Motor Imagery for Brain-Computer Interface Application and funded through the American Recovery and Reinvestment Act of 2009.' However, this was not the only funding involved — as we can see from the declarations in the article, the National Institute of Health (NIH) provided funding, as well as the Multidisciplinary University Research Initiative and the University of Minnesota. Notably, we find out only via the NSF Youtube channel that this research was part of the US Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative (cf. Dando 2020 Chapter 6).

> **He:** The goal is eventually to make this technology to go to really help people to control a wheelchair, with a variety of disability.
>
> **Narrator:** The interface is designed to help with simple everyday tasks like turning on a light switch, but Professor He and his team chose the quadcopter for the testing phase to keep participants challenged and eager to succeed.
>
> **Narrator:** Whether it's a wounded veteran or a stroke patient, the aim is independence. Eventually, He says, this interface may help rewire brain circuits to bypass damaged areas.
>
> **He:** You want to make a phone call, you want to turn on the TV, you want to switch the channel, you want to surf the internet: there a huge societal and economic benefit to society eventually with this research.
>
> **Narrator:** Harnessing brain power to help people with disabilities do for themselves is a *high-flying idea*: just think about it.

In these videos, Bin He seems eager to communicate that the potential usefulness of the research for disabled people is less to do with the UAV application than the reconfigurability of the system framework, and that it is other devices altogether that he envisions as being utilized for disabled individuals.

Between the article and the videos, LaFleur et al. have provided quite a lot of talk about future uses. By LaFleur et al. (2013) a technology has been developed whose primary purpose is a *capacity for control*, which has been tested specifically with a wireless, airborne prosthetic. So what derivative purposes are spoken of by LaFleur et al. involving the system in action with some kind of device, which may or may not be a UAV: and in what context?

Dealing with the videos first, there are several derivative purposes mentioned. The system could be used to help disabled people control a wheelchair, or an artificial limb, or to help with such tasks as turning on the light switch. These are specific derivative purposes, which are contextualised as beneficent. Where Professor He mentions that the system could also be used for making phone calls, switching TV channels and surfing the internet, we move into a more ambiguous space in which the user may or may not be a disabled person. These specific derivative purposes are beneficent if eventually aimed at disabled

individuals, but neutral if aimed toward healthy users. The videos mention five specific derivative purposes: two of which are beneficent, and three of which are beneficent and or neutral. However, none of these pertain to the UAV application, which is side-lined as a mere means to other ends, as well as a way to keep researchers and participants entertained during the experimental process.

Moving onto the article, the first derivative purpose (which is said to pertain equally to the BCIUAV as to any other application of the system framework) appears to be 'world exploration' (2013:14). However, in an important sense 'world exploration' is a re-description of the primary purpose of control because no conceivable application of control (interpreted here as resulting in movement in space) could be excluded from the category of world exploration and vice versa.[79] 'World exploration' is a derivative purpose of the primary purpose of control, but so broad as to be a ***general derivative purpose***. 'World exploration' in its generality is also tonally/affectively neutral. So, on one hand, there is almost a tautology at work in citing 'world exploration' as a future use of the BCI prosthetic. On the other, this could be interpreted as a philosophically minded observation regarding the generality of action achievable by incorporation, signalling the vastness of the technology's potential. The system may have, as LaFleur et al. seem to suggest**,** an infinity of derivative purposes all involving 'world exploration' in its broadest sense, but the specific derivative purposes they *choose to cite* are a transitional assistive technology for people paralyzed by brain stem lesions before they can progress to an invasive form of BCI using electrocorticography (ECoG); and an assistive technology for those with ALS and other paralyzing conditions. The latter is clearly given more emphasis, and in the article anyway (and it should be said that this is my way of framing it) they certainly *do not exclude* the UAV application from this beneficent prospection. Here, again, we catch a

[79] For example, the grasping motions of a robotic arm, could be categorized as modes of 'world exploration'.

glimpse of a possible *assistive* brain-computer interface unmanned aerial vehicle. (cf. Yu et al. 2012)

So, in the article, LaFleur et al. give two specific derivative purposes of their technology,[80] both of which it could be claimed are, in principle, 'beneficent'. Importantly, only the ALS related purpose pertains, as least in possible terms, to both the BCIUAV *and* their BCI system framework with another kind of application. The idea of a transitional technology for patients paralyzed by brainstem lesions does not concern the UAV application and only refers to the BCI system framework.

But they also give us an ostensibly neutral general derivative purpose, 'world exploration': which, again, it would seem is meant to pertain to the BCIUAV *and* any other neuroprosthetic device linked to their system framework but cannot be limited to any specific user population. However, conceptually, this general derivative purpose could subsume any manifestation of the specific derivative purpose of an assistive technology for ALS (and other disabled) patients, which would then be beneficent.

With all these derivative purposes being mentioned, the shifts from making claims about the system framework to the control of the UAV application, as well as between aiming the technology toward healthy users or specific patient populations (or both), we see the utility of having terminological tools for pinning down what is actually going on. However, in the summary at the chapter end , I only give the derivative purposes relating to BCIUAV control, rather than those mentioned for system frameworks.

So, the basic terms we have used so far to account for various descriptions of future uses as derivative purposes, and which will not be added to further during the rest of the review or the thesis at large, are:

[80] And by extension, their research.

***Specific* derivative purpose** (e.g., assistive technology for ALS patients)

***General* derivative purpose** (e.g., world exploration)

Derivative purpose *area* (e.g., rehabilitative medicine)

We will soon see this third term become applicable to the BCIUAV rather than only to the system framework.

Kim, B.H., Kim, M. & Jo, S. 2014, "Quadcopter flight control using a low-cost hybrid interface with EEG-based classification and eye tracking"

Institution: Department of Computer Science, Korea Advanced Institute of Technology (KAIST)

Funding: 'supported by Basic Science Research Program through the National Research Foundation of Korea funded by the Ministry of Education (2013R1A1A2009378) and by the MOTIE (The Ministry of Trade, Industry and Energy), Korea, under the Technology Innovation Program supervised by KEIT (Korea Evaluation Institute of Industrial Technology), 10045252, Development of robot task intelligence technology.' (2014:92)

Referencing Royer et al. (2010), Doud et al. (2011), and LaFleur et al. (2013), although placing particular emphasis on the latter, the Korean team Kim et al. (2014) offer up their own prototype BCIUAV system. They argue that as an instance of multi-state classification[81] LaFleur et al's (2013) system is disadvantageous in terms of training time. Even when familiar, the general difficulty of sustaining the level of concentration and skill required for successful control is a barrier to continuing use. Ideally a BCI system classifying only two brain states would ensure ease of use.[82] However, this would mean that the number of BCI output commands are reduced to two. And in a standalone BCI, binary classification proves less useful for control than a multi-class approach. To solve

[81] In the sense that there are multiple commands corresponding to the distinguishable brain states produced by the wilful evocation of motor imagery apprehended through the singular EEG output modality.
[82] Over time we will see that this statement about binary classification, which is repeated by others in more or less the same time period, seems less relevant to other modes of and control paradigms for EEG-based BCI beyond MI, e.g., steady-state visually evoked potential (SSVEP).

this problem, and in order to achieve three-dimensional control, instead of using a single BCI output modality the authors propose a *hybrid interface* involving a two class EEG-based BCI component alongside an eye tracking device. In terms of functional compensation, using one BCI and one non-BCI output increases the number of available commands whilst redistributing signal acquisition and control across the two modalities. The low-cost EMOTIV EPOC[83] headset is used for EEG acquisition. The drone used is the same as LaFleur et al's, the Parrot 2.0 quadcopter, complete with onboard high-definition camera for remote visual feedback. Command signals to and video feedback from the drone are transmitted over WiFi. However, Kim et al. do not utilize a MI paradigm. Take-off and landing of the quadcopter work via the classification of EEG signals corresponding to 'two mental states: intentional concentration and non-concentration' (2014:84). When beginning a trial, '(a) subject can cause the quadcopter to take off by concentrating mentally with their eyes closed' (2014:85). Concentration and non-concentration brain states were identified in the data acquisition section of the experiment, wherein the five test subjects stared at a computer screen without moving their eyes so as not to contaminate the EEG data with electrooculographic (EOG) or electromyographic (EMG) artifacts. The display alternated at several second intervals between showing nothing and displaying a moving visual stimulus, inducing non-concentration and concentration states respectively. For non-concentration states, Alpha waves were detected in the occipital lobe between the frequencies of '11 and 13 Hz' (2014:85), whereas concentration states produced Beta waves between '13 and 19 Hz appearing in the 'frontal lobe'(ibid.). It is these two brain states that the BCI software component recognises as commands for take-off and descent. EEG (concentration and non-concentration state) classification was found to be at 91.67% (ibid.). Flight control is

[83] https://www.emotiv.com/ (https://perma.cc/H6CD-E2SG)

largely delegated to the eye tracking unit. There are eight commands; ‘up and down, left and right, forward and backward translation, and left and right turns.’ (ibid.). These are split across two control modes on the screen, A and B, which can be selected by ‘concentrating mentally while gazing at the central area’(ibid.) Thus, they utilize the concentration state twice: once for take-off, and again when in flight for selecting control mode A or B.

In this way, Kim et al. achieve an exhaustive mapping of the ‘possible flight actuations’ (2014:83) afforded by the drone. The eye tracking component focuses only on one eye and works by capturing sequential images of it at ‘a sampling rate of ‘33 Hz’ (2014:84). These images are then processed by a software layer (Gaze Tracker) that estimates the position of eye gaze relative to the dimensions and areas of the screen displaying the graphic user interface through which the user both selects flight actuations and receives feedback from the drone’s camera. To this aim, during the data acquisition process subjects were required to fix their gaze on nine points on the screen in a certain sequence. Gaze information centred on the position of the pupil is recorded and ‘transformed to a screen coordinate’ (ibid.) for later use in flight control of the drone. With their $40 device cobbled together from ‘an infrared camera, and light emitting diodes (LEDs) … [five of which are] … fixed around the edge of the infrared camera that is connected to the frame of a pair of glasses about 8cm away from the left eye’ (2014:83), Kim et al. claim to have rivalled the classification accuracy of a commercially available eye tracking unit priced at $25,000. [84]

First, Kim et al. conducted a keyboard control trial in the interests of comparison with later hybrid interface tests. Subsequently, the flights using hybrid interface took place in a school gymnasium, and used helium filled balloons as markers that test subjects could

[84] Khan and Hong (2017:8), also a South Korean team, write of Kim et al’s system that the little LED light shone into the user’s eye to constrict the pupil, thus increasing the iris/pupil ratio, would have been fatiguing with continued use.

control the drone around in ‘a figure-eight trajectory flight path’ (2014:87). This required each actuation in the drone to be tested at least once. In the end, the system ‘achiev(ed) 85.55% of the success rate achieved via the keyboard-based system (2014:90) and control was achieved in a manner Kim et al. think is ‘natural and intuitive’(ibid.). A key advantage of this system by contrast to LaFleur et al’s is that it does not require constant mental effort to stay airborne. Instead, it continues to execute the last command given until receiving another.

One drawback of Kim et al’s system is, by their own admission, the clumsiness of their EEG data processing algorithm, found in its inability to properly distinguish between ‘neural and non-neural’ signals. The presence of EOG and EMG artifacts (unwanted signal noise) in the EEG data that come from the muscles in and around the eye lead to discarded trials and might pose a problem for control broadly. As Kim et al. note, LaFleur et al’s system is in principle less prone to signal contamination from EOG and EMG because they use standalone EEG-based BCI. Nevertheless, LaFleur et al. also try to eliminate artifacts in their active, standalone EEG-based BCI system in terms of ‘eye blinking and muscle activity’ (2013:6). With regard to artifact interference in both standalone and hybrid interfaces involving EEG-based BCI, the capacity for nuanced and accurate discrimination within electrophysiological excess is essential for future iterations.

Kim et al. also note that several of their test subjects suffered from anxiety caused by making mistakes in flight and this affected the quality of subject’s flight control negatively, in a kind of vicious circle. In reductionist terms ‘unstable mental states…produce psychological artifacts causing inconsistent EEG patterns.’ (2014:91).

Future Uses?

> The proposed interface enables both disabled and fully capable people to complete their tasks with various commands in 3D physical space. Through this low-cost and easily wearable device, people can control their flight naturally and easily in everyday life. (2014:91).

Less philosophical than 'world exploration' (LaFleur et al. 2013:14), *everyday flight*, as it were, is still vague enough to be considered as a *general* derivative purpose of the primary purpose of control, which pertains to 'both disabled and fully capable people'(Kim et al. 2014:91). Where the latter are concerned, the derivative purpose, in principle, is neutral. We may also interpret everyday flight as beneficent, because Kim et al. write that '(i)n particular, the present scheme is beneficial for physically disable [sic] people. EEG-based binary classification is simple and trainable with few complications.' (2014:90). However, while this latter statement about EEG-based binary classification may be true, there is not just EEG-based BCI involved in their system. As Kim et al. acknowledge, the eye tracking component is itself only useful for those who can 'move their eyes voluntarily' (2014:82).[85] The vast majority of people can move their eyes voluntarily, but as we will discuss in Chapter 4, there are some people suffering from severely paralyzing conditions who struggle to do this. One thing we can draw from this analytically is that unlike LaFleur et al's standalone MI paradigm BCI system,[86] the type of hybrid interface BCI Kim et al. present does not entirely bypass the muscular system. The two class EEG-based BCI output does, but the eye tracking unit does not.

With relation to the hypothetical case of patients suffering from paralyzing neurodegenerative diseases, the system confers an advantage on the already 'fully capable' (2014:91) user which it does not confer on the former. In comparison to LaFleur et al's

[85] This acknowledgement is an example of the recognition of the complex 'role responsibility' (Forge 2013a:123) attributable to BCI researchers, rooted in the historical context within which BCI emerged. More on this later e.g., Chapter 4, Chapter 7.
[86] For control, anyway.

system which required a moderator to perform the take-off, with Kim et al's system, from take-off to landing and inflight, the user may operate the system entirely without the intervention of a moderator. If the individual in question has hands, and importantly the nervous system functionality to control their hands, then the wearable system could be described in common tech parlance as 'hands-free' (Kim et al. 2014:ibid). In an important sense it is always already hands-free, but the fully capable user may be able to perform other actions with their hands *as well* (see Chapter 5).

Shi, T., Wang, H. & Zhang, C. 2015, "Brain Computer Interface system based on indoor semi-autonomous navigation and motor imagery for Unmanned Aerial Vehicle control"

Institution: The Institute of Mechatronic Engineering, Department of Mechanical Engineering, North Eastern University, Liaoning, China

Funding: University Innovation Team of Liaoning Province and National Natural Science Foundation of China

Shi et al. do not reference any of the BCIUAV studies available before the date of their own publication. However, regarding the two subsystems of their BCIUAV system we can see the influence of research into two broad kinds of application. The 'decision subsystem' (2015: 4197) associated with the two class MI paradigm EEG-based BCI component, is, as one might expect, underpinned by foundational work on BCI that tended towards beneficent applications for severely paralyzed patients (Pfurtscheller et al. 1998). For the 'semi-autonomous navigation subsystem' (Shi et al. 2015:4197), Shi et al. find ground in another lineage of research concerning the development of various aspects of *autonomous* UAVs. The goal of 'navigation'[87] which logically comes under the primary purpose of control is key to both Shi et al's work and research into autonomous UAVs. In the latter sorts of studies, researchers are concerned with fully autonomous navigation, whereas in

[87] Equivalent to LaFleur's 'world exploration'.

Shi et al's work the task of navigation is delegated only in part to an autonomous subsystem. The top-down controller of the 'decision subsystem' (2015:4198) is a human user who makes navigational choices based on the environmental information processed by the autonomous subsystem. Shi et al. claim that autonomous UAV navigation, particularly in previously unknown indoor spaces given the unpredictability of the obstacles, is difficult to achieve and has a high computational cost — too high in this case to achieve 100% success. At 'intersection(s)' (2015:4197) where the autonomous subsystem might not otherwise be able to both process environmental information and make successful navigational decisions for itself, having a human-in-the-loop helps raise the intelligence level of the system overall whilst also reducing computational cost.

As for previous attempts to incorporate BCI control and a semi-autonomous component within a single system, three studies stand out in Shi et al's bibliography. One is 'A Brain-Controlled Wheelchair Based on P300 and Path Guidance' by Rebsamen et al. (2006), who were among the first to work on the semi-autonomous P300 EEG-based BCI wheelchair. Another is from Perrin et al. (2010), 'Brain coupled interactions for semi-autonomous navigation of an assistive robot', who drawing upon semi-autonomous wheelchair research indicate the future utility of their own work as pertaining to this latter sort of application. The third is from Ron-Angevin et al. (2011), 'A two-class self-paced BCI to control a robot in four directions', who state that their research is 'a previous step before using a real (BCI driven) wheelchair' (2011:2). Semi-autonomous BCI systems are perceived as particularly useful for people with certain physical conditions requiring that they be in a wheelchair, and cannot use ordinary motor functions to control their navigation through space: because *shared control* reduces the command load on the user.

Breaking with the BCIUAV studies reviewed thus far, the drone used by Shi et al. is a carbon-fibre frame hexacopter (six rotors) that the team have built to their own specifications using:

> motors...an ARM9 processor with the Linux system embedded…a pressure sensor and the 9 degrees of freedom miniaturized inertial measurement unit with three-axis gyroscope, three-axis accelerometer and three-axis magnetometer...front facing CMOS camera with 90° angle lens and a URG-04LX laser range finder (2015:4198).

For the semi-autonomous navigation subsystem, the team deploy a 'laser range finder and front-facing real time video' (2015:4197). The range finder emits a laser beam with a 180° 'obstacle recognition threshold' (2015:4202) extending four meters from the UAV, which feeds back environmental information (location and size of objects etc) to the processing unit in the drone. Two functions are extracted from this data. The first allows the drone to automatically steer clear of obstacles without input from the decision subsystem. The second is to 'provide feasible directions' (2015:4205) overlaid onto the real time video feedback from the drone on a display monitor to the user. As the top-down controller of the decision subsystem, the user chooses a path by performing left or right-hand MI corresponding to acceptance or rejection of the suggested direction from the autonomous subsystem. Recalling Kim et al's (2014) remarks, this binary choice is based on the underlying assumption that 'the two-class classifier has the best classification accuracy' (Shi et al. 2015:4200). However, if the feasible direction provided as an option to the user by the autonomous subsystem is rejected, a secondary mode of operation kicks in temporarily, in which the task of navigation is delegated entirely to the decision subsystem. Here the MI commands are mapped not to the selection of suggested directions given by the autonomous subsystem, but directly to commands in the drone itself. '(I)magination of left-hand movement to turn left; imagination of right-hand movement to turn right; idle imagination to keep flying forward.' (ibid.). In both modes, the drone will hover 'at any crossroads' (2015:4203) while presenting feasible directions and/or awaiting

new instructions from the decision subsystem. In each mode an idle or rest state is also recognised by the decision subsystem as a command to take off. So, while the team provide only two-dimensional control via the decision subsystem, the presence of the semi-autonomous subsystem reduces the 'required control instructions' (2015:4200) given by the user in the first place. The system worked well for most of the six subjects in the target searching task, but some struggled to perform the MI commands.

Future Uses?

Shi et al. say: 'Usually the BCI system can be utilized to restore the motor functions or to offer mobility for the motor disabled individuals' (2015:4196), but here the aim is to provide a system that can 'achieve the easy-to-use and stable *control* of a low speed unmanned aerial vehicle (UAV) for indoor target searching' (ibid. emphasis added). As we know, control is the primary purpose of BCIUAV research and technology broadly. However, there is a novel derivative purpose *area* given too: 'indoor target searching'.[88] An interesting phrase made more so because they do not at any point, with relation to their own work, specify the domain in which this activity might have relevance, nor to what ends. On the surface at least, 'indoor target searching' is framed as neutral.

But what do we find when we look for this term in the research Shi et al. cite involving autonomous UAVs? What more specific meaning might this have, and what contextual factors can we come upon that would help us interpret this, seeing as this information is not given explicitly? How is the term 'target searching' being used there? What kinds of targets are we talking about? Why are we searching for them? And what will we do when we find them? Particularly interesting in this regard is the paper Shi et al. cite by Quintero

[88] 'Indoor target searching' is difficult to classify. On one hand, for a *specific* derivative purpose we really want a user and/or a context to be specified, which Shi et al do not do; but on the other, it's too specific to be a *general* derivative purpose. I have therefore classed it as a derivative purpose *area*.

and Hespanha (2014), detailing work towards fully autonomous flight and target tracking with a small automated UAV. This work, with its goal of *target tracking*, forms the strongest explicit link to the derivative purpose area Shi et al. mention, 'indoor target searching'. Quintero and Hespanha's research was funded by the U.S. Army Research Office (2014:41) and took place in the department of Electrical and Computer engineering University of California, Santa Barbara. The 'target' is taken to be 'an unpredictable moving ground vehicle' (2014:28). Clearly, this is the kind of application that lends itself well to both military and policing uses. It could, in theory, also be used by a hostile sub/non-state or terrorist group in surveillance and/or targeting as part of the operations of a weapons system.

However, autonomous flight and target tracking is quite different from BCI controlled semi-autonomous navigation of a UAV for 'indoor target searching'. Aside from this ostensibly neutral derivative purpose area, Shi et al. give no hint as to the future uses of their work, and their funding seems innocuous, if not opaque.

Lin,J-S.,Jiang,Z-Y. 2015. Implementing Remote Presence Using Quadcopter Control by a Non-Invasive BCI Device.

Institution: Department of Computer Science and Engineering, National Chi-Yi University of Technology, Taiwan.

Funding: National Science Council of Taiwan; grant 103-2221-E-167-027.

This paper from Taiwanese duo Lin and Jiang does not refer to any of the previous BCIUAV studies. Rather than motor imagery, Lin and Jiang have used actual motor functions, a series of facial expressions or 'facial states' (2015:125),[89] to produce the EEG signals in turn mapped to commands in the drone. These are 'left/right smile, raise/frown

[89] See also Kosmyna et al's (2014a) involvement of facial expressions in bi-directional feedback BCI training.

brow, and left right wink'(ibid.), mapped to left/right, forward/backward, take off/landing in the drone respectively. Therefore, it appears as though Lin and Jiang have achieved three-dimensional control. They worked with the low-cost EMOTIV EPOC neuro headset. Of its 14 electrodes, only 6 were deployed.[90] They used a quadcopter model of quadcopter about which I can find no information online – but their illustrations suggest it is similar to the AR Parrot drone. Little detail is given, and no real description of the experimental process.[91]

Future Uses?

Notably, their BCIUAV research is posed as a means to another end: developing effective BCI control strategies in other neuroprosthetics, specifically for people with disabilities that might require 'wheelchair(s) or electric beds.' (2015:123). Lin has previously worked on BCI control for electric wheelchairs, so as part of a grander creative process one can imagine why working in this roundabout way might be fruitful (cf. Gell 2013). Quite rightly, Lin and Jiang mention that 'the application of Unmanned Aerial Vehicle (UAV) and Micro Aerial Vehicle (MAV) can apply to [a] variety of area(s) such as military, rescue mission[s], film making, agriculture and others' (2015:123). But as noted, their own work involving the BCIUAV is posed as a roundabout way to make better BCI wheelchairs and electric beds. In this way they cite just one beneficent *specific* derivative purpose, but one that applies to the system framework when involving other, non-UAV applications in future. They do not cite a purpose for the BCIUAV.

[90] 'AF3, AF4, F3, F4, F7, F8' (2015:126) (see Nuwer et al. 1998).
[91] What they do give some good information on is the quadcopter subsystem.

Khan, M.J., Hong, K-S., Naseer, N. & Bhutta, M.R. 2015. "Hybrid EEG-NIRS based BCI for quadcopter control"

Institutions: Pusan National University; Republic of Korea, Department of Cogno-Mechatronics Engineering, School of Mechanical Engineering

Funding: National Research Foundation of Korea under the Ministry of Science, ICT and Future Planning, Korea (grant no. NRF-2014-R1A2A1A10049727).

Khan et al. cite only LaFleur et al. (2013) as precedent. Khan et al's conference paper introduces a true hybrid BCI system[92] involving EEG output in a MI paradigm, simultaneously operating with 'an optical imaging technique' (2015:1177) called functional near infrared spectroscopy (fNIRS). The hybridized MI paradigm EEG-based BCI and the fNIRS-based BCI components are both in the active BCI category. They also use another modality of EEG-based BCI separately although still within the same system, by incorporating a 'steady-state visually evoked potential' (SSVEP)-based component.[93] In the SSVEP modality, electrodes placed over the occipital region of the user's scalp detect the frequencies of a flickering visual stimuli on a display that their gaze is focused on. When the software component recognises a frequency, it translates it into a command in the drone. Because the brain signals are evoked by the user looking at exogenous visual stimuli, SSVEP BCI is classified as reactive, rather than active. SSVEP-based BCI plays a small role in the present system. However, this visual modality of BCI will be discussed again later when dealing with systems that deploy it in a more central manner: in this chapter Chen et al. (2016), but particularly Meriño et al. (2017) in Chapter 4.

fNIRS is a relatively recently developed optical neuroimaging technique that emerged in a stable form in the early 1990s, and has since been shown to have potential for the control

[92] 'True' hybrid BCI because unlike Kim et al's (2014) hybrid interface which uses one BCI and one non-BCI output, Khan et al's system utilizes two different kinds of BCI: electrophysiological and metabolic.
[93] In a sense this is a hybrid twice over: once in the simultaneous use of EEG and fNIRS to record (active) endogenously generated signals from the motor cortex; and again, in the synergy within the system overall between the former and the (reactive) SSVEP component whose signals are recorded from the occipital cortex – making it an active-reactive hybrid too.

of external devices through BCI (Coyle et al. 2004). In comparison to EEG-based BCI which is electrophysiological, fNIRS is categorized as *metabolic* BCI (see Sitaram, Lee and Birbaumer 2012). Whereas EEG is a direct method of measuring (electrical) brain activity, fNIRS is indirect (Kübler 2020:163). It works via the relationship established between a near-infrared light source (emitter) and a detector (optode). Emitter and optode pairs are arranged around EEG electrodes positioned according to the international 10/20 system, an earlier standardization using fewer electrodes (see Jasper 1961).[94] Near-infrared light is directed toward a selected region of the brain. Invisible to the human eye, this spectrum of light with its wavelength range of 600-1000nm, is able to 'propagate several centimetres through tissue, through the scalp and skull' (Boas et al. 2014:1). Hemoglobin, the metalloprotein in red blood cells that moves oxygen around the body, is not absorbed by cells 'beyond 650 nm' (ibid.). Both oxygenated and deoxygenated hemoglobin 'have different absorption coefficients for different wavelengths of NI [near-infrared] light' (Naseer and Hong 2015:2). Variations in concentrations of oxygenated and deoxygenated hemoglobin in brain tissue caused by the firing of neurons (here corresponding to the generation of MI) can be registered at that scale by observing fluctuations in the amount of photons travelling from the light source, in their characteristic 'banana-shaped paths'(2015:3) through skin, skull, cortical tissue, and then scattering back out toward the detector. The 'optical absorption rate' (Boas et al. ibid.) is calculated via observing the 'relationship between the exiting-photon intensity and the incident-photon intensity' (Naseer and Hong ibid.). As metabolic BCI method, fNIRS is not prone to electrophysiological artifacts but rather 'physiological noise' (ibid:5). During the signal

[94] The 10/10 system mentioned earlier fills intermediate positions between those included in the 10/20 (see Nuwer et al. 1998)

processing phase Khan et al. used filtering techniques to remove 'respiratory and heartbeat noises' (2015:1178).

Broadly, hybrid fNIRS-EEG-based BCI is thought to be advantageous for two main reasons. The first being the possibility of a greater number of commands in a single system,[95] and the second being 'higher classification accuracy' (2015:1177) (cf. Khan and Hong 2017) when used simultaneously to monitor events in the same brain region. In terms of the system under discussion, which had very few commands anyway, it is the latter advantage that Khan et al. (2015) hoped the hybridization to achieve. The EEG recorded the electrophysiological correlates of the neuronal firing associated with the evocation of MI, and the fNIRS recorded the hemodynamic changes caused by the same event.

For the reactive SSVEP EEG-based BCI component, Khan et al. record electrophysiological responses[96] in the occipital cortex to a 6Hz flickering stimuli which is displayed on a screen to the user. This is used exclusively for 'start/stop' (take-off and landing) commands. The combined EEG-fNIRS component is used for inflight navigation, but unfortunately the authors do not give details of the MI command(s) performed by the test subjects. Signals are sent to the drone via WIFI, but no feedback is given from the drone's onboard camera to the three test subjects. It therefore appears that Khan et al. have restricted the experiment to a small area where the drone is visible to the naked eye of the pilot. Using the simultaneous hybridization of EEG and fNIRS, Khan et al's system facilitates only a single in-flight navigation command: move forwards. However, because the SSVEP component controls take-off and landing, the system facilitates two-dimensional control of the drone. They acknowledge this falls short of earlier attempts that

[95] As with any hybridization.
[96] These are the 'steady-state visually evoked potentials'.

achieve three-dimensional control, citing LaFleur et al. (2013) but omitting reference to their compatriots Kim et al. (2014). Still, having provided the commands for start and stop of the drone via the SSVEP-based BCI, and making the forward motion a command achieved by hybrid fNIRS-EEG rather than an automatism in the drone[97] (cf. LaFleur et al. 2013), Khan et al. do not entirely disappoint. Further, this is the first time we see SSVEP or fNIRS in a BCIUAV system at all, let alone in the same system.[98]

Future Uses?

'The current need is development of a simple BCI that can be used for locked-in patients' write Khan et al. (2015:1177). Nevertheless, they do not give any derivative purposes for BCIUAV technology itself.

Song, Y., Liu, J., Gao, Q. & Liu, M. 2015, "A Quadrotor Helicopter Control System Based on Brain-Computer Interface"

Institution: Tianjin University of Technology (Tianjin Key Laboratory for Control Theory and Application; School of Electrical Engineering)

Funding: 'Young and Middle-aged Backbone Innovative Talents Training Project Foundation of Tianjin, China under Grant 20130830, and the undergraduate teaching quality and teaching reform research projects of general higher academy, Tianjin, China under Grant JW20120315.' (2015:1483)

Chinese team Song et al. (2015) reference compatriots Shi et al. (2015) but no other previous BCIUAV study. Using a low-cost fourteen electrode EMOTIV EPOC headset, they present an EEG-based BCI quadcopter control system. However, they did not actually apply their control system to a real, airborne quadcopter. They merely demonstrated their system's potential to fly a quadcopter in future, using Quadrotor Helicopter Experiment

[97] Their drone hovers until receiving the command to go forward.
[98] Khan and Hong stand out due to their persistent experimentation with fNIRS in BCIUAV systems. See Khan and Hong (2017), Khan Zafar and Hong (2017a, 2017b) Zafar, Khan, Park and Hong (2018), Zafar, Ghafoor, Khan and Hong (2018), Zafar, Ghafoor, Yaqub and Hong (2019).

Platform (QHEP), an education and innovation device developed by Canadian company Quanser. QHEP is a tabletop quadrotor simulator that allows for the development and testing of control strategies.

Throughout the experiment, to operate the system each of the ten subjects looked at a virtual cube on a computer screen. When the MI commands were performed, the cube moved in the direction specified, providing feedback on progress. The QHEP responded in turn. Song et al's system only afforded three commands, all in a MI paradigm. These commands corresponded to three-degrees of freedom in the drone, which are present in nearly any aircraft. The 'pitch' of the drone, which refers to control of elevation, was changed by imagining movement of the right hand. The 'yaw' of the drone, which means the rotation around the vertical axis (i.e., left/right movement) was changed by imagined movement of the left hand. The 'roll' of the drone (tilt from side to side) was changed by imagined movement of both hands. Imagining nothing resulted in the drone hovering. While the commands do technically pertain to three degrees of freedom, in practical terms I think they would need six commands to achieve practical control of these three elements in future. Although the system was not very accurate in terms of picking up MI commands and translating them into commands in the QHEP, and was slow in terms of information rate transfer, they say that it has demonstrated a reasonably reliable way of controlling an actual quadcopter in future.

Future Uses?

The authors give no real indication of any derivative purpose, but they do write briefly upon the way drone technology allows for '(t)he possibility of removing human pilots from danger' (2015:1478), which suggests that they may have done at least some thinking about the potential applications of BCIUAV technology in future.

Kosmyna, N., Tarpin-Bernard, F. & Rivet, B., 2015b, Towards brain computer interfaces for recreational activities: Piloting a drone.

Institution: University of Grenoble: Grenoble Institute of Engineering and Management (GINP); John Fourier University, Grenoble (UJF); (Gipsa-lab)

Funding: None declared

Kosmyna et al. (2015b) cite only Royer et al. (2010), Doud et al. (2011), and LaFleur et al. (2013). Kosmyna et al's main focus is on the training aspect of active BCI systems broadly, but they too take up the exciting task of flying a drone with BCI. The 'Operant Conditioning (OC)' or BCI training phase is the duration in which both user and software components come to terms with each other. The user must become proficient at generating MI, and the software must be able to reliably identify the corresponding brain states to be mapped to commands in a device. This can take from anywhere between '10 min and 2 months' (2015b:506). LaFleur et al's OC phase involved a lot of intense, frequent sessions before the system was calibrated to a standard that the moderators considered acceptable to allow the incorporator to actually fly the drone. Kosmyna et al., however, sought to test a hypothesis that another method might be more appealing and even reduce overall training time. If, in 'an incremental and interactive training process'(ibid.) the actual control of the drone via the BCI could in every case follow a shorter training session than the ones deployed by LaFleur et al, 'a balance of quality versus time versus degree of control' (Kosmyna et al. 2015b ibid.) might be achieved. This is the idea behind what Kosmyna et al. call 'Co-learning BCI (CLBCI)' (2015b:507) (see also Kosmyna, Tapin-Bernard and Rivet 2013). CLBCI 'lies at the intersection of BCI co-adaption and interactive machine learning, where the interaction drives the training of a classifier.' (2015b:510).

In their directly comparative study in relation to LaFleur et al. (2013), Kosmyna et al. conducted experiments over 'three-time durations: 1 day, 1 week, 1 month' (2015b:ibid.). Half of the 24 subjects trained via standard OC, and the other half via CLBCI. Aside from

the differences in training durations, LaFleur et al's entire OC procedure and the manner in which the system itself worked was replicated by Kosmyna et al. (2015b).[99] As noted, the major difference is that whereas the subjects in LaFleur et al's study had to wait until the end of the full training duration to fly the actual drone, in Kosmyna et al. (2015b), at the end of each CLBCI session the actual flight task was attempted. That is, following the first couple of calibration sessions characteristic of the CLBCI paradigm, which allow the test subject to have informal input into the customization of the BCI to their preferences with regard to 'perceived self-control' (2015b:514), they were able to experiment with the task of flying the drone via BCI.[100] There were a couple of limitations concerning the performance of the system itself, such as the restrictive number of commands, which with more training time could be increased[101] along with the need for a fuller rage of electrodes to be used in future iterations.[102] However, the take-away finding is that '(a)ccording to all indicators, CLBCI performs better for training durations up to a month (H1), while the OC training slightly outperforms CLBCI after a month of training (H2).' (2015b:519).

Building up to 2015b, in 2014 a, 2014 b, Kosmyna et al. present the application of their earlier work on BCI architecture (Kosmyna, Tapin-Bernard and Rivet 2013) to the control of a drone (see also Kosmyna et al. 2015a). Notably, in Kosmyna et al. (2014a), for the co-learning calibration stage, which they claim can allow someone to 'learn to control a drone within 5 minutes' they reveal a novel mode of bi-directional feedback between human and machine, proposed in (Kosmyna and Tapin-Bernard 2013). The user registers approval or

[99] The calibration phase, the initial performance of the 1D cursor task to determine rotational control proficiency, then again in 1D for up/down, then a 2D cursor task with all four control together until a threshold of 80% accuracy is reached in both dimensions. Then, moving onto the virtual helicopter and eventually followed by the actual flight task. The methods of evaluation documented in 'the Minnesota paper'(2015b:513n4) and the MI paradigm and controls are also replicated.

[100] Another difference is that they did not provide any video feedback from the drone to the user.

[101] Kosmyna et al. 'used a g.tec USBAmp EEG amplifier with 16 electrodes over the sensorimotor cortex' (2015b:512)

[102] One they don't mention which is inherited from LaFleur et al. and highlighted later by Meriño et al. (2017) is constant forward motion.

disapproval of the system's classification of EEG signals by smiling or frowning, thus producing electromyographic (EMG) signals picked up by the placement of a single electrode 'between the eyes and one the left side of the lips' (Kosmyna et al. 2014a:482). The system sends feedback in terms of past and present state classifications and the accuracy of those classifications, also based on the user feedback, to a visual display. This method of EMG feedback from user to system was chosen due to less interference with EEG signals from the sensorimotor cortex than touch-based feedback would cause. In any case, EMG-based feedback to the system is not something Kosmyna et al. have included in the more substantial paper on CLBCI with a drone (2015b). Interestingly, in neither of the 2014 conference papers concerning quadcopter control, nor in their report on these two works in 2015a, do they reference the Minnesota experiments or any other previous BCIUAV study.

Future Uses?

Kosmyna et al's work is geared toward recreational use broadly and 'inspired by the application of educational science research to BCIs' (2015b:510). In contrast to 'critical application areas' (ibid.) such as assistive technologies, recreational uses of BCI, by definition, are 'noncritical' (2015b:520) and thus standards of synergy between human and machine needn't be so stringent before actual use. CLBCI fills a gap concerning the balance between quality control and 'user experience, comfort and enjoyment' (ibid.) appropriate for non-critical application areas. Initial impressions of the CLBCI for control of a drone from test subjects were deemed positive overall. Some reported motivation to keep going and improve their performance given how quickly they were able to achieve proficient flight, which in most cases was as soon as one week. However, standard OC test subjects found their experience monotonous and experienced increasing fatigue as the

training went on. While Kosmyna et al. have investigated the derivative purpose *area* of recreationally controlling a drone, the insights concerning training methods have implications for BCI-controlled devices in general.

Zhang, D., Jackson, M.M, 2015, *Quadcopter navigation using Google Glass and brain-computer interface*. [Online]. Georgia Institute of Technology. Previously Available at: https://www.cc.gatech.edu/~dzhang95/ [Accessed 02/12/2019]. [103]

Institution: Georgia Institute of Technology

Funding: None declared

This work does not appear in a peer reviewed journal, nor in the proceedings of a conference. It is a short, co-authored article unfortunately no longer available online, but appears to be part of Zhang's master's degree project. Of previous BCIUAV studies, the paper cites only LaFleur et al. (2013). Although the title suggests that this is a hybrid interface BCI using Google Glass and EEG for flight control, in fact, each mode of control is tested separately with a mind to conduct further research into their usability together. The first edition of Google Glass, which Zhang and Jackson use, is now discontinued. It was a head-mounted display (HMD) unit that allowed for both visual feedback and eye-based command selection, as well as touch-based gesture control. For flight control via Google Glass, Zhang and Jackson utilized the touch control interface on the frame, mapping a series of tapping and swiping gestures made with the fingers to commands in the drone. They made use of the assisted flying elements of the drone to allow the user to

[103] This paper is no longer available online, and the original website it came from has been deleted. There is no record of the paper on the internet archive Wayback Machine either, although parts of the original website have been archived. This paper disappeared online after I contacted the authors via email, and after a short exchange made clear that I was interested in talking to them about the openly dual use statement (see below), and its place within the wider body of BCIUAV research. Having been initially keen to participate, once they knew what I was interested in, they made excuses and went silent. My mistake was not anticipating that the article and its online source might be deleted, and not self-archiving the website it came from at the time of discovery. As a bibliographic compromise, I have referenced the date at which the earliest backup of the pdf article exists on my hard drives as the date of last visit, which will nevertheless be approximately when I first visited the site and downloaded the article (I only settled on this topic for the thesis in Autumn 2019).

enjoy quickly acquired and smoother control. In this mode, they also experimented with the 'accelerometer, gyroscope, and magnometer located in the optics pod' (2015:3) of the Google Glass, which can allow for head posture to be mapped to pitch, roll and yaw in the drone. This 'posture control mode' (2015:2) could in turn be selected via the touch interface. For visual feedback, they stream the first-person view video from the drone's camera to the 'prism display' (2015:2) fitted in the right-eye lens of the Google Glass, removing the desktop screen element from the system.

The low-cost EMOTIV EPOC Headset is used for EEG signal acquisition in a MI paradigm. Due to its limited number of electrodes which do not adequately cover the sensorimotor cortex without modification, the authors 'bend it backwards' (2015:4) to get two of the electrodes into the requisite scalp regions. The MI commands consist in imagining nothing, 'left-hand, right-hand, both-hands movement' (2015:4), eventually mapped, rather oddly, to forward, left, down, and up respectively. The authors tried to include both-foot movement MI in the initial stages of their experiment but found that the accuracy of EEG pattern recognition decreased significantly and so did not include it in the test flights. This could explain the odd configuration seen in the final list of MI mapped to commands in the drone. Nevertheless, it seems as though Zhang and Jackson have achieved three-dimensional control of the drone. Further, modest though this project was, according to my research, it marks the notable debut of a head-mounted display (HMD) utilized for control *and* visual feedback in a BCIUAV system.

Future Uses?

> This research can be applied to many circumstances such as enabling locked-in patients to explore surroundings at will, developing mind-controlled UAV that can be used in military tasks, and becoming affordable toys that can promote entertainment and socialization. (2015:1).

This quote gives one specific derivative purpose, and two derivative purpose areas. We are becoming familiar now with the theme of BCI technology being used to help severely paralyzed patients. This theme will be discussed further in due course with relation other papers, but when Zhang and Jackson write of 'locked-in patients', they refer to those paralyzed to the extent of being able to use only a very few, or just one normal muscular output. They also say the technology has potential to create 'affordable toys that can promote entertainment and socialisation'. This broad recreational and commercial remit, ostensibly neutral, is an interesting avenue of inquiry but will not be interrogated at this time.

However, another, but so far unfamiliar derivative purpose area is cited. This humble paper marks a pivotal moment, when for the first time, the term '*military*' is explicitly associated with future uses of BCIUAV technology by researchers. They imagine 'a mind-controlled UAV that can be used in military tasks.' Like the creation of 'affordable toys', 'military tasks' is a derivative purpose area — but one which, following Forge, I classify as *harmful*. The authors do not hint at of what kinds of military tasks they have in mind. Before contemplating the appearance of this new and harmful derivative purpose area, I will briefly review the three BCIUAV papers published in 2016.

Das, A.K., Tan, T.L., Suresh, S. & Sundararajan, N. 2016, "Meta-cognitive Interval Type-2 Fuzzy Controller for Quadcopter Flight Control – An EEG based Approach"

Institution: School of Computer Engineering, Nanyang Technological University, Singapore

Funding: Ministry of Education, Singapore

Das et al. reference all three Minnesota experiments (Royer et al. 2010) (Doud et al. 2011) LaFleur et al. 2013), as well as Kim et al. (2014) and Lin and Jiang (2015). Das et al. (2016) use an EMOTIV EPOC headset to record EEG signals in a two-class MI paradigm

BCI for control of a quadcopter, tested with only one healthy male subject within the organic line of sight, and no video feedback is provided. Only two commands on the horizontal plane (left/right) are given, and thus only 2D control is achieved. The majority of the short article is taken up by computer science talk. However, the MI command they use is interesting: 'the subject imagined catching a ball thrown towards him' (2016:2504) for right or left hand, and thus left/right flight actuation.

Future uses?

Nothing is said about future uses of the BCIUAV, although they do acknowledge the general need for BCIs that are fully independent of normal muscular outputs for those with 'serious motor impairment(s)' (Das et al. 2016:2501) (see Wolpaw et al. 2002). In this respect, Das et al. adhere to a requirement that facial and eye muscle movements should not be used for control.

Chen, Y., Chen, S., Zaeni, I. & Wu, C. 2016, "Fuzzy Tracking and Control Algorithm for an SSVEP-Based BCI System"

Institutions: Southern Taiwan University of Science and Technology, Tainan – Department of Electrical Engineering; Kun-Shan University, Tainan - Department of Computer and Communication

Funding: 'Ministry of Science and Technology of the Republic of China, Taiwan… Contracts MOST 104-2627-E-006-001 and MOST 104-2221-E-218-019.' (2016:10)

Chen et al's work breaks the mould of previous studies (none of which do they cite) in three important ways. Firstly, they do not use a rotor drone but instead use a commercial toy called an 'air-swimmer': a remote-controlled helium filled fish shaped balloon with a motor at its rear. The motor is connected to a fin-like appendage which flaps left or right according to the control signals input by the user, causing the air-swimmer to turn in flight.

A small ballast unit is attached to the underside. Usually, these toys are controlled by a hand-held device paired with the motor unit, and so it seems that Chen et al. have just replicated and remapped the commands available in the hand-held device, in their BCI system. The second difference with relation to previous studies is that this is a standalone steady-state visually evoked potential (SSVEP) BCI. There are five flickering stimuli positioned on an LCD screen viewed by the user, corresponding to the commands in the drone for 'elevate', 'dive', 'turn left', 'turn right', go forward' (2016:3). The authors write of their concern that flickering stimuli frequencies between 15-25 Hz can trigger epileptic seizures in some people, and so the frequencies in this system are kept below 10 Hz. Interested readers should refer to the original for information concerning the fuzzy tracking and control algorithm developed and deployed by Chen et al. to ensure the efficient recognition of SSVEP frequencies, the discussion of which takes up the largest portion of the paper.

Future Uses?

The third difference is that although they test the system with a sample of 15 healthy users, they also claim to have tested it with five ALS patients. With relation not only to the studies that preceded theirs, but also all of those which come after in the bibliography of research to date, Chen et al. appear to be unique in this respect. However, their aim is not to provide an assistive technology for ALS patients but to assess the possibility of a *recreational* one. Taken as a sample, the ALS patients achieved an average score on the revised amyotrophic lateral sclerosis functional rating scale (ALSFRS-R)[104] of '29.8' (Chen et al. 2016:10), which indicates that on balance, they were only moderately and not severely affected, at that time, by this neurodegenerative disease. It would have been more

[104] https://www.alspathways.com/wp-content/themes/alspathways/assets/pdf/ALS-Functional-Rating-Scale-Revised-Guide.pdf (https://perma.cc/VZ5J-W54J) Published by Mitsubishi Tanabe Pharma America.

insightful, however, if the team had provided a breakdown of individual patient's scores on the ALSFRS-R. In Chapter 4 ALS will be discussed in some more detail, and too, with specific reference to the use of SSVEP BCI. What can be said here is that for recreational rather than assistive purposes, the constraints on what any BCI system can claim to, or indeed needs to offer are much less stringent. Further, with patients who score nearly 30 on the ALSFRS-R, the requirements for their use of a BCI system are bound to be less exacting than those scoring far lower, because they will retain a relatively high degree of normal muscular function. However, worth noting before the longer discussion of both ALS and SSVEP BCI in the following chapter, is that the ALSFRS-R does not include anything about vision quality or oculomotor control. In the ALSFRS-R there are four categories of assessment: 'bulbar', 'fine motor' control, 'gross motor' control and 'respiratory'. Under 'bulbar' it covers speech, salivation and swallowing. Under 'fine motor' it covers handwriting, cutting food and dressing and hygiene. Under 'gross motor' it covers turning in bed, walking and climbing stairs. And under respiratory, it covers dyspnea (breathing whilst awake), orthopnea (breathing whilst asleep) and respiratory insufficiency, the latter addressing the level of technological assistance for breathing. Each element addressed by the rating scale is scored from one to five, one being normal and five being extremely impaired. All of this relates to muscular function. With relation to the use of SSVEP BCI for ALS patients, a purely visual method of BCI — which certainly as Chen et al. configure it, relies upon the user's gaze control, albeit in a very modest way, moving gaze from stimuli to stimuli and also to monitor the progress of the air-swimmer in the room beyond the screen: this feature is vital to assess.

Evaluating their work, Chen et al. (2016:10) write that

> (s)ince the proposed application is to relax subjects with ALS by operating the air swimmer drone vehicle, the entertainment value is more important than the recognition rate. Thus, to quantify the entertainment value of the proposed system, the caregivers

> helped us to ask each subject to answer the question "Is the system interesting?" Then, each subject was asked to provide a mean opinion score (MOS) ranging from 5 (excellent) to 1 (unsatisfactory). The average MOS was 4.3. Thus, the subjects responses indicate that the proposed system can hold the interest of subjects with ALS.

Chen et al. have posed a beneficent, specific derivative purpose for their BCIUAV system.

Song, X., Mann, K., Allison, E., Suk-Chung Yoon, Hila, H., Muller, A. & Gieder, C. 2016, "A Quadcopter Controlled by Brain Concentration and Eye Blink", *2016 IEEE Signal Processing in Medicine and Biology Symposium (SPMB)*.

Institution: Widener University, Chester, Pennsylvania, USA.

Funding: None declared

Song et al reference only LaFleur et al. (2013) and Kim et al. (2014) from previous studies in my review. Song et al's solution to the limitations of the 14 electrode EMOTIV EPOC headset, is to utilize both cortical EEG and EEG signals obtained from eye blinking. All the EEG signals are recorded from the frontal cortex. For the eye blinking signals, they record from the F7 and F8 electrodes positioned near the front of the scalp on opposite sides. The signals corresponding to each eye blinking are then eventually translated into commands to turn left and right in the inexpensive UDl U818A quadcopter. Blinking both eyes simultaneously is mapped to the command for backwards. Interestingly, for the forward command, they ask the user to simply concentrate. They record signals from the F3 and F4 electrodes which 'are located above the dorsolateral prefrontal cortex' (2016:2). Apparently, just this 'increase of brain concentration' (ibid.) is enough to produce significant enough EEG signals to move the quadcopter forward but reflecting on their results they write that this is the most difficult of the commands for some users. We might ask what it is they concentrate *on*, as it were (if anything), and why this particular area of the brain is thought to index increased brain concentration.[105] Some light is shed on this in

[105] Recall that when discussing the EEG component of their hybrid interface, which was concentration and non-concentration state based, Kim et al. (2014) write that concentration states produced Beta waves

the section addressing the human-machine training process. Song et al. tell us that in order to both get the user used to generating the commands, and in order for the system to learn to recognise the requisite signals as commands, they asked the subjects to 'imagine …rais(ing) both arms slowly while trying to minimize eye movement by looking at an icon on the computer desktop'(2016:3). So, there is some evidence to suggest that 'increased brain concentration', actually refers to the generation of MI commands. There were five participants involved in the testing of the system proposed. Despite coming three years after LaFleur et al's seminal attempt, Song et al. do not achieve 3D control. Aware that this is a major criterion in terms of judging the functionality of BCIUAV systems, they note that 'more facial expression patterns can be identified to support additional operation commands so that the quadcopter control can be expanded to three-dimensional space.' (2016:4).

Future Uses?

No derivative purposes are offered.

3.5: Summary

Having reviewed **16**[106] papers from 2010 to 2016 , authored by teams in **6 countries** (China, France, South Korea, Singapore, Taiwan, USA) at **14 institutions**.

4 of the papers reviewed were simulation studies (Royer et al. 2010) (Doud et al. 2011) (Akce at al. 2013) (Song et al. 2015)

between '13 and 19 Hz appearing in the frontal lobe' (2014:85). If Song et al. had meant that their system was a truly concentration based one, then this would have explained it.

[106] I exclude Kosmyna et al. (2014a, 2014b) which were dealt with briefly under the heading of Kosmyna et al. (2015b) as well as (2015a) which is not a study but discusses 2014a and 2014b; and Doud, Lucas and He (2011) which has been cited in text but not been reviewed as it is just the conference paper version of the more substantial article from the same year.

12 of the papers reviewed were actual drone flight studies: (Akce et al 2010) (Yu et al 2012) (LaFleur et al. 2013) (Kim et al. 2014) (Shi et al. 2015) (Lin and Jiang 2015) (Khan et al. 2015) (Kosmyna et al. 2015) (Zhang and Jackson 2015) (Das et al. 2016) (Chen et al. 2016) (Song et al. 2016)

Of the actual drone flight studies:

7 achieved 3D control (Yu et al. 2012) (LaFleur et al. 2013) (Kim et al. 2014) (Lin and Jiang 2015) (Kosmyna et al. 2015b) (Zhang and Jackson 2015) (Chen et al. 2016)

5 achieved only 2D control (Akce et al. 2010) (Shi et al. 2015) (Khan et al. 2015) (Das et al. 2016) (Song et al. 2016)

In terms of the systems themselves, we have seen **2** kinds of BCI:

-Electrophysiological (EEG)[107]

-Metabolic (optical - fNIRS)

14 of the BCI systems used only EEG-based BCI: (Akce et al. 2010) (Royer et al. 2010) (Doud et al. 2011)(Yu et al. 2012) (Akce et al. 2013) (LaFleur et al. 2013) (Shi et al. 2015) (Lin and Jiang 2015) (Song et al. 2015) (Kosymna et al. 2015) (Zhang and Jackson 2015) (Das et al. 2016) (Chen et al. 2016) (Song et al. 2016)

But there was also:

1 Hybrid interface using EEG-based BCI and eye tracking (Kim et al. 2014)

[107] In terms of the ways EEG has been deployed, we have seen mainly active motor imagery paradigm EEG, but we have also briefly seen facial state paradigm EEG based BCI (Lin and Jiang 2015), and reactive SSVEP-based EEG (Khan et al. 2015). Notably Chen et al. 2016 were the only team to use standalone SSVEP BCI.

1 Hybrid BCI using EEG and fNIRS (Khan et al. 2015)

In fact, in some form or another, we have already seen in this chapter all of the kinds of BCI and all modalities of EEG-based BCI that will be used in the bibliography of BCIUAV research, available in Appendix 1. Although variations of note occur in and between future systems, we have to a greater extent completed the learning curve when it comes down to the nature and composition of BCIUAV systems (albeit, only on the anthropologically relevant level).

In terms of the UAVs used in the testing of the systems, we have seen:

1 fixed-wing glider (Akce et al. 2010)

8 quadcopters (Yu et al. 2012) (LaFleur et al. 2013) (Kim et al. 2014) (Lin and Jiang 2015) Khan et al. 2015) (Kosmyna et al. 2015) (Zhang and Jackson 2015) (Das et al. 2016) (Song et al. 2016)

1 hexacopter (Shi et al. 2015)

1 Air-swimmer (Chen et al. 2016)

As established early on, using Forge's terminology, in all cases the *technology* being developed and demonstrated is the means of *control* of an aerial drone via BCI.[108] Building on Forge's account, the set of terms we have come to use when accounting for the descriptions of future uses given by researchers are: *primary purpose* > *derivative purpose*(s), and with relation to the latter we can now distinguish *specific* derivative purpose/ *general* derivative purpose/ derivative purpose *area*. These can be described

[108] Because I do not think it could be immediately transferred to the control of another device without at least some modification – I take it to be specifically the control of an aerial drone that is being *primarily* worked on (technically, it is) – despite whatever else is said about the system framework's or the relevant techniques' applications in future.

further with the addition of the terms *beneficent*, *neutral* and *harmful*. Finally, then, we can ask what derivative purposes ***for the control of an unmanned aerial vehicle*** have been given by authors so far?[109]

The authors give the following:

- ALS/ locked-in patients - *assistive* (LaFleur et al. 2013) (specific; beneficent)
- World exploration (LaFleur et al. 2013) (general; neutral)
- Everyday flight (Kim et al. 2014) (general; neutral/beneficent)
- Indoor target searching (Shi et al. 2015) (area; neutral)
- Recreation (Kosymna et al. 2015b) (area; neutral)
- Locked-in patients (Zhang and Jackson 2015) (specific; beneficent)
- Affordable toys (Zhang and Jackson 2015) (area; neutral)
- Military tasks (Zhang and Jackson 2015) (area; harmful)
- ALS - *recreation* (Chen et al. 2016) (specific; beneficent)

3.6: Saying 'It'

The paper by Zhang and Jackson (2015) deserves attention because of the new derivative purpose area they give. The fact that they mention both 'locked-in patients' and 'military tasks' with relation to the future uses of the BCIUAV means that they have triggered criteria B, and present a dual use technology with the possibility of both civilian and military usage.[110] From this point *other* researchers reading up on attempts to control a UAV with a BCI and who may be planning their own attempts, potentially now have access to this knowledge and possibility. However, at that time, only those most assiduous followers of the research into this application of BCI would be in a position to become

[109] I am excluding any derivative purposes cited that refer only to system frameworks.
[110] This would be true even if no one ever said it out loud; but it is crucial to my analysis that these authors *have* said it out loud.

aware, because this article was not even published in a proper journal. Nevertheless, their paper was cited in the main internal review of BCIUAV research to date (Nourmohammadi et al 2018) and by all the other relevant review papers (Tezza and Andujar 2019; Zhang and Wang 2021; Hekmatmanesh et al. 2021). A few years would pass before the first peer-reviewed journal article to openly state dual uses of BCIUAV technology appeared, which is the review paper by Nourmohammadi et al. (2018) (see Chapter 7). But according to my research, Zhang and Jackson were the first to *say* it. For this reason, their paper has micro-historical, and optical significance.

A keen eye will have noticed that there were other possible signs leading up to this moment. The science fiction allusions in Royer et al. (2010) where Firefox takes precedence as a future oriented narrative, and in which, notably, the control of weapons rather than flight was cited as the capability BCIs were advancing on. The sudden Apache helicopter reference made by Doud et al. (2011), seems more important now given that it appears to indicate that the reality of dual use was being entertained, at least in some way. And too, the glib acknowledgement of the role of drones (although crucially *not* the possible role of the BCIUAV itself) in military operations by Lin and Jiang (2015). In terms of the discussion in Chapter 2, none of these were evidence of criteria A or B, and so, given legal concerns had to be left alone. Given what we have just discussed via Zhang and Jackson, however, consider this quote from Forge:

> (S)uppose that a given line of research, R1, is already established as dual use. By this I mean it is known that its implications are such that there are bad uses as well as good or neutral ones. It may seem strange that anyone would work on such a project, and indeed it may be hard to find many real-life examples. (2013a:127)

3.7. Red Flags

I now list all the subsequent papers that satisfy criteria A or B as set out in Chapter 2.

Excluding the first example just discussed (Zhang and Jackson 2015) the following are red flag papers from the wider body of BCIUAV research, triggering either criteria A or B.[111]

- Meriño et al. (2017): **Criteria A** – USA, US Army Research Laboratory (see Chapter 4 and Chapter 7)

- Yin and Gong (2017): **Criteria B** – China

  In the military field, people in reality can fight in a battlefield only through certain technical equipment thus avoiding being wounded (brain-actuated UAV). (2017:2210)

- Corichi et al. (2017): **Criteria B –** Mexico

  With the following quote, these authors demonstrate knowledge of combat uses of BCUAV technology by what appears to be a reference to Meriño et al. (2017), although the latter is not *explicitly* cited by Corichi et al.:

  Scientists at the University of Texas at San Antonio (UTSA) are trying to turn science fiction into reality by developing technology that will allow soldiers to control a drone only with their minds remotely. (2017:339)

- Nourmohammadi et al. (2018): **Criteria B** – Netherlands (see Chapter 7)

  In future, these integrated systems could serve more practical purposes—some conceivable applications are as follows: in hospitals where patients with severe disabilities could use them for transporting objects; in battle fields where wounded soldiers could use them to proceed with the combat; and in space where they could assist astronauts to accomplish multitask missions outside the spacecraft. (2018:338)

- Vijayendra et al. (2018): **Criteria A** – India, Defence Development Research Organization (DRDO)

- Vishwanath et al. (2018): **Criteria A** – India, Defence Development Research Organization (DRDO)

[111] In total there are 12 red flag papers across the entire body of research, with 4 of these coming under criteria A alone, 7 under criteria B alone, and 1 under both criteria A and B.

- Duan et al. 2019: **Criteria B** - China

  In the future, this multi-modal BCI system could provide more practical purposes. (1) Injured soldiers could rely on it remain in combat in battle fields. (2) It could assist astronauts to accomplish multitask missions in space. (3) Patients with severe disabilities could use them for transporting objects (Nourmohammadi et al., 2018). (2019:8) [112]

- Sun and Ma (2019): **Criteria A and B** – China.

  Sun and Ma do not declare any funding but in my view do meet criteria A because they are researchers from the Air Force Engineering University of the People's Liberation Army (PLA), Xi'an. However, on careful inspection, they also trigger criteria B when they write:

  The US. military has set up a similar research and development team, which aims to control UAV with human mind. (2019:300)

  Whether by 'similar research and development team' they mean similar to their own team, or not: they clearly demonstrate knowledge of the militarized possibilities of BCIUAV research and technology.

- Al-Nuaimi et al. (2020): **Criteria B** – United Arab Emirates

  In this paper, we present a new way of controlling drone by using a P300-based brain-computer interface that supports the military field as assistive technology. The main idea is that the drone can be controlled by the soldier's brain activity using electroencephalogram (EEG) to chase other drones and discover hidden enemy areas. (2020:74)

- Belkacem and Lakas (2021): **Criteria B** – United Arab Emirates

  This system is aimed at supporting and assisting complex and cooperative multitask military missions (2021:297)

  This paper provides proof of concept for enhancing military capabilities to save soldiers' lives and time/energy. In addition, it has applications in medicine because the robot can move and transport objects, such as medicine (ibid:301)

[112] Notice the reordering of the uses by Duan et al. when they all but copy Nourmohammadi et al's paragraph into their own article. I will refrain from speculating on the implications of this subtle rearrangement.

- Dumitrescu et al. (2021): **Criteria B** – Romania

This study only uses a simulated drone, but the authors trigger criteria B when they write:

> The application in its current form can be used in the medical field for the recovery of patients with various neurological disorders, for increasing low cognitive performance and increasing the drone driving skills of military personnel. (2021:22)

There is some ambiguity, however, with regard to their funding source, which appears to be more along the lines of militarized policing than the military per se.

> The research work contained in this paper was supported within the frame of the project "Innovative system for cross-border fight against terrorism, organized crime, illegal trafficking in goods and persons", national funding SIPOCA-SMIS 121596, 2021. (2021:24)

My cautious assessment of this statement is that the paper approaches but does not properly meet the conditions set for criteria A in this thesis.

One exception, because it isn't in itself a BCIUAV research paper but in a sense, triggers both criteria A and B, is a journalistic article by Paul Tullis (2019) in the widely read MIT Technology Review. The article includes quotes from DARPA officials involved in the Next Generational Nonsurgical Neurotechnology (N3) program (funded in 2019 to the tune of $104 million), about the fact that they are working on non-invasive BCIUAV technology. They clearly view it as a crucial weapons system in future wars:

> Surgery is expensive, and surgery to create a new kind of super-warrior is ethically complicated. A mind-reading device that requires no surgery would open up a world of possibilities. Brain-computer interfaces, or BCIs, have been used to help people with quadriplegia regain limited control over their bodies, and to enable veterans who lost limbs in Iraq and Afghanistan to control artificial ones. N³ is the US military's first serious attempt to develop BCIs with a more belligerent purpose. "Working with drones and swarms of drones, operating at the speed of thought rather than through mechanical devices—those types of things are what these devices are really for," says Al Emondi, the director of N³. (Tullis 2019)[113]

[113] https://www.technologyreview.com/2019/10/16/132269/us-military-super-soldiers-control-drones-brain-computer-interfaces/ (https://perma.cc/SDB7-T9SA)

I argue that this constitutes, in Forge's terms, a clear 'threat to make and use' (2010:116) combat BCIUAV technology and could be considered a key moment in a *perception process* rather than a 'misperception process' (Dando 2015:118). Such processes concern the dynamics of arms races, and the ways that nations and militaries perceive or misperceive the state of play in terms of their antagonists capabilities, present and future. The quote from Al Emondi in 2019 reinforces the hypothesis that *all* research into the BCIUAV was/is technically dual use (but the vast majority *unknowingly*), and indeed, might make us wonder whether from some angles and in some quarters, an arms race is underway.

3.8: Conclusion

In this chapter I reviewed BCIUAV research from 2010-2016, with attention to the technical aspects of the BCI systems,[114] as well as the ways in which researchers talk about future uses of BCIUAV technology. A summary of findings in both these respects was presented. Because all of the modes of BCI and nearly all ways of using them across the entire body of BCIUAV research has now been observed, there is no need to review all of the BCIUAV research papers in the same way. As discussed, Zhang and Jackson (2015) is the first appearance of a harmful derivative purpose *area,* which reveals explicitly that BCIUAV technology is dual use. This first 'Red Flag' case marks a sea change in how both the external analyst and other BCI researchers are able to understand the nature and possible trajectories of the technology. Finally, the 'red flag' cases across the entire body of BCIUAV research were listed, for it is really this kind of research that I am most interested in. Several special red flag cases will be discussed in subsequent chapters.

[114] 'Technical' in as far as I could understand the workings of the systems and convey these to an anthropological readership, but not technical in the strictest sense of professional understanding reserved for BCI researchers themselves.

4: Ophthalmoplegia

4.1: Introduction Part 1: Overview

Bronislaw Malinowski (1884-1942) 'passed on to his students an invaluable awareness of the tension which is always there between what people say and what they do' (Kuper 1996:34) (Beatty 2014:546-547), which is still regarded as a vital sensibility for the anthropologist and ethnographer. It is this insight that is at work in my analysis of Meriño et al's (2017) paper in this chapter, something which I qualify further below. Also informing my analysis is another anthropological insight, derived from material-semiotic approaches in science and technology studies: 'agency is…not locatable in either humans or nonhumans… [and] is rather an effect or outcome, generated through specific configurations of human and nonhuman entities' (Suchman 2007:261). This simple insight has deep implications for assessing the intimate relations established between the users of BCI systems and the individual systems themselves. Indeed, the 'user-centred design (UCD)' (Kübler et al. 2014:1) perspective in BCI research aims to ensure that design principles appropriate to the target users of BCI systems – who are often individuals with severely paralyzing neurodegenerative conditions such as amyotrophic lateral sclerosis (ALS) – are applied at every stage of the research process. This first of all means simultaneously assessing the capacities of users and the affordances of BCI systems to ensure that agency can emerge for the user, with reference to the intended 'context of their use'(Kübler 2020:171) i.e., the criteria of '*usability*'. Systems that meet this basic requirement are subsequently evaluated by the criteria of '*effectiveness*', '*efficiency*' and '*user satisfaction*'(ibid). As part of the moral vision of BCI research, the UCD perspective is also broadly concerned with increasing the transfer of cited benefits of BCI research and technology to the patient populations in question – in other words, whether and how the claims made by BCI researchers about the beneficent potential of their work are embodied

by it. With their concept of the 'translational gap'(ibid) BCI researchers Kübler et al. signal that this transfer is not realised anywhere near enough.

Guided by the two anthropological insights and inspired by the idea of user-centred design, I appropriate and slightly modify Kübler et al's concept of 'translational gap' in order to highlight the ways in which the individual BCI system presented by Meriño et al. falls short of meeting the needs of the severely paralyzed ALS patient they figure in their article. This is done with respect to the criteria of *usability*, and in purely hypothetical terms. I also assess the ways in which Meriño et al's claims could be seen in a more positive light. But rather than assessing Meriño et al's claims concerning their work's possible relation to the kind of ALS patient they figure as true or false, I utilize the more appropriate concepts of felicity and infelicity, or happiness and unhappiness taken from the work of J.L. Austin (1979a), introduced below. I argue that Meriño et al's claims are both happy and unhappy, but that they are also *careless*. However, as I discuss in Chapter 7, despite being careless in one sense, Meriño et al's claims may also be *carefully placed* in another.

First, I present some background to assist the analytic review of Meriño et al's visual BCI system regarding possible translational gaps. This concerns the pathologies of ALS with a focus on the most extreme manifestations of neurodegenerative paralysis, which can even extend to the eyes. Hence posing significant, but not necessarily insurmountable problems when it comes down to designing *visual* BCI systems for these patients. Considering this visual problem space, I also make reference to two relevant studies that use the same modality of visual BCI as Meriño et al., which shed light on how claims about systems with relation to patients can be seen to be embodied by the work done in both 'proof of concept studies' (Eddy et al. 2019:20) and studies involving patients.

So, in this chapter, I am at once conducting an inquiry in line with the two anthropological truisms stated above *and* engaging in analysis by using, in part, what we might call 'indigenous concepts' derived from BCI research itself. For obvious reasons, existing 'anthropological' concepts have not evolved to discuss the technicalities of BCI systems. Getting to grips with 'indigenous' concepts designed specifically for the purpose of describing and analysing BCI systems is a necessary task for the anthropologist trying to understand BCI research. Indeed, *anthropologically* I argue that it is only through the use of concepts indigenous to BCI research that we are able to make a reasonable anthropological assessment about the *what they say*/*what they do* tension in Meriño et al's case. In this respect, it is the BCI (and related medical) literature drawn upon throughout the chapter, that is the 'relevant literature' *in anthropological terms* – even if it is not strictly 'anthropological literature'.

It was after all Malinowski who instructed anthropologists to 'grasp the native's point of view…to realise *his* {sic} vision of the world' (2014:24). In the present chapter, it is at the very least an *adjacent* (Rabinow 2008) perspective to the native's point of view, as learned through their literature (and some interviews) – that I attempt to achieve and then deploy in the interests of an anthropological analysis. The picture is, of course, complicated by the fact that one research culture (anthropology) is studying and deploying the terms of another (BCI research) in the former's own interests — and so a sort of blurring of visions occurs. In turn, this attests to the anthropological- or ethnographic-ness of the result; as well as being one version of what (albeit single-authored) multi- or even inter-disciplinary anthropological work looks like. This being a philosophical anthropology – as noted above, there is also relevant philosophical literature involved, specifically an essay by J.L. Austin (1979a), which provides a useful adjunct to the Malinowskian insight concerning the tension between what people say and what they do.

However, Meriño et al's paper is both a representation of action (i.e., the research), and a form of action in itself, as a representation. So, what I am actually dealing with is the possible tension between *what they say about future uses of the technology developed through their research*, and *what they say they did when developing that technology through their research*. Not quite as straightforward, then, as *what they say* vs *what they do* in the Malinowskian sense.[115] So, in the analysis, where I refer to what Meriño et al *do,* I am technically referring to *what it is that they say they do.* Having flagged this distinction, and thus the subtle, layered conception of 'doing' that is in play: in what follows I treat *what they say they do* as the analytic equivalent of *what they do.*

> And is it complicated? Well, it is complicated a bit; but life and truth and things do tend to be complicated. (Austin 1979a:251)

4.2: Introduction Part 2: Line of Sight

First, the paper under scrutiny (Meriño et al. 2017) is introduced. I then consider the relationship between ALS and BCI research, the distinctions between the locked-in and completely locked-in states in ALS, and between dependent and independent BCI, all with particular relation to visual problems. After reflecting on the possible role of BCI in a finalist schema of human capacity and dignity, I introduce a 'proof of concept' (Eddy et al. 2019:20) study on gaze-independent BCI (Allison et al. 2008) and an at home patient study with gaze-dependent BCI (Hwang et al. 2017). Both of those studies are conducted in relation to people with severely paralyzing conditions, which gives insight into ways in which claims concerning paralyzed patients can be seen to be borne out by the actual work done. Subsequently, I draw attention to the distinction between the 'individual BCI' (Allison et al. 2008:407) and the system framework, and, after introducing relevant

[115] Although, saying is a form of action.

elements of Austin's essay, contemplate the happiness of Meriño et al's remarks about ALS in relation to a 'general controller' (Holz et al. 2012:158). Moving onto unhappiness, I then conduct an analytical review, examining the ALS patient that Meriño et al figure and juxtaposing it with the individual BCI system they configure and test, identifying *translational gaps*. Having done this, Meriño et al's (2017) military funding source is briefly discussed in light of an interview with one member of the team, and with relation to *neuroweapons* (DeFranco et al. 2020).

4.3: The Paper Under Scrutiny

> Meriño, L., Nayak, T., Kolar, P., Hall, G., Mao, Z., Pack, D.J. & Huang, Y. 2017, "Asynchronous control of unmanned aerial vehicles using a steady-state visual evoked potential-based brain computer interface", *Brain-computer Interfaces*, vol. 4, no. 1, pp. 122-133.

Institutions: University of Texas, San Antonio; University of Tennessee, Chattanooga

Ethics clearance: Institutional Review Board of the University of Texas at San Antonio

Funding: Army Research Laboratory https://www.arl.army.mil/ (https://perma.cc/5293-2EGH **)**

Of the papers discussed so far, only Akce et al. (2013) and the three Minnesota experiments (Royer et al. 2010, Doud et al. 2011, LaFleur et al. 2013) are referenced by Meriño et al., with emphasis put on LaFleur et al. (2013). According to Meriño et al., the problems with motor imagery (MI) BCI control of a quadcopter, and with reference to LaFleur et al. (2013) are several. Extensive training is required for successful flight, moving in stages from 1D to 3D control. The requirement for constant mental effort on the part of the user to keep the quadcopter airborne, along with 'imagining nothing' set as a negative command for the quadcopter to rapidly descend, means that LaFleur et al's system does not allow for the detection of an idle brain state in the user. There are a small

number of commands (four) in LaFleur et al's system, but more broadly Meriño et al. claim that 'the number of commands configurable in motor imagery is limited compared to SSVEP systems.' (2017:133) (see below). Further, constant forward motion without a command for backward poses annoyances when rectifying errors in flight.

The supposed advantages of hybrid interfaces (Kim et al. 2014) and hybrid BCI (Khan et al. 2015) for UAV control were said to be an increase in number of commands and a higher signal classification accuracy. However, Meriño et al. present a 'conventional "simple" BCI' (Pfurtscheller et al. 2010:1). They opt for a single BCI control modality that does not involve motor imagery, but still works via electroencephalography (EEG), and is reliant on human vision for control: a steady-state visually evoked potential (SSVEP) BCI.

> A steady-state response to a visual stimulus is elicited from the occipital and parieto-occipital cortex of the human brain, when the stimuli presented oscillates at a rate ranging from 1Hz to 100Hz. (Meriño et al. 2017:123)

As noted in the introduction to the thesis, the first EEG-based BCI system was published in 1977 by J.J Vidal from UCLA as part of The Brain-Computer Interface project (see also Vidal 1973). [116] Meriño et al's system was based on similar principles to Vidal's (Allison, Faller and Neuper 2012:243), as both used visually evoked potentials (VEPs). The introduction of standalone SSVEP BCI to the BCIUAV positions Meriño et al's work as relatively novel, seeing as only one other team (Chen et al. 2016) had tried this previously.[117] The SSVEP-based BCI drastically reduces training time because acquiring the requisite brain signals for control is in the first instance a matter of looking at flickering stimuli on a screen. By directing eye gaze toward the selection of stimuli,

[116] A decade earlier William Grey Walter had some success with human subjects involving an EEG-controlled slide projector. However, Walter did not publish anything on these experiments (Graimann, Allison and Pfurtscheller 2010:2).

[117] Khan et al. (2015) also utilized SSVEP in their functional near-infrared spectroscopy (fNIRS)-EEG hybrid.

visually evoked potentials are generated in the occipital cortex, which register at the same frequencies as the flickering stimuli. In this way, SSVEP-based BCIs are categorized as 'reactive' (Zander and Kothe 2011). Training can take as little as ten minutes (Kosmyna and Lecuyer 2019:8). '(L)earning to use these [SSVEP-based] BCIs may be more like learning facts, events, or other declarative memories.' (Allison, Wolpaw and Wolpaw 2007:465) Users seldom develop their performance beyond the basic required proficiency for control achieved in the first instances of use (ibid). This suggests (the hypothesis) that at present the skill ceiling for SSVEP BCI control of an external device is comparatively low with regard to, for instance, the potential for expert MI paradigm EEG-based BCI (cf. Doud et al. 2011). The SSVEP-based system also increases 'the number of commands that can be configured to control an external device' (Meriño et al. 2017:123), at least when using standalone BCI.[118] Compared to the four commands in LaFleur et al (2013), in Meriño et al's system there are six flickering stimuli around the edges of the screen corresponding to commands in the drone (up, down, left, right, forwards, backwards) and a 'fixation mark (non-flickering)' (2017:125) placed in the centre.[119] The team installed the Robot Operating System (ROS) platform in a subsystem of the quadcopter's on-board processor. After receiving the command information transmitted by the BCI component over Wi-Fi, these 'high-level' (2017:125) signals are then translated by the subsystem to 'low-level machine instructions'(ibid.), which are carried out by the drone.

Offline recordings with forty-two individuals were made involving a purely screen based task (trialled twice), consisting in looking at the flickering stimuli to determine the EEG signals for command states. Further, in order to acquire the EEG data indicating idle brain states across test subjects, two kinds of idle event were provoked:

[118] Amongst present BCI paradigms SSVEP is thought to have the fastest information transfer (Mei et al. 2020).

[119] As a point of comparison, there are six non-BCI commands mapped from the eye tracker to the drone in Kim et al's (2014) hybrid interface, with another two from EEG-BCI.

(a) Attention to the non-flickering fixation mark in the centre of screen

(b) in a third recording involving an identical task, at the latter end of the active trial, the researchers distracted participants with conversation in order to acquire 'rest' data.

The data from these recordings were then to be used together in the classification of an idle state when BCI controlling the drone in the online recordings. The online recordings had two parts:

(a) keyboard control of the drone for comparative reference in terms of performance with

(b) SSVEP-BCI control of the drone, involving a sample of eleven test subjects 'two of whom had participated during offline recordings' (2017:127).

Meriño et al deploy a novel machine learning algorithm called 'likelihood ratio test' (LRT) to reliably determine which outgoing EEG signals should be interpreted as idle states during flight. With the active commands, the subsystem in the drone continues executing the last command given, until receiving further active command selections. But when the idle brain state is detected, the drone hovers (rather than descending as seen in LaFleur et al.). The idle state detection (ISD) feature reduces the mental strain of operation and decreases frustration, a feature with importance spanning across all potential user populations. Meriño et al's system is defined as asynchronous because it is self-paced: the user imposes commands at will upon the system. And with the ISD feature it is semi-autonomous in a more intelligent sense than LaFleur et al's. As with the active commands, the ISD requires next to no training on the human end (for a majority of their sample anyway) given that the data is collected in essentially the same manner and by the same

means (2017:124). Summarizing their results, Meriño et al. write that in the online experiment: 'All 11 participants, except for two, successfully controlled the drone with efficient detection of the '"idle" brain state.' (2017:133).

4.4: Future Uses?

What future uses are proposed by Meriño et al.? How are they thinking and talking about their machine? And by extension, how do they want us to think about it? In terms of near past and thus presumably also prospective uses for human-computer interfaces (HCI) they say:

> Technological trends in recent years have seen great interest in the development of human-computer interfaces (HCIs) with applications in clinical medicine, the military, recreation and other domains (2017:122).

With regard to EEG-based BCI they say:

> (T)he brain can be viewed as an electrical signal generator.[120] These signals are then analysed to control prosthetic devices [18,19], wheelchairs [20-22], cursors on computer monitors [23,24], and spellers for typing [25-28]. One such type of device of interest for such a means of control is unmanned aerial vehicles (UAVs) which can lead to pilot-less control, recreation, and advances in other automated devices. The goal of this work is to design a BCI for autonomous unmanned aerial vehicle control. (ibid.).

And they conclude their article:

> A significant advantage of such a system is that it can be applied to a plethora of SSVEP-based BCI application, including exploration of unsafe environments. With our proposed SSVEP-based BCI system framework instead of a UAV any other external device can be implemented with successful detection of the idle brain state. One particular group who could use the full advantage of such a design is patients with amyotrophic lateral sclerosis (ALS), whose only means of communication is via SSVEP. (ibid.:133)

Pointing to how their 'system framework' has the potential for almost unlimited connectivity in term of devices, they mention 'exploration of unsafe environments', which without further information, sounds like a *neutral* derivative purpose area, and certainly

[120] A neuroreductionist claim (cf. Nagel 2010), meaning that it reduces the complexity of consciousness to measurable (electro) physiological phenomena.

chimes with what a UAV application might be useful for. However, Meriño et al also claim that 'patients with amyotrophic lateral sclerosis (ALS), 'whose only means of communication is via SSVEP' (2017:133) will benefit in particular from their system design. This is a *beneficent* derivative purpose. It must be noted, however, they don't actually say that the BCI *UAV* would be of use for their imagined future ALS patient(s). Rather it is their BCI *system framework*, or *system design*, with emphasis on the idle (brain) state detection feature (ISD) they speak of in in this way. That is why in the sections that follow, I largely ignore the UAV application. Instead, my inquiry focuses on the 'system framework' and the 'individual BCI' (Allison et al. 2008) they present: the latter being a specific configuration of the former. Although brief, Meriño et al. are (incredibly) specific about ALS when they write that these patients, who they imagine will benefit in particular from their work, can *only* communicate via SSVEP. In fact, this is the only information they give about ALS. The possible significance(s) of this remark needs considerable explanation and will be further discussed in Chapter 7. Of primary interest is that they identify ALS patients as potential beneficiaries of their research. This fact propels the following sections, and forms the basis for the analysis concerning the tension between what Merino et al. say and what they actually do. This analysis is in turn informed by Suchman's insight about agency already mentioned. First, then, we need to learn some facts about ALS and its relationship to BCI research and technology.

4.5: Visual Problem Space

Huggins et al's (2011) telephone study '*What would brain-computer interface users want? Opinions and priorities of potential users with amyotrophic lateral sclerosis'* found that '(o)ver 25% of respondents… reported difficulties controlling blinking and 13% reported

difficulties controlling eye gaze' (2011:322). Further, as Wagner, Daly and Väljamäe (2012) write in their discussion of the need for multimodal and hybrid BCIs with special reference to patients living with ALS:

> For severely disabled patients with poor vision, non-visual BCI approaches may be the only option. For example, Jacobs and colleagues [31] showed that vision deterioration is an inevitable aspect of the later stages of amyotrophic lateral sclerosis (ALS), a common target user-group for BCIs (for example, see [39, 62, 71]). Gradually decreasing, or even complete loss of eye-movement control prevents the use of common BCI technologies that rely on visual displays and spatial vision [46]. Similarly, many potential BCI users can have cortical or subcortical lesions, which may lead to neuropsychological conditions such as hemineglect or agnosia that make it difficult or even impossible to focus attention on visual stimuli. [Even] (f)or non-visually impaired BCI users, there are strong neurophysiological reasons to use multisensory BCIs. In the last two decades multisensory research has clearly demonstrated that human perception and cognition is largely multisensory [19] which may have important implications for future BCI systems development. (Wagner, Daly and Väljamäe (2012:375)[121]

So, in principle, purely visual approaches to BCI systems for ALS patients are not perceived to be ideal, due to the progressive deterioration of vision and gaze control that patients experience (see also Holz et al. 2012). However, we are considering a singularly visual system with specific relation to ALS patients. Here, our analysis will benefit from a distinction crystallized by Wolpaw, Birbaumer, McFarland, Pfurtscheller and Vaughan (2002:769) which Meriño et al do not *explicitly* recognise. This is the distinction between dependent (indirectly depending on the operation of a normal neuromuscular output) and independent (without dependency on any such output) EEG-based BCI. Since Wolpaw et al. (2002) introduced the dependent/independent terminology into the lexicon of BCI research, some methods of EEG-based BCI once thought to be independent, have been revealed as dependent *in practice* (Riccio et al. 2012:2). Something like the reverse happened with VEPs. Wolpaw et al. (2002:773) set VEP-based BCI apart from other

[121] See also Sharma et al. (2011)'Oculomotor Dysfunction in Amyotrophic Lateral Sclerosis: A Comprehensive Review'.

modes under consideration at the time, due to dependence on eye-gaze in previous examples of practice. However, they wrote that work was being done to ascertain whether an independent VEP-based BCI was possible on the hypothesis that 'VEP amplitude...reflects attention as well as gaze direction.' (Wolpaw et al. 2002: ibid). They also acknowledged that further research was needed into the other modes of EEG-based BCI's claims to independence. Indeed, looking back on the intervening decade of BCI research, while methods for achieving high degrees of independence for control have been identified, Riccio et al. (2012) think that the distinction between independent/dependent BCI is only conceptual. Practically it is a matter of proximity to ideal poles: degrees of indirect dependence on, and degrees of relative independence from, normal neuromuscular outputs. Researchers that I interviewed in 2021 with experience of working with both severely disabled patients and healthy subjects, contested this blanket claim. However, the distinction still stands as a useful heuristic.

Independence in BCIs is of the greatest practical importance to those suffering from 'the most severe neuromuscular disabilities' (Wolpaw et al. 2002:769) such as ALS. In North America, where Meriño et al. (2017) did their research 'ALS… is [taken to be] limited to those clinical syndromes where *both* UMN [upper motor neurone] and LMN [lower motor neurone] clinical pathology exists along the neuraxis, often affecting bulbar and limb regions.' (Rosenfeld 2012:4). Clinical symptoms can '(v)ar(y) widely: [but include] weakness, atrophy,[122] spasticity,[123] dysarthria,[124] dyspnoea,[125] dysphagia.'[126] (2012:2). More generally, however, patients experience progressive neuronal degeneration and thus loss of voluntary and involuntary motor function, becoming tetraplegic, and usually living

[122] Wasting
[123] Muscle stiffness
[124] Problems speaking
[125] Problems breathing
[126] Problems swallowing

only handful of years after diagnosis. There are thought to be a range of forms of ALS. Some appear to be familial and associated with mutations in a number of genes. Others appear in 'endemic clusters' (Rosenfeld 2012:13) in certain geographical regions at varying rates of incidence and prevalence.[127] Environmental factors affecting incidence and prevalence broadly may include wealth, diet and proximity to industrial activity (e.g., Santurtún et al. 2016). Other 'anatomical variations' may only or predominantly involve spinal or bulbar symptoms rather than leading to complete paralysis, and yet others affect 'only one extremity.' (Rosenfeld 2012:11). However, these types are extremely rare. 'Sporadic' ALS, the classical type named by Charcot in 1874, leading to total paralysis, with no known reason for onset and not thought to be inherited[128], counts for over 90% of cases of this already rare neurodegenerative condition in the USA.[129] It is also the most common presentation more broadly (Rosenfeld 2012).[130] Physical degeneration of neurons in the cerebral cortex and corticospinal tracts are still taken to be the central features of ALS (Rowland and Shneider 2001). However, it is now considered to be a multisystem disorder found existing with various co-morbidities, notably 'frontotemporal dysfunction' (Rosenfeld 2012:7) and cognitive decline. It is thus not limited to but rather 'culminat(es) in dysfunction of the motor system as its hallmark manifestation' (Strong 2017:599).

When it comes down to BCI for ALS patients, given that their primary focus is on designing systems attuned to the bodies of patients[131], what researchers are often interested in is the distinction arising in the late stages of progression, between a *locked-in state*, and

[127] According to the ALS Association, within some professions incidence and prevalence of ALS are higher, notably those having served in the US military. https://www.als.org/navigating-als/military-veterans (https://perma.cc/J6QK-HS5T)

[128] Although Rosenfeld notes there is reason to suspect that genetic factors have a bigger role to play than often thought in many cases of diagnosed sporadic ALS.

[129] https://www.ninds.nih.gov/Disorders/Patient-Caregiver-Education/Fact-Sheets/Amyotrophic-Lateral-Sclerosis-ALS-Fact-Sheet_(https://perma.cc/42JG-LAS5)

[130] Onset of symptoms differ between spinal and bulbar varieties – paralysis in the former beginning from the limbs and ending with the head, and the opposite order in the latter (Nijboer and Broermann 2010:186).

[131] Rather than aetiologies.

a *completely-locked-in state* (CLIS) (Birbaumer 2006) (Kübler and Birbaumer 2008). These states can actually result from a range of paralyzing conditions including ALS, 'traumatic brain-injury, hypoxia, stroke, encephalitis, a tumour or the chronic Guillain-Barre syndrome.' (Nijboer and Broermann 2010:188). The key difference between the two states is that in a locked-in state at least one muscle is still functional, whereas in CLIS all muscle function is lost. The rarity of CLIS ALS patients is down to the fact that not many live long enough for the disease to progress this far (Furdea et al. 2009) which if allowed to take its natural course, usually results in death from respiratory failure somewhere between three to five years after diagnosis (Rowland and Schneider 2001). Historically this led clinicians to believe ALS symptoms (and thus the underlying neurological degeneration) didn't extend to the oculomotor system. But in more recent times, given advances in medical technology some patients have chosen to have a tracheostomy,[132] and to be ventilated before breathing naturally stops. This has revealed pathologies of ALS that would otherwise have remained unknown to medical science (Sharma et al 2011) but more importantly, unexperienced by patients. The complete loss of oculomotor control – *ophthalmoplegia* – is one such pathology: today a very real possibility[133] for those living with ALS who choose [134] to have a tracheostomy and move onto long term ventilation, and therefore may live longer. In a cruel exchange, this symptom's condition of possibility is

[132] An ALS patient discussing his choice to opt for life sustaining intervention is quoted in Bach (1993:348): 'I have decided that I want to live, even though my life is severely limited. In the midst of it all, life still brings us satisfactions and pleasures. We hope for the best.'

[133] Cf. Hayashi and Oppenheimer (2003) whose study challenges the idea that all ventilated ALS patients will become completely locked-in, in other words, that CLIS is an inevitability: because only 8 of their 70 patients developed CLIS. This is interesting because others such as Wagner et al. (2012), Holz et al. (2012), Sharma et al. (2011), figure the progression to ophthalmoplegia as something of an inevitability if tracheostomy is chosen. During interview, Kübler also revealed that in her experience, this is generally 'the way it goes', if the patient lives long enough.

[134] Or as the case may be their physician or family members choose for them: see Smyth et al. (1997) for a short (and now quite dated) cross-cultural analysis of factors affecting uptake of ventilation. Cf. Nijboer and Broermann (2010).

clinical intervention to maintain respiration, and precisely what allows Birbaumer (2006:520) to write that 'usually the eye muscle or the external sphincter' is the last to go. Japanese team Mizutani et al. (1990) present the case study of an ALS patient, who due to artificial intervention in the natural disease course, did progress to the extent of ophthalmoplegia. 'Since we lost ordinary means of communication with him, we employed the external anal sphincter as the only mode of communication' (1990:312), control of which was subsequently lost, leading to a '"totally locked-in state"'(ibid.). (see also Hinterberger et al. 2005). At the end of the autopsy report, reflecting on their experience with the individual in question, Mizutani et al. air doubts about the quality of life of long-term survival in ventilated patients.[135] Mizutani et al. wrote at a time when only one or two BCI studies were being published per year (Kübler 2013:2001).[136] They quite clearly didn't have an intermediary option as penultimate resort, to 'bridge the gap between inner and outer world'(Nijboer and Broermann 2010:188)[137] as a step in-between the onset of ophthalmoplegia, and the resort to communication via external anal sphincter. Nor, indeed, as a final resort when all else failed (Holz et al. 2012:166). Farwell and Donchin (1988) reported the first (P300) EEG- based BCI speller tested with healthy users. But it was over a decade later when Birbaumer et al. (1999) published their results demonstrating the first successful tests of a BCI speller ('thought translation device' (Kübler et al. 1999)) with two *locked-in* patients.[138]

The intermediary and/or the last resort absent from Mizutani et al's account (written in a time before even clinically available BCI in industrialized nations) serves to illustrate

[135] However, as BCI expert Femke Nijboer and BCI user and ALS patient Dr Ursula Broermann (2010) argue, we shouldn't necessarily jump to conclusions about quality of life for locked-in patients.
[136] They also wrote at a time when Japanese patients were often at the behest of their clinician when it came down to the decision whether to move onto permanent ventilation, in a 'paternalistic vitalism' (Smyth et al. 1997:595)
[137] E.g., gaze independent, covert attention SSVEP-based BCI
[138] The speed of communication with this system using slow cortical potentials (SCPs) was glacial, allowing for only 'two characters per minute' (Birbaumer et al. 1999:297).

where, how, and why BCIs come into their own, for people who *need* them. Admittedly, this is to use a rare and extreme case to make a broader point, about what I take to be the potential role of BCI technology in *a finalist schema of human capacity and dignity*. During one of several online video interviews, I asked Professor Andrea Kübler, a member of that first team to succeed with BCI for communication for locked-in patients led by Birbaumer, about the method of communication via the anal sphincter with late-stage ALS patients. She was adamant that not only was this a super rare and possibly no longer extant strategy, but that the reason for this concerned precisely the response that any reader, contemplating this possibility now, will have already glimpsed:

> …this muscle is still useable. But I think this is just impossible, to do this widespread. To ask these people to use this muscle for communication: there is too much shame and taboo going along with it. I once read that the most common skin cancer is at the anal sphincter because doctors don't look there, so they don't detect it. So, I don't think there is even much research on this (communication via anal sphincter)...because…I mean…*imagine*…you have to talk to patients: "*let me test your anal sphincter right now and whether you can communicate with it*" … I have never experienced any symposia or anything, within the BCI field (on communication via anal sphincter)…(Kübler interview 2021)

The *prospect* for those living with a wide range of neuromuscular conditions, even at very advanced stages, has surely been improved by decades of BCI research. In some cases, practical benefits have been demonstrated for those in *locked-in states.*[139] And yet three decades after Mizutani et al's paper was published, there is still no bridge between inner and outer world as a last resort. It is almost half a century since Vidal (1977) published the first human BCI study with healthy subjects, and twenty years since Birbaumer et al's (1999) paper showed that locked-in patients could communicate via BCI. But there is still

[139] During interview, Dr Huggins indicated that the number of patients she was aware of in the United States using a BCI at home is very small indeed, but she wouldn't give me an exact number.

'no scientifically sound evidence' (Spüler 2019:3) (cf. Chaudhary et al. 2017)[140] (cf. Gallegos-Ayala et al. 2014) to show that even one CLIS patient has been afforded communication via any method of BCI.[141] A cruel fact, because as Kübler and Birbaumer (2008:2659) write, '(t)hese patients may have the greatest need for a BCI to restore communication and interaction with the social environment'. The reasons for this failure are presently unknown, but there are two prevailing theories not only as to why this has not happened *yet*, but *may never* happen, which I gloss at the most general level as the cognitivist and physicalist theories.[142] The former relies on the assumption that paralyzed individuals might eventually lose the cognitive ability to entertain goal-directed thoughts in the absence of continual reinforcement of the link between intention and action. This would be at its lowest ebb when patients become completely locked-in. Even a locked-in patient can facilitate some kind of goal directed action with what remains of their muscle function. By losing the capacity to carry out goal-directed action altogether they might lose the capacity to entertain goal directed thoughts.[143] The physicalist theory, however, works from ALS's categorization as a neurodegenerative disease, which as noted earlier is also now widely recognised as a multi-systems disorder and very often found to be co-existent with frontotemporal dementia. A certain level of neuronal degeneration might render the

[140] This paper has been redacted. See Chaudhary et al. (2019) for a response to Spüler.
[141] Or, rather, being impartial - there is *no agreement* – as Dr Huggins suggested in our interview, and presumably as Gallegos-Ayala et al (2014) and Chaudhary (2019) believe. I do not have space here to discuss the controversy that these papers represent. Suffice to say that the issue of communication for CLIS patients is taken very seriously. Martin Spüler's (2019) reanalysis of Chaudhary et al. (2017) and Gallegos-Ayala et al. (2014) who had both claimed to have succeeded in this regard, cast doubt on the veracity of their claims and had severe consequences for everyone involved: including Spüler.
[142] Of the two theories, the physicalist seemed to be favoured by Kübler when I spoke to her in 2021. In both theories, there is an implication that some vital element of consciousness is lost. See also Kübler (2020:175-176)
[143] This theory appears as a sort of inversion of the manner in which BCI training is understood as a process of 'operant conditioning' (Kosmyna et al. 2015b).

individual, on a physical level, unable to perform not only motor tasks but even the most basic cognitive tasks,[144] which when you unpack them are actually not uncomplicated:[145]

> If you look at the brains of animals who are able to do cognitive tasks, they all have high levels of interconnectivity. If you look at the brains of birds and primates that can do cognitive tasks — higher cognitive tasks — not only learning like a dog, but up to me knowing when I look in the mirror that it is me; this concept of 'me' is a highly cognitive task. Birds and animals that can do this have a highly interconnected brain. And I think that is lost. (Kübler interview 2021)

4.6: Looking Up

Having discussed the relationship between ALS and BCI, with emphasis on the progression to ophthalmoplegia in the case of patients who opt for tracheostomy, now we need to understand something about the two main kinds of study in BCI research which pertain most directly to disabled patients. These are proof of concept studies involving healthy subjects, and studies involving patients. One example of each kind is reviewed in the following two sections, and both are conducted using SSVEP BCI, the same kind Meriño et al. work with. This will demonstrate the ways in which BCI researchers conduct and frame their experiments and design their systems – with specific relation to their claims concerning patients as beneficiaries of their work, in cases where this can be seen to be a genuine potential or actual outcome. We are about to see two examples of what people say matching up, more or less, with what they do, where this concerns facilitating the outcome of agency in visual BCI systems directed toward patients with ALS.

4.7: A Proof of Concept Study

Given the varied and complex challenges that neurodegenerative diseases and other serious physical disabilities pose for patients, aspects of BCI performance can be affected as a

[144] Such as yes/no communication
[145] See Chaudhary et al. (2019) for further arguments concerning sleep and wakefulness in CLIS patients with relation to the challenge of getting BCI for communication to work.

result. Patients are also a vulnerable group who pose ethical and practical difficulties for recruitment into research. Thus, healthy subjects — who are easier to recruit, and facilitate the development of techniques using clearer and more consistent signals — are often used for 'proof of concept' studies (Eddy et al. 2019:20). This is accepted as part of the 'balancing act' (Holz et al. 2012) of BCI research. Ideally, proof of concept studies would lay the ground for and tend toward yet more studies, which would be become part of iterative attempts to translate the accumulation of findings to the specified end user(s). The latter's needs would have been factored into the proof of concept studies with healthy users in the first place: a process undertaken in the spirit of 'user-centred design' (Eddy et al. 2019:22). Although, as I will touch upon in later sections, Eddy et al, following Kübler et al. (2014) recognise that the ideal does not become reality anywhere near enough.

Following on from the sections above, we approach an acute problem space associated with the extremes of ALS progression, where a pressing question is: *how do we make a visual BCI work for someone who struggles to, or cannot control their eyes*? Riccio et al. (2012) conduct a review of EEG-based BCI modalities for communication that are 'eye-gaze independent' (2012:3). These include non-visual modalities such as those involving auditory steady-state evoked potentials (ASSEPs), and tactile BCIs involving steady-state somatosensory potentials (SSSEPs) (2012:10) (see also Muller-Putz et al. 2006). However, Riccio et al. also survey 'visual EEG-BCI systems developed specifically to overcome the impasse of gaze dependence' (2012:3), which are of particular interest here. One of these latter kinds of studies is a proof of concept study working with SSVEP BCI by Allison et al. (2008), who note that while 'SSVEP BCIs work with healthy subjects…and subjects with moderate disabilities…they have not been validated with subjects unable to control gaze' (2008:400). Eye-gaze dependent SSVEP BCI indirectly depends on the movement of the eye's gaze between flickering stimuli spaced apart on a screen, and thus relies on the

capacity for overt visual attention. However, with the aim of developing SSVEP BCIs which are gaze-independent, Allison et al worked from the already demonstrated hypothesis that 'people can shift attention without shifting gaze…[a]… phenomenon called covert attention' (ibid).[146] Relying on the subjects' capacity for covert attention, they explored whether an overlapping of different frequency flickering stimuli within a fixed visual field can still allow for at least two different SSVEPs to be reliably classified as command signals for an external device. In theory, and it seems practice (for half of participants, all healthy (2008:405)) this solution shows promise for gaze-independent SSVEP BCI, because it could eliminate distances between displayed stimuli that are impossible for a patient with little to no gaze control to move between.[147] Allison et al. conclude that '(d)ependence…is best regarded as a facet of *individual BCIs*, rather than a whole category of them.' (2008:407 my emphasis). In practice, it is the manner in which flickering stimuli are displayed that dictates the degree of relative gaze-independence of any individual SSVEP-based BCI.[148] So, Allison et al. identify a specific problem (patients who cannot control their gaze) and try and develop something that will be of benefit to them. Then they have factored this problem into the way they design and configure their BCI system, and the way they conduct their experiments with healthy subjects.

4.8: A Patient Study

Gaze dependent SSVEP-based BCI (in this case for simple, pragmatic communication) has shown clinical feasibility for *some* ALS patients, as seen in Hwang et al's (2017)

[146] Recalling Wolpaw et al. (2002:73) on whether 'VEP amplitude reflects attention as well as eye-gaze'.
[147] For the same reasons, Lesenfants et al. (2014) make a subsequent attempt to achieve gaze independence, also using covert attention with an SSVEP-based BCI. Working under the assumption that some patients cannot even open their eyes Lim et al. (2013) present an 'eyes-closed' SSVEP-based BCI.
[148] In terms of output for control anyway.

contribution, in which 'all experiments were conducted according to the Declaration of Helsinki in each patient's home' (2017:445). The authors claim to have involved patients with more 'severe ALS' (2017:445) than previous studies who only involved 'incomplete [ALS] patients' (2017 449).[149] By this they mean the latter retained some non-ocular as well as some oculomotor function. However, technically, in light of insights reached above, Hwang et al's study might be best described itself as a study of patients with 'incomplete' ALS, so to speak (cf. Bauer 1979). All the individuals in Hwang et al's sample were in the 'classic' (Kübler et al. 2001:358) locked-in state. They retained at that time oculomotor control 'to different extents ranging from very weak to moderate' (Hwang et al. 2017:450). The patients normally used this residual oculomotor function to communicate by 'slight eye blinking' (2017:445). Gaze-dependent SSVEP-based BCI was thus a reasonable road to take. The four very practical commands patients could select from displayed on the monitor were chosen based on interviews with the patient's families.[150] When the user selected a command by directing their gaze to one of the flickering stimuli, a computerized voice announced it so that caregivers could respond. The team also used the same system to enable patients to answer a post-experiment questionnaire. This was both a way to gauge user experience of the previous application and test both the user and the system with a slightly different application that 'simulate(d) a practical interactive communication situation' (2017:449). Concluding, Hwang et al reflect on the practical difficulties in the short and longer-term of positioning electrodes for SSVEP-based BCI over the occipital area in bedridden, permanently ventilated ALS patients, which all of the patients in their sample were. Hwang et al's study doesn't follow the logic of disease progression to the nth degree, which is not to say, however, that they

[149] Hwang et al. conflate ALS with locked-in syndrome (LIS), conditions with different aetiologies but which can both lead to a locked-in and completely locked-in state (Bauer 1979).
[150] "My legs are uncomfortable" "My arms are uncomfortable" "Turn on the TV" and "Change my body position" (2017:447)

haven't taken disease progression seriously (Schneider, Fins and Wolpaw 2012:381). Adherence to the practical requirements of their patient sample, in terms of their current stage(s) of progression has taken precedence: informing the team's research, and the nature of the individual BCI they configure and test.

4.9: What is Happiness?

In further preparation for a critical analysis of Meriño et al's claims concerning their work's relation to ALS patients, I now present a brief discussion of an early essay by the philosopher of language, John Austin.[151] For Austin, the things people say are seldom only either true or false. To assume that anything not conforming to either was nonsense, is 'the descriptive fallacy' (Austin 1979a:234). Austin first discusses the perceived difference between statements - in philosophy, usually regarded as either true or false, and which can be decided via reference to facts, because they do or do not *report on* facts; and another type of utterance which does not report on facts, but

> looks like a statement and grammatically, I suppose, would be classified as a statement, which is not nonsensical, and yet is not true or false ... if a person makes an utterance of this sort we should say that he is *doing* something rather than merely saying something…'I apologize'… 'I name this ship Queen Elizabeth'… I bet you sixpence it will rain tomorrow' (1979a:235).

These 'performative utterances'(ibid) are to be judged instead by whether they are 'felicitous or infelicitous' (1979a:247), in other words, happy or 'unhappy' (1979a:237). Later on, however, he decides that this distinction between statements and performative utterances does not hold up, because in any case, both terms refer to speech-acts which can be judged by their happiness or unhappiness, as well as in many cases by whether they are indeed true or false (1979a: 247-248). Further, 'stating something is performing an act just

[151] Originally a lecture in a series delivered in 1955 at Harvard, and first published in *How to do things with words* (Austin 1962).

as much as giving an order or giving a warning'(1979a:251), the latter also being examples of kinds of performative utterances.

Anyway, whether utterances are happy depends both on the existence of conventions by which the utterance would be a sound, believable and/or effectual one, and on the presence of the 'appropriate circumstances' (1979a:237) in which the utterance can be happily made. At least in the respects just mentioned, this is not a question of intention, or inner states. Rather, taking an externalist tack, Austin decides 'it is better…to stick to the old saying that our word is our bond.' (1979a:236).[152] One utterance in one set of circumstances may be happy but taken out of those circumstances and into others where the relevant conventions may, although not applicable in the new circumstances, still, strictly speaking, exist – would become an unhappy one. For example, if Zeitlyn is on a flight to Cameroon when somebody falls ill, and the call goes out 'is anyone a doctor', Zeitlyn's reply 'I am a doctor' would be unhappy. Because while the existence of conventions concerning what holding a doctorate in anthropology means presumably still exist, they are not relevant, and the appropriate circumstances in which Zeitlyn's being a 'doctor' count are not in play. Moreover, the *fact* is that Zeitlyn *is* a doctor, but *not* a medical doctor. If (anywhere outside a child's make-believe or on stage) Zeitlyn cries 'I am a unicorn', then clearly this would be an unhappy utterance; neither the conventions nor circumstances in which this might be a happy one, exist: but perhaps most importantly, no *facts* whatsoever support this utterance, and so it is not only unhappy but also patently untrue.

In the end, Austin is concerned with what people do (or do not do) when they say certain things, but, also whether the things people say correspond with 'the facts' (1979a:251).

[152] Austin also raises a worry about another form of unhappiness concerning intention. If our intentions do not match our utterances, there is 'insincerity' (1979a:239) at work, and our utterances are unhappy. In general, I am avoiding talk of intention, we are not concerned with this form of unhappiness.

Even the terms '(t)rue' and 'false' are just general labels for a whole dimension of different appraisals which have something or other to do with the relation between what we say and the facts.' (1979a:249-251). It is this repeated mention by Austin of the centrality of 'the facts' to the determination of happiness or unhappiness (or indeed truth or falsity) that strikes me as being particularly important, and worth thinking about a little more. Clearly, conventions and circumstances relevant to any utterance are in a sense, in themselves 'facts'; but there are other facts that weigh in which are not necessarily either conventions or circumstances in themselves. As Austin writes, '(i)f the umpire says 'Over', this surely has at least something to do with six balls in fact having been delivered rather than seven, and so on.'(1979a:247). The conventions supporting the umpire's utterance's force (i.e., definition of an over), and the circumstances in which he may utter it happily (i.e., the appropriate moment during an actual game of cricket) are not themselves the fact of how many legitimate balls have actually been played.

To my mind, this returns us to Malinowski's insight already discussed, concerning the tension between what people say and what they actually do. In the chapter so far, we have been considering material in order to analyse the happiness and/or unhappiness of Meriño et al's claim about their work's possible beneficent relation to ALS patients, in comparison with what they actually did. We know already some (and central) conventions to which the remark appeals and by which it might acquire some kind of '*force*' (Austin 1979a:251). These are that it is BCI research and BCI research very often aims to help disabled patients, and also, that it is said in more or less appropriate circumstances (i.e., in a BCI research paper published in a BCI research journal). The question is whether, how and to what degree it corresponds with 'the facts'. The facts being in this case those we have derived from the wider context of BCI research, *and* the facts embodied by Meriño et al's own work.

4.10: The Happiness of having a General Controller

Several features of Meriño et al's 'system framework' are potentially useful for those with advanced ALS or other severe physical disabilities. For example, reduced training time with SSVEP[153] (Riccio et al. 2012:13), the purportedly asynchronous nature of the system, and connected to the latter, what seems to be their major contribution: the proprietary idle state detection (ISD) method. If Meriño et al's work was a 'proof of concept study' (Eddy et al. 2019) (aside from proving the feasibility of standalone SSVEP for *quadcopter* control – which I think was a world first) it was a proof of concept study of the ISD feature itself, in a SSVEP BCI (UAV) tested on healthy persons. However, it was not a proof of concept study concerning this feature in relation to ALS patients (in the strict sense, anyway).[154] Even so, by deriving their EEG signal data from healthy subjects when developing techniques such as the ISD, they could be said to be contributing to efforts:

> to create a 'general controller', i.e., a BCI system that can be connected to various individually tailored applications or assistive devices, that requires only little set-up and preparation time, and is reliable in various settings and useable for users in various conditions. (Holz et al. 2012:158) (cf. Wolpaw et al. 2002:786).

Looking, for one moment, beyond a focus on 'assistive devices', an idle state detection feature, for example, could benefit the healthy as much as the severely disabled user, and in the abstract is independent from any individual user considerations. Indeed, along general controller lines, Meriño et al. insist, much like LaFleur et al. (with whom they remain in almost exclusive conversation), that the techniques developed are useful for the BCI control of 'any other external device' (Meriño et al. 2017:133).[155] The 'system

[153] Although see Hwang et al. (2017:450) on SSVEP and the difficulty of accessing the occipital lobe in ALS bedridden, ventilated patients.
[154] During interview, Dr Huggins told me that one element of her present work is developing precisely this kind of feature in BCI systems specifically for severely disabled patients.
[155] This is essentially a re-description of the concept of BCI for control.

framework', which when viewed in light of the general controller in the sense just discussed, is essentially diagrammatic, and has the potential to be configured in future systems for specific use by ALS patients (with some kind of external device). So, in my estimation, the **happiness** of the remark by Meriño et al. concerning ALS, relies almost entirely on the separation being made between the *individual BCI*,[156] and the real possibility of different configurations of the *system framework* in future (i.e., in other individual BCIs).[157]

4.11: Translational Gaps

We have just seen how Meriño et al's remark might be a happy one, with relation to the system framework. Now for the unhappiness. Two questions are being asked:

> 1: Could the *individual BCI* Meriño et al present allow agency to emerge for the kind of patient they figure? In other words, does it meet the criterion of *useability* central to user-centred design in BCI research, 'that implies asking how well a specific technology suits its purpose and meets the needs and requirements of the intended end-users.'(Kübler 2020:171).
>
> 2: What, therefore, is the extent of the tension between what Meriño et al. say and what they do?

Kübler (2013) recognised a 'translational gap' (Kübler et al. 2014:2) in BCI research, between laboratory studies and the translation of the potential benefits discovered to identified end users. She observed that between 2008 and 2010 of the 470 papers published, '(f)ewer than 10% of the papers…deal with individuals presenting motor restrictions, although many authors mention these as the purpose of their research.'

[156] The actual configuration of the system framework tested.
[157] After all, we only need, or more to the point, can only, '*believe* about the future' (Austin quoted in Zeitlyn 2020:502).

(Kübler 2013:2001).[158] Curious as to whether this translational gap had closed up at all in the subsequent years, Eddy et al. (2019) writing in the same journal as Meriño et al (*Brain-Computer Interfaces*) conducted a review of '*Trends in research participant categories and descriptions in abstracts from the International BCI Meeting series, 1999 to 2016'.* They found that 58% of the 627 abstracts of studies included in their analysis 'identified PWD [people with disabilities] as being the target beneficiaries of BCI research, though only 22% [actually] included participants with disabilities, suggesting evidence of a persistent translational gap.'(2019:22). While an increase in the specificity of the description of 'PWD diagnoses' (2019:17) was noted over time, 'a decreasing trend' was also registered in the percentage of studies that said they 'aimed to benefit PWD' (2019:19), although Eddy et al. think the burgeoning BCI research aimed at non-disabled users may explain this.

Only healthy individuals take part in Meriño et al's (2017) study,[159] although theirs is not a proof of concept study with relation to PWD in the strong sense. However, they do *identify people with disabilities as being at least one of the target beneficiaries of research,* and in doing so — recalling the discussion of *ekphrasis* in Chapter 2 -— figure the body of an ALS patient in relation to their own work, in the minds of their readers. In the following analytical review, I consider the presence of 'translational gaps' in a slightly different but related sense to the way Kübler et al. mean it. By this I mean gaps between the *individual BCI* Meriño et al. configure and test, and the mental image of the body of the ALS patient evoked by their text. I will also consider a possible translational gap in the

[158] Journals publishing BCI research are a mixed bag when it comes down to studies 'aiming to benefit' people with disabilities (Eddy et al. 2019:21), ranging from no specification of preference, to enshrined requirements that people with disabilities be involved to meet publication criteria. *Brain-Computer Interfaces* only *prefer* that people with disabilities are included.

[159] As with all the BCIUAV papers reviewed so far with the exception of Chen et al. (2016)

text itself when compared with a contemporaneous BCIUAV offering from the same year (Khan and Hong 2017).

Meriño et al's remark about ALS patients 'whose only means of communication is via SSVEP', is puzzling given the existence of multimodal BCIs, which make it difficult but not impossible to imagine a patient with such a requirement. If we take it at face value, however, following the logic of the rhetoric, then given what has been discussed above, an ALS patient who could *only* communicate via SSVEP, would have little or no motor function. They would most likely be experiencing (possibly severe) optical difficulties, if not ophthalmoplegia, quite possibly in a *completely locked-in stat*e, or something close**.** They would almost certainly be beyond the stage of progression of Hwang et al's (2017) patients discussed above. I say this because if they had even residual eye or face movement, they would likely be able to communicate even minimally via that, and thus not 'only' via SSVEP. Having drawn out the figure of the ALS patient — whether my interpretation is erroneous and/or over literal, or not — for the purposes of this exercise I shall proceed with that *image in mind*.

Recalling that '(d)ependence on muscle control is best regarded as a facet of individual BCIs, rather than a whole category of them' (Allison et al. 2008:407), in the specific way Meriño et al. configure and test it and thus in practice, SSVEP BCI indirectly depends on the user's eye gaze for command selection. Each flickering stimuli is placed separately around the edge of the 24-inch screen (2017:125). For an ALS patient with ophthalmoplegia, 24 inches may as well be 24 miles. What's more, the user has to move their gaze from the screen to the room beyond the screen to see the drone's flight progress. The ISD feature is used by participants in the experiments to deal with this visual-spatio-temporal interval that occurs in the movement of gaze from the stimuli screen to the room beyond. Thus, in another, not insignificant sense, the interval actually serves an

experimental function in testing the effectiveness of the ISD feature itself. The latter, as already remarked, is a useful feature generally and may well have future application in an assistive BCI for ALS patients of (nearly) all severities, with any number of devices. Keeping in mind that we could in theory substitute any other kind of prosthetic device for 'drone', Meriño et al. say that in future 'the same system can be implemented to use the camera mounted on the drone to receive real time feedback of its location on a second display unit.' (2017:133). Even if this was done, there would still potentially be problems for patients experiencing severe oculomotor deterioration, as they would have to control their gaze between two screens: one for the flickering stimuli and one for the feedback. That said, even the reactive Brain Painting (BP) set ups created for two locked-in ALS patients by Kübler (Holz et al. 2015), which used visual stimuli to evoke P300 event-related potentials (ERPs) in order to select objects, colours and so on for the creation of digital artworks, had the visual control matrix for command selection on one screen, and the digital canvas (feedback) on a second screen positioned next to the first. Thus, at least to my mind, they introduce a potentially gaze dependent element in terms of switching between the two screens, and in selecting commands positioned around the screen. But like Hwang et al's (2017) participants, the severely paralyzed artists in Holz et al. (2015) were in classic locked-in states, still retaining some oculomotor function and usually communicating via small eye movements and slight facial gestures.[160] However, Meriño et al's hypothetical ALS patient can *only* communicate via SSVEP – which means that they *cannot* move their eyes, blink, or make facial gestures. It follows from this that they would likely be able to communicate *only* via an SSVEP-based BCI that was *gaze*

[160] In any case, with BP, we are talking about very small distances, and quite small screens (dimensions variable depending on the screens the patient already has in their home) positioned very close to each other on a desk, which they sit facing at a distance of 1m – so the threshold for gaze dependence (for both feedback and command selection) is brought down to a very low level (see Holz et al. 2015:118 Fig.1 for JT's set up).

independent: not via a gaze dependent SSVEP-based BCI. Even in the imagined two-screen configuration they would struggle to reliably control or be unable to control their eye gaze across the screen from stimuli to stimuli, and/or move their gaze from one screen to another. But these problems already exist in the individual BCI they present, with the user having to control their gaze across the screen to select commands and having to look beyond the screen to the room to monitor the device they control. Translational gaps between the individual BCI and the figured body appear in how the configuration is at least two visual-spatial removes from (even potential) usefulness for the patient they evoke**.** This is an actual configuration of their system framework in an individual BCI, that to be clear, is not necessarily one useless to *all* ALS patients.[161] It is *only* useless for the kind of patient that Meriño et al. themselves depict – who can *only* communicate via SSVEP, and thus must be in a(n) (almost) *completely* locked in state.

Subsequently, a third translational gap is found in the text. It might have been prudent for Meriño et al. to qualify their individual BCI as having potential benefits for (as of yet) *incomplete* ALS patients, retaining a certain quality of vision and degree of oculomotor control. By comparison, when presenting their hybrid EEG-functional near infrared spectroscopy (fNIRS) BCIUAV, South Korean team Khan and Hong (2017) are somewhat more circumspect in addressing its relevance to both locked-in *and* completely locked-in patients. Khan and Hong join the ranks of those who have achieved 3D control in actual space with their BCIUAV.[162] Previously the hybridization of EEG-fNIRS deployed by Khan, Hong, Naseer and Bhutta (2015)[163] 'simultaneously deco(ded) EEG and fNIRS signals for the same activity and combin(ed) the features' (Khan and Hong 2017:2). In the 2017 paper, Khan and Hong use the two methods to acquire signals from different brain

[161] Although it would likely cause difficulties for many, and this is still to ignore the UAV application.
[162] At Khan and Hong's time of writing, this group included LaFleur et al. (2013) Kim et al. (2014) Lin and Jiang (2015) Kosmyna et al. (2015b) Zhang and Jackson (2015) Chen et al. (2016) and Meriño et al. (2017).
[163] As reviewed in chapter 3.

activities occurring at different moments, albeit within the same overall region (pre-frontal and frontal cortex).[164] Both the EEG and fNIRS components of the hybrid system are categorized as active: all commands are endogenously generated by the user. There are an impressive eight flight actuations[165] in the drone mapped to BCI signals. The four mental commands decoded via fNIRS were 'mental counting', 'mental arithmetic', 'mental rotation' of an object and 'word formation'. The four EEG-based commands all involved eye movements: 'Two eyeblinks', 'Three eyeblinks' 'Up/down eye movement', Left/right eye movement'. Each mental task and its corresponding command in the UAV, was counterposed to an eye movement and its corresponding command in the UAV. The command for forward in the drone corresponding to three eyeblinks by the user, was counterposed to the command for backward movement corresponding to mental counting. Clockwise rotation in the drone corresponding to 'word formation'[166] was counterposed to counterclockwise rotation in the drone corresponding to up/down eye movement, and so on. According to Khan and Hong, this arrangement allows for swift recovery when a mistaken command is actuated in one mode (e.g., EEG), by switching to the other (e.g., fNIRS).[167] As with Meriño et al. (2017) it appears that the UAV was visible to naked eye of the subjects, and no video feedback was given.

However, while they are careful about saying that their work pertains, or they intend it to pertain to any patient population: Khan and Hong (2017) *qualify* their work as being potentially useful to 'partially locked-in patients (with minor eye movements)' (2017:9).

[164] Here we can see the distinction quite clearly between e.g Kim et al's (2014) hybrid interface, which uses one BCI and one non-BCI output; and the hybrid BCI proper demonstrated by Khan and Hong (2017), using two BCI outputs.

[165] 'up/down movements, clockwise/counterclockwise rotations, forward/backward movements, and start/stop.' (2017:6)

[166] 'formation of five scrambled words (e.g., "lloonab"), the first letter of which is shown as a cue (e.g., "B")' (2017:4)

[167] A swift recovery because switching from one mode of BCI to another between the counterposed commands, means that temporal delays between the frequency of commands able to be actioned sequentially in one mode are sidestepped by moving to the other mode of BCI.

> Our proposed work is more advantageous for more users, as those suffering from locked-in syndrome cannot properly perform motor tasks. Another advantage of our work is the reduced command-generation time using fNIRS. This enables patients who are partially locked-in (with minor eye movements) to use eight commands in controlling a robot in online/real-time scenarios. (Khan and Hong 2017:9)

Subsequently, they go on to acknowledge the difficulties that 'motor disabled patients' (2017:10) would face when using the EEG-based component of the individual BCI they have actually configured and tested, directly utilizing eye movements as it does:

> A limitation of this method is the acquisition of activities using eye movement tasks. Although the use of eye movement for robot control has already been demonstrated to be effective (Ma et al., 2015), eye movements are related to motor activity, and so, it is difficult for motor-disabled patients to generate four EEG-based commands. The selection of different active tasks for EEG can improve the results. (Khan and Hong 2017:10)

Thus, by 'motor disabled patients', we can infer them to mean those in a more advanced or even completely locked-in state. Here they suggest ways to overcome the limitations posed by their individual BCI with regard to CLIS patients in future, utilizing another way to produce the EEG signals that doesn't rely on oculomotor control.[168] Khan and Hong only address their individual BCI negatively in relation to completely locked-in patients. But in doing so, they demonstrate an awareness of the complex '*role responsibility'* (Forge 2013:123) attributable to them as those with the power to design and test BCI systems. Considering what Meriño et al. (2017) did and did not write, similar qualifications could have smoothed over the first two translational gaps identified between the (lack of) capacity for eye movement of the severely paralyzed body they evoke, and the individual BCI they present.

[168] What might be added to Khan and Hong's reflections about the usability of their individual BCI with regard to differently capacitated locked-in patients, who may struggle with such a range of mental tasks, is that the cognitive workload is presently quite high – higher, I think, than any other previously reviewed system, and any after it to my knowledge. Due to its fiendish complexity it does not pose an attractive prospect even for 'healthy' users.

A fourth translational gap appears for Meriño et al. (2017). Returning to their individual BCI, general and easily transposable though it may seem, in practice, ALS patients might require special consideration even in relation to the ISD feature. This is because it still relies on 'the prominence and stability of specific signal features and [the user's] capacities for initially demonstrating or acquiring and subsequently maintain(ing) control over these features.' (Wolpaw et al. 2002:785). These factors can vary widely between end user populations and individuals broadly, but particularly for those with severe disabilities. Again, this isn't to say the feature couldn't become part of a BCI system useful for (some) ALS patients — this is a real possibility. Neither is it to deny that work with healthy subjects can help develop features for (ALS) patients, even indirectly. But it is to note another (also undiscussed) translational gap between the body of the ALS patient they figure, and the individual BCI they present. However, unlike the first two translational gaps, this gap between the ISD feature's actual calibration to the healthy test subjects, and the requirements of any individual ALS patient with relation to the usability of this feature, would have been present even in a strong proof of concept study conducted with relation to but not involving people with disabilities. Drawing attention to it reminds us that the agency of a feature such as the ISD, as much as the BCI system taken as a whole, is always and only 'an effect or outcome, generated through *specific configurations* of human and nonhuman entities' (Suchman 2007:261 my emphasis). Which, of course, also applies to the first two translational gaps identified. This is why considerations of user centred design are so important in the context of BCI research involving paralyzed individuals, but I think also why they have relevance even when no actual patients are involved, and neither is the study a strong proof of concept with relation to patients — but when researchers identify people with disabilities as being at least one of the target beneficiaries of research.

4.12: Happiness, Unhappiness, and Carelessness

What can be said following this analytical review is that the specificity of the ALS body that Meriño et al. (2017) figure hasn't been factored into the way they have actually configured, tested (nor discussed) their system framework, as it appears in their description of the individual BCI. In fact, given the first two translational gaps, the individual BCI presented by Meriño et al. is basically useful/useable for everyone except the kind of patient they evoke. The remark about ALS appears to be little more than an afterthought, and, in our terms, is something of an ***unhappy*** one. Nevertheless, there is *some* happiness to Meriño et al's remarks about ALS and their system framework, in relation to the general controller and the real possibility of future configurations. And to be fair, they did only make this remark with relation to the system framework — not necessarily the individual BCI. But beyond their abstract existence as essentially diagrammatic entities, system frameworks have no reality other than their actual configuration in individual BCIs. So, it is only reasonable to have examined the individual BCI in such detail to explore the happiness/unhappiness of their claim. After all, the individual BCI is *what they did*. However, I admit that the exercise just conducted holds Meriño et al. to standards that they themselves clearly do not regard as being a primary concern. Had the remark about ALS been more prominent in their framing, then presumably they would have *done* things differently. In following the logic of the rhetoric of their remark and fixing on the image of a body evoked by it, drawing out its implicit characteristics, I have taken it very seriously. But the seriousness of ALS and especially CLIS cannot be overestimated**.** Scholars who mention ALS patients with relation to their own work should be prepared to be subjected to a critical user centred design analysis. Having seen how their system framework could be useful in future to ALS patients, and identified translational gaps between the individual BCI and the image of the ALS patient, I conclude that the remark about ALS is both happy

and unhappy. This seemingly mealy-mouthed conclusion still reflects the distinct sense in which the remark about ALS, far from being straightforward, is a *careless* one.

And yet, in Chapter 7, where the work being done by this very same figured body and others is the focus of a different species of critical analysis — I will also explore, another quite different sense, in which the remark could be interpreted as being *careful*; or rather, *carefully placed*. In the meantime, there are other contextual factors to be considered. Now we must discuss the implications of the declared US Army Research Laboratory (ARL) funding for Meriño et al's (2017) research.

4.13: "Once the rockets are up, who cares where they come down? That's not my department!" (Tom Lehrer)

Despite the US Army Research Laboratory (ARL) funding source, which triggers criteria A, in their article Meriño et al. (2017) do not mention *explicitly* any military use that might be made of their research or the BCIUAV itself. Happily, I managed to secure an interview with one of the team involved. I refer to this individual as S5. We talked about all sorts of things to do with BCI, and this project specifically. At around the hour mark, the idea of military uses of BCI was brought up by S5, really only in passing, and so, already eager to understand this aspect of the work, I asked:

'With regard to your work in the 2017 paper, given that it was funded by the ARL, how do you envision the potential military uses of the BCIUAV?'

> **S5:** *I think the most direct application is control, control that can be fine-tuned, fine-tuned to take less time to make commands, or maybe to process more commands for more complex control. Or maybe it can be fine-tuned so it will induce less fatigue in the user. The asynchronous part can also be improved so it will respond faster (in terms of the LRT for ISD) but the main application is control. To control what, what kind of robot...it's up to the task… But...err...yeah…we basically, erm, demonstrated that SSVEP could be used for complex tasks because we can have many commands, and that this specific approach to make it asynchronous, was good.*

Then S5 suddenly goes off on a tangent about data collection, how to collect better signals with better devices – evidently trying to move away from the question concerning the military funding and possible military activities conducted with this kind of technology. Not willing to scupper the chance of getting more information on various themes for the study, I let this slightly uncomfortable moment slide under the radar, satisfied that I had the video recording to come back to. We talked for another hour or so after this about less pressing, more technical aspects of BCI and left at the end with the possibility of another interview in future if required.

Reflecting on the quote above, I didn't get a straight answer from S5. Instead, I got an answer that was exceptionally general, and contained no details about military uses of the BCIUAV. Then, quickly positing the (functionally) 'good' nature of the technology the team had developed, S5 moved onto other topics. Using the terminology of Forge (2019), as established in Chapter 2 and further developed in Chapter 3, S5 redescribes what we already know, which is that the primary purpose of the technology developed by all the teams is *control*. S5 also vaguely communicates a version of the classic, even archaic, also irresponsible, defeatist and potentially dangerous position which philosopher Thomas Douglas (2014) terms '*scientific isolationism*'. This position holds that scientists can do research that is immune from any moral or ethical discussion about its practical applications: even when in this case, it is quite obviously 'applied' research in the first place. Indeed, the title of this section taken from the lyrics of Tom Lehrer's satirical ballad about the German rocket scientist 'Wernher von Braun' (1965) reflects a similar sentiment, albeit much exaggerated for comic effect.

Recalling the discussion of red flag cases in Chapter 2, however, we don't need a straight answer from S5, or actually any of the team involved in Meriño et al. (2017), to infer via abduction something about the very important derivative purpose they do not (seem to

want to) mention. The US Army Research Lab's *raison d'etre* is to support US supremacy in the fast-evolving contemporary battlespace, and by extension a great deal if not all of their activities could be described as WR. That Meriño et al. are conducting WR (at least *in part*) is not something verifiable beyond doubt and they do not make explicit reference to (any) military tasks in the article. But without making any assumptions about what Meriño et al. intended, or about what they knew; *we* know that this research is dual use and that they are in a *position to know* (PTK) this too. Following DeFranco et al's (2020) taxonomy, whatever else they might be *doing* Meriño et al. are likely contributing to the development of a future 'brain-machine interface' type neuroweapon system (De Franco et al. 2020:50). Probably, a neuroweapon of the 'hard' sort, an instrument of kinetic warfare: an improvement on existing combat UAV systems**,** some variation on the theme of 'model airplanes that can blow people up. *Whoop-de-doo'* (Graeber 2014: 5:45). Precisely what variation in both artefactual terms and in terms of context of use is unclear here, although the funding source might help narrow it down: it is from the army, and not the navy or air force research laboratory. The army deploys ground troops in greater numbers than the air force or navy. In the next chapter I will contemplate possible artefactual variations and contexts of use.

In any case, even without knowing the specifics, it would be categorizable as an *electronic* neuroweapons system, in a doubled, exceptionally hybrid sense. The brain signals used for control via EEG-based BCI would be electrophysiological – which in this case is also what makes it 'neuro',[169] *and* the BCI system as well as any drone technology controlled by it are thoroughly electronic (Requarth 2015). Recalling the manner in which the happiness of the remark concerning ALS rests on the real possibility of the system framework's future

[169] Any method of BCI would also have the effect of making it 'neuro', just not all would qualify as electronic in terms of the signals being exploited for control (e.g., metabolic BCI using optical imaging techniques such as fNIRS — although this would still be electronic in other senses).

configuration, given the pre-position of military funding, and thus the triggering of criteria A, it seems only logical to assume that configuration as a neuroweapon system is an *equally real possibility* as a configuration that has utility for paralyzed patients.[170] Although Meriño et al. (2017) don't mention this in the article (a conspicuous absence), nor S5 in the interview: the ARL funding speaks volumes.

The major difference, to my mind, between Meriño et al. (2017) and the other earlier BCIUAV studies, is the openly declared military funding source. From the perspective taken here if there were any questions before as to whether the BCIUAV really was, 'at best', a dual use technology, and that certain examples of research into it could be 'at best' dual use research, they are now dispelled. Moreover, this openly declared funding source is, I think, an unambiguous signal, that other countries doing their own literature surveillance will recognise and may well respond to. On the logic of arms races, this is a signal in itself enough to catalyse international paranoias, and if it were another country's army research laboratory, funding research into the same application, say Iran, China, or Russia 'we' would likely be concerned (see Dando 2020:97). Crucially, the literature shows that it is only after 2017 (and therefore, after Meriño et al's paper, which was the first of that year) that we see other *openly* militarily funded or militarily associated BCIUAV studies emerge. Interestingly, however, despite it being a relatively novel introduction of a standalone SSVEP control modality to this application, with a proprietary ISD feature, published in the BCI Society's own journal — Meriño et al's study has been (explicitly) referenced by only three other BCIUAV papers since, none of which meet criteria A or B (Yan et al. 2020, Parikh and George 2020, Choi et al. 2020).

From where I stand, Meriño et al's research seems 'at best' dual use because of the fact that they figure an ALS patient as a potential beneficiary. Particularly in light of criteria A

[170] But the former is probably *more real*, and *more likely*, than the latter by several orders of magnitude.

but also taking into consideration the specific UAV application they test the individual BCI with: I would have been inclined to diagnose this research as NWR if they hadn't mentioned a beneficent derivative purpose of their system framework. This line of argument will be picked up again in Chapter 7.

4.14: Conclusion

My inquiry in this chapter has been guided by the tension between what people say and what they actually do, and the STS position that agency is an outcome of specific configurations of human and nonhuman entities. These were linked up with the criterion of *usability* taken from the user-centred design perspective in BCI research, which was applied to an analytical review of Meriño et al's work with relation to the claim they make about ALS patients. To this aim, the relationship between ALS and BCI research and technology was explored, with emphasis on the visual problem space that looms when patients progress to the completely-locked in state, and experience ophthalmoplegia. BCI technology has a vital role to play in what I have termed a finalist schema of human capacity and dignity. Both proof of concept and patient studies were discussed, which tried to address ALS patient's needs in the design and implementation of SSVEP BCI systems. An analytical review of Meriño et al's SSVEP BCI study followed. Borrowing terms from Austin, I argued that Meriño et al's remark containing the image of the ALS patient was both *happy* (in light of the system framework's possible relation to a 'general controller') and *unhappy* (due to the translational gaps between the individual BCI and the capacities of the ALS patient they figure).

In light of the translational gaps, and when juxtaposed with the insights gathered from the wider context of visual BCI research, the remark about ALS was somewhat *careless*, something further highlighted by comparison with Khan and Hong's (2017) comments

about their own BCIUAV work. But this is not to say that Meriño et al's remark was not carefully placed, as I will speculate upon in Chapter 7. Finally, Meriño et al's military funding source was discussed, which on the analytical scheme employed here means that whether they like it or not their research is a red flag instance, in light of criteria A, and is a likely contribution to the development of the next generation of electronic neuroweaponry. Meriño et al. are in a uniquely qualified position to know this, although we cannot reliably determine whether they do. However, in my honest opinion, it is 'at best' dual use research, because they *do* figure an ALS patient as potential beneficiary of the system framework.

5: ‘Model Airplanes That Can Blow People Up’: A Contextual Montage

> We still don’t have a cure for cancer, we still don’t have the immortality drugs. I mean, we’ve got Ritalin and Prozac, and all this stuff that is useful for social control, but the really good stuff we never got even that. And even military technology: Where is Klatu? Where is the giant killer robot shooting death rays? *We know they’ve been working on that*! They’ve got these model airplanes that can blow people up. *Whoop de do.* (Graeber 2014)

5.1: Introduction

What kind of ‘model airplanes that can blow people up’ are we likely dealing with when thinking about *combat* BCIUAVs? At the time of writing combat BCIUAV is an imaginary future artefact. Thinking about it involves observing tendencies from the near past and present, and imaginatively attuning to the ‘on the way to being given’ (Ingold 2014:389). To this purpose, promotional videos for small combat drones are treated as data providing valuable contextual information (Forge 2010) in relation to the weaponized tendencies of BCIUAV technology. I then consider an aspect of the aesthetics at work in two of the videos with reference to Suhr and Willerslev’s (2013) anthropological work on montage and invisibility, which leads to an observation about the optics of BCIUAV research and the ethics of BCI research, addressed further in Chapter 6. Subsequently, theoretical reflections on the integration of BCI control into combat UAV systems are offered. Part of this entails thinking about why and how BCI technology might be used by otherwise ‘healthy’ people. In this respect, instead of adopting BCI research discourse concerning “induced disability” (Allison, Graimann, Graeser 2008), I provide an alternative conceptualization of ‘enhancement’ helped by the work of philosophical anthropologist and critical disability theorist Margrit Shildrick and bioethicist Julian

Savulescu, combined with insights from Enlightenment philosopher Benedict de Spinoza. From here the BCIUAV as enhancement in combat situations is theorized.

In the end *flight control* is the most important aspect of the combat BCIUAV since without flight this type of weapons system is nothing. Dull though it may seem, this observation both gets at the specific complexity of the BCIUAV as a weapons system and reinforces the dual use nature of *all* BCIUAV research.

5.2: Drone Essentialisms

The anthropological literature reviewed in Chapter 1 almost exclusively addressed large military high-altitude long-endurance (HALE) drones, mirroring the focus of the majority of interdisciplinary drone studies literature to date (Jackman 2022). HALE drones are in this sense but also more broadly, the main point of comparison in terms of thinking about developments in military UAVs moving forward. As the only exception to the focus of the literature reviewed in Chapter 1, at the end of his monograph *Drone: Remote Control Warfare* (2016), Gusterson correctly forecasts that 'scientists will produce new iterations of the technology that will make drones smaller, deadlier and cheaper.' (2016:156). In Chapter 3 we saw small drones being used to test BCIUAV systems. In fact, the vast majority of BCIUAV research where actual drones are used, involves small drones. When beginning my research, I wondered whether the BCIUAV research involving small drones was just a steppingstone towards the control of HALE drones, at least where red flag instances were concerned (see also Chapter 6). However, as I will argue in this chapter, small drones (sUAVs)[171] are a more likely candidate than HALE drones for use in future combat BCIUAV technology — at least for now. Geographer Anna Jackman (2022) who

[171] In this chapter, to mark the contrast with large HALE military drones, I will use the acronym sUAV for small drones, and BCI-sUAV for small drones controlled by BCI: but in subsequent chapters will largely revert to the acronyms UAV and BCIUAV for both generality's and simplicity's sake.

also addresses the visual culture of sUAVs, albeit at defence tradeshows, observes that despite being largely absent from drone studies literature, sUAVs now 'comprise the majority of global military arsenals' (2020:1). This surprising fact serves to underscore the importance of thinking about sUAVs from an anthropological perspective, but also reveals that the present work is playing catch up to the present while also attempting to imagine futures. So, as an initial point of comparison I begin this chapter by highlighting several features of large military HALE drone use that may not be carried over into the use of combat sUAVs and moreover, combat BCI-sUAVs

As discussed in Chapter 1, a key advantage of military HALE drones is the avoidance of injury to personnel, because the operator is situated a long way beyond the actual battlefield. This has featured as one of the main reasons-cum-justifications for military drone use, and is the central principle of 'virtuous war' (Der Derian 2009), which today is centred around information technologies and virtuality. The (one-sided) perception of virtue arises from the fact that '(t)he death *of* distance enables death *from* a distance…project(ing) power without vulnerability.' (Gregory 2011:192). Alongside this home advantage, the operators of large fixed-wing HALE drones like the General Atomics Predator and Reaper widely discussed in drone studies literature, are never alone. The now normalized remote armed drone strikes post- 9/11 conducted by the US Air Force as part of the 'war on terror', are a matter of premeditated killing where operators act as part of a network involving upwards of '185 personnel' (2011:194). Operators occupy the sharp end of a 'kill-chain…[that] can be thought of as a dispersed and distributed *apparatus,* a congeries of actors, objects, practices, discourses and affects, that entrains the people who are made part of it and constitutes them as particular kinds of subjects.' (2011:196) After 2008, following a change in command for the US Air Force (still the major drone-using military power today), closer attention was given to the application of Rules of

Engagement when conducting drone strikes in an attempt to reduce the number of civilians killed. Now, part of the 'legal armature' (2011:199) of the late-modern kill-chain, inhabiting the 'longer dwell times' (ibid) made possible by HALE UAVs (which has long been over twenty-four hours, and models being tested today approach one month (Eversden 2022))[172] is the judge advocate. They review video footage from the drones, look over intelligence on the target, weigh up risks of a potential strike, and advise staffs on the laws of armed combat.[173] Legal experts in the kill-chain are perceived by some military strategists as an obstacle to 'effective and timely' (Elish 2017:1113) war work, even subverting traditional chains of military command. However, these judges aren't impartial in their "prosecution" of the target' (Gregory 2011:ibid) and frequently judge in favour of the military's interests given inherent biases in the latter's favour built into the relevant international legislature. Following from the discussion in Chapter 1 the reality appears to be that the presence of lawyers in the kill-chain has done little to reduce civilian collateral.[174] The point is that they serve, *in principle*, along with other mediating personnel and technologies, as a kind of resistance in the kill-chain, performing checks on lethality.

Gusterson's 'drone essentialism', (2016 & 2019) refers to a fallacious but commonly held notion that due to inherent properties of the technology, HALE drones are, in practice as well as in theory, precise, targeted assassination tools that reduce civilian collateral damage. However, this term can also apply to the fact that by repeating descriptions of

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[172] https://breakingdefense.com/2022/07/after-setting-ultra-endurance-record-army-zephyr-drone-keeps-flying-whether-it-wants-to-or-not/ (https://perma.cc/4PP3-JBH5)

[173] Whether in the circumstance of 'deliberate targeting' over days, or 'dynamic targeting' in just a few minutes.

[174] At times before the introduction of lawyers into the kill-chain, civilian to militant kill ratios were known to have been 50:1 respectively (Sluka 2012:27), and, for example, even after the introduction of lawyers the recorded ratio in five months between 2012 and 2013 revealed that 90% of victims of US military drone strikes were not the intended target (Stancil 2021). https://www.commondreams.org/news/2021/07/27/drone-whistleblower-daniel-hale-sentenced-45-months-prison-exposing-us-war-crimes
(https://perma.cc/AEU2-RHRP)

(HALE) drone use from now conventional military sources, we can easily become drone essentialists of a different sort, albeit still by assuming that the 'properties of the technology determine its use in practice and that this use is essentially singular in nature' (2019:73). The recent evidence shows a migration closer to the ground, a downscaling of drone size, a reduction of the physical distance between pilot and battlefield, and in the length of the kill-chain.

I argue that the kinds of UAVs that bear most relevance to BCIUAV research and technology, are sUAVs that will be used by *ground troops* in combat. While this cannot exhaust the range of possible uses or contexts of use for BCI-sUAVs, it may help to some degree to explain the specificity of Meriño et al' s (2017) funding source: the Army Research Laboratory. Unlike HALE drone operators, these soldier-pilots would be *in harm's way*; powerful *and* vulnerable, not hundreds or thousands of miles beyond the battlefield. In the case of BCI-sUAV use in future wars, any potentially safeguarding set of obstacles between the pilot and the trigger seen in the conventional post 9/11 military UAVs, (such as the judge advocate in the US example), is unlikely to be present. The responsibility for decision making concerning the discharge of weaponry (*if armed* — see below) is likely to be with the individual solider-pilot in the field. With sUAVs, 'dwell time' is no longer necessarily even a feature. Alongside the changed context of use, the kinds of payload or armaments that sUAVs can support are going to be smaller and less destructive than those managed by a HALE drone. Firepower and thus collateral damage will be constrained by these factors to some degree.[175] In the last few years, arms

[175] However, recent developments in the Russia-Ukraine conflict show that off-the-shelf consumer sUAVs have been modified by Ukrainian troops to, for example, carry live grenades inside Bait Bombs (fishing bait containers) which can be dropped onto targets or into open tank hatches. (Hambling 2022) https://www.forbes.com/sites/davidhambling/2022/07/07/ukrainan-drop-drone-bomb-through-open-hatch-to-score-first-kill-on-russias-oldest-tank/ (https://perma.cc/2ALA-6EPB). This is a relatively mild demonstration of what is possible to do even now. Future research should investigate the dual use nature of consumer sUAVs in warzones, as well as the broader implications of such modification techniques, which may well proliferate and will unlikely remain confined to battlefields. Notably, in 2022 commercial small drone manufacturer DJI has stopped sales to Ukraine and Russia due to concerns over its products being

manufacturers around the world have revealed their own development and testing of sUAV technology, not *yet* BCI controlled — although the head of DARPA's N3 program, Dr Alfred Emondi, is reported as saying that this is both desirable and imminent (Tullis 2019).

In the following three sections a selection of video advertisements for combat sUAVs are reviewed, which allows for both reflections on the aesthetics of these videos, and theorizations concerning the integration of BCI control technology into sUAV systems in future. The videos are in their own way technologies of enchantment (Gell 1992): minimal realist military fictions looking to attract buyers but also to fascinate publics and perhaps even intimidate 'enemies', whoever they may be.

5.3: Existing Combat sUAVs

1: Skylord Xtender[176]

The first example is found in a recent promotional video from Israeli tech company XTEND produced for the purposes of marketing their Skylord Xtender system (*Defense Update* You Tube),[177] a virtual reality headset quadcopter set up designed for urban warfare (which is by nature and now strategic intent, chaotic (Robben 2012)). The Skylord operator from the Israel Defence Forces (IDF) Special Operations Engineering Unit is holding a control pad, and wearing a custom head mounted display (HMD) for immersive real-time video feedback from the onboard camera of a small black quadcopter. He stands outside some tatty buildings which, with his help, are being cleared of a single enemy combatant by two other IDF ground troops wielding assault rifles. The first scenario shows

modified to cause harm (Burgess 2022) https://www.wired.co.uk/article/drones-russia-ukraine-war (https://perma.cc/PLD3-W789)

[176] https://www.youtube.com/watch?v=NsL0LHi8Xjs (https://perma.cc/P9QH-FZDK)

[177] https://xtend.me/ (https://perma.cc/3Q8N-YHHP)

'pre-entry indoor reconnaissance'. The drone goes into the building ahead of the troops and up the stairs. Locating the enemy combatant, it chases him down a corridor, trapping him in a room where he surrenders as the soldiers move in. The scenario enacted is called 'hostiles detection, chase and deterrence'.

In the next scenario, the drone engages in 'complex environment exploration', flying through the narrow walkway of the wreck of a bus where enemy combatants might be hiding, as the ground troops watch from a window. Now, moving at high speed through the labyrinth of doorways inside the building, brick dust sprays out from under as it swoops just inches from floor. The slapstick-esque finale demonstrating 'tactical hostiles manipulation', sees the enemy chased by the drone down a corridor, right into the arms of the troops who jump on him. All the while, ominous music plays.

The Xtender is depicted not only as an advantageous reconnaissance device, an eye up the stairs and down the hall – but as a threatening object engaged in close combat with human counterparts. It does not appear to be armed, however.[178] But even if the drone is unarmed, and the operator only surveys through it, in this context it functions as part of a hybrid weapons system.[179]

2: Asisguard Songar[180]

Armed sUAVs could be a devastatingly advantageous for individual and team alike, in a wide variety of situations. Indeed, there are a number of armed sUAV systems that either

[178] Although on XTEND's website it is made clear in the description of the Xtender that 'it enables…remote control of payloads deployed indoors'. https://xtend.me/

[179] Frantzman (2022) reports for *Defense News* that the Pentagon has signed a $9m contract with Xtend for the supply of their small drone systems. https://www.defensenews.com/unmanned/2022/10/17/xtend-signs-9m-drone-deal-with-pentagons-irregular-warfare-office/?utm_source=sailthru&utm_medium=email&utm_campaign=dfn-unmanned (https://perma.cc/L4R9-YR4U)

[180] https://asisguard.com.tr/en/ (unable to archive)

already exist or are being developed with, for and by militaries — armed not with massively destructive missiles as are the longer range and larger UAVs, but with small arms.

Turkish defence company Asisguard's Songar combat sUAV system is armed with a machine gun. Operated via handheld pad controller most of which is taken up by a screen receiving real time video feedback, the operator switches between the drone's on board cameras – one for flight and a barrel camera for accurate aiming and firing. Night vision is another notable feature of the Songar, as well as GPS navigation. But the real trick of the Songar is that flight and thus aim of the machine gun is stabilized against the recoil of each round discharged. In the single scenario constructed in the 2019 promotional video,[181] a group of Turkish soldiers are driving through a mountain pass. In the road ahead of them an explosion occurs. They swiftly reverse back down the pass, stop the vehicle and produce the Songar from the boot. Soaring vertically up from its standing position on the ground, it proceeds down the pass. At a bend in the road, the Songar hovers, taking aim at a rock formation, that, it is implied, harbours enemy combatants: raining down suppressing fire on the invisible, imaginary hostiles while the Turkish troops drive past unharmed.[182]

3: TIKAD: The Future Solider

A very similar instance of a small arms equipped combat sUAV is the octocopter TIKAD system from the Florida based start-up company Duke Robotics. TIKAD allows for multiple kinds of (American made) small arms to be attached to the undercarriage, including an SR/25 sniper rifle by Knight's Armament Company, a variety of the M32A1

[181] https://www.youtube.com/watch?v=obyuBeixIM8 (https://perma.cc/5JCA-EKEJ)
[182] As of 2022, according to their website, Asisguard offer a version of Songar fitted with a grenade launcher, as well as a version fitted with a single mortar shell launcher.

grenade launcher by Milkor USA, and the M4 rifle by Colt Defence.[183] A quote on Duke Robotics' website reads: 'TIKAD is changing the way military operation [sic] are executed and is designed to serve the growing need for technological solutions in the combat field, that provide stand-off abilities, in order to minimise loss of military personnel.'[184] The promotional video for TIKAD called 'The Future Soldier' which first appeared in 2017, has slightly higher production values than the one from Asisguard, and a lot of snazzy, informative computer generated imagery (CGI), complete with cheap sounding dubstep music.[185] At the beginning, stock footage of a General Atomics Predator drone in flight flashes up, followed by footage of a small robot on tracks probing a car for explosives. Then, American troops in combat…explosions. The manly sounding narrator, resembling in tone and delivery the sort of commentary found on American wrestling shows, says, 'robots are replacing combat soldiers' as a military funeral guard carrying American flags flashes up across the screen, accompanied by the spoken words 'unnecessary casualties'. Midsentence, the image changes to a group of infantrymen on the ground with the drone hovering beside them (resembling images of units posing with their service dogs) … 'are a thing of the past'. Duke Robotics place emphasis on the idea that troops no longer need be put into dangerous situations. TIKAD, the future soldier, is here now. No more funerals for the troops. A virtuous war. However, we shouldn't be distracted by this sort of drone essentialism (as Gusterson defined it). These kinds of drones, given their size and equipment with small arms, could be used in much closer proximity to, and by troops on the ground: where the latter's skin is very much in the game, although clearly there is scope for more remote strikes as well.

[183] As with the Songar, the proprietary stabilization system developed to deal with weapon recoil is given a slow motion close up of its working.
[184] https://dukeroboticsys.com/ (**https://perma.cc/ZLV9-679X**)
[185] https://www.youtube.com/watch?v=Mmt_kTUvx8o (https://perma.cc/NCH5-AHFZ)

In ‘The Future Soldier’, there are no scenarios of use depicted. Flight is shown through CGI drones superimposed on first person view aerial footage from another aircraft flying over scrubland. Weapons operation is demonstrated briefly in rather less flash actual footage of TIKAD suspended in the air firing off a few shots at balloons pinned to a board in the distance. This allows the prospective customer to use their imagination concerning potential human targets.

5.4: Invisible Enemies

These promotional videos share an explicit theme: how drone technology stops the wounding of *some* bodies. ‘Friendly’ ones, of course, rather than the bodies designated as ‘enemy’. The latter are to be wounded with ever increasing force and ingenuity, as particularly the Songar and TIKAD attest to. Indeed, the premise of the technology (and the videos promoting it) relies necessarily upon the existential demand of an enemy target, to which the technology is a response, and without which it loses much if not all of its meaning. Combat is a social activity. Noteworthy, then, that in the case of the videos for Songar and TIKAD, in different ways and to different degrees, the existence and nature of ‘the target’ is managed via an aesthetic of invisibility. The human target is invisible in the videos for Songar and TIKAD, but in each case they are implied; made present by and in their absence. Moreover, and at the same time, the target, who is the *non*-user of the system being advertised, is also the excess which emerges between the frames of each video, and indeed, between the videos as I have described and assembled them in this contextual montage:

> strange things happen when two elements are brought together in montage. Never is the result simply the sum of the single components. Something extra, a surplus or an excess, is always produced...We see in the juxtaposition of montage components the opening of a gap or fissure, through which the invisible emerges. (Willerslev and Suhr 2013:1)

Interestingly, in the optics of BCIUAV research as defined in Chapter 2, with the exception of one red flag case in which there is a mention of an 'enemy solider' (Al-Nuaimi et al. 2020), as a sort of double invisibility — we see neither the details of combat BCIUAV's, nor the target of the BCIUAV as weapons system in future. As I will discuss in the next chapter, the optics of BCIUAV research in a sense mirror the ethics of BCI research, in that they focus on and figure users of the technology, rather than *non*-users, here specifically as human targets. This concerns a blind spot in the moral vision of BCI research. As I see it, it is the anthropologist's job to expand the field of view, by, for example, as in this chapter, looking at possibilities in terms of combat BCIUAVs; but also by trying to expand the moral vision of BCI research more broadly to include the non-user as an ethical subject (see Chapters 6, 7 and 8).

5.5: Future Wars: Imagining BCI controlled combat sUAVs

These examples of small combat drone systems originating in two NATO member states and Israel, not only serve to illustrate the nature of sUAV creep into the contemporary and future battlespace, but also to demonstrate likely future uses for which BCI control technology for sUAVs will become relevant. The example of the Skylord Xtender, can reveal a theoretical advantage that adding BCI control could afford. If the individual soldiers storming the building had wireless EEG caps lining their helmets, and the HMD for e.g., SSVEP stimuli *and* video feedback (see Wang, Li, Zhang, Li and Zhang 2018)) [186] it would allow them to operate the UAV *hands free*. But free for what? In cases like those portrayed in the promotional video, the answer may well be *also* operating an assault rifle,

[186] Perhaps in future having modes for augmented as well as virtual reality allowing for immersion in feedback from the drone, and/or forms of visual overlay that do not obstruct the users view of their immediate surroundings but extend their awareness of it via other data streamed back from the drone.

or some other combat related activity with which their hands are (already) busy. Thus, following BCI researchers Allison, Graimann and Graeser (2008), the BCI-sUAV could be seen to ameliorate an occupationally specific '*induced disability*':

> One approach to considering BCI applications in healthy users is: When are healthy users like disabled users? That is, under what circumstances are healthy users unable to use conventional interfaces? If someone's hands are busy, and voice communication is unfeasible due to background noise or the need to maintain silence, BCIs might be the best communication tool. Surgeons, mechanics, soldiers and pilots are examples of healthy people who might experience this phenomenon of "*induced disability*" (Allison, Graimann, Graeser 2008 emphasis added)

However, I prefer to see this view subsumed by the following theoretical approach, which focuses on the prosthetic: fitting, since any external device control via BCI is by definition a 'neuroprosthetic'. The prosthetic 'has come to evoke a sense in which the human/technological interface figures not as a matter of instrumental expediency but as a deep ambiguity and final undecidability' writes Margrit Shildrick (2017:154). The prosthetic blurs categorical assumptions around what a 'disabled' body is. In theory there is no significant difference between 'disabled' and 'able' bodies, as all bodies are constituted by an ever-shifting association with other material elements. In this way, and channelling Derrida, Shildrick argues that ontologically *all* human bodies are always already incomplete. From here, we can begin to see and use prosthesis beyond its conceptualization as replacing something missing, and as remedies for disabilities — the latter being deviations from the 'clean and proper body' (Shildrick 2017:157). Prostheses are always additive, always transformative. Clearly many prostheses, particularly those framed in medical contexts, operate within the paradigm of lack. As such they often respond to this through aspects such as skeuomorphic iconicity, functional and formal affinity and mimetic surface aesthetics in relation to the organic human prototypes that they seek to replace (Taylor-Green 2021). This may obscure the always additive dimension. However, neuroprosthetics such as the BCIUAV, no matter what kind of body

incorporate them, foreground the virtual potential of the prosthetic (Grosz 2015:174) by pushing past the thresholds exhibited by prostheses that conform to the human prototype in the replacement framework. Drones are perfect examples of pushing beyond the human prototype, whether BCI controlled or not. To some extent redefining the prosthetic in this way issues a challenge to both the medical and social models of disability: not pathologizing difference with recourse to a questionable idea of 'normal' and looking beyond the limitations imposed by social discrimination in light of the possibilities of technology. Channelling Deleuze and Guattari (drawing on Spinoza), Shildrick thinks that nothing can be defined about a particular body in advance, and it is only by observing how a body affects and is affected by other bodies that we can approach the question of what that body is. In other words, we define bodies by what they can (or as the case may be, cannot) *do* (2017:168).

> (T)he prosthetic body makes no distinctions between the organic and inorganic, between the natural and artificial, between therapeutic and enhancement, or ultimately between self and other. (2017:156)

All these blurred distinctions are relevant to the BCIUAV, but it is the third — between therapy and enhancement — that I want to focus on here. The therapy/enhancement distinction is meant to point to those interventions in the body that restore or replace damaged or missing aspects that represent deviations from the 'normal' or 'healthy' body, and those which enhance the functioning of an already healthy or normal body, respectively. Bioethicist Julian Savulescu offers an alternative way to think about this. While he is not thinking explicitly about 'the prosthetic' – in his 'welfarist' definition of *enhancement,* Savulescu, equates enhancement with an increase in value experienced by the individual as contributing to their sense of a 'good life' (2006:324). In Savulescu's scheme enhancements crosscut the distinctions between '(m)edical treatment of disease', '(i)ncreasing natural human potential' and '(s)uperhuman enhancements'(2006:326). To

enhance is ‘to raise in degree, heighten, intensify (qualities, states, powers, etc)’ (2006:325). Here ‘an enhanced state is a capability’ (2006:324) and ‘(t)reatments are a subclass of enhancements’ (ibid). I take the term ‘capability’ to be important, which Savulescu defines as: ‘(a)ny state of a person’s biology or psychology which increases the chance of leading a good life in circumstances C’ (2006:324)

I want to keep this definition of capability in play, but also explicitly extend it to the inorganically constituted ‘prosthetic body’ (Shildrick 2017:156) because *capability* allows us to emphasise that enhancements increase the individual’s capacity to *act.* In this respect ‘therapeutic’ prosthetics are enhancements; and too, those prosthetics that could be said in certain contexts to ameliorate “induced disabilities” (Allison, Graemann and Graeser 2008) in healthy people.

So, remixing insights from Shildrick and Savulescu, the way that I am defining enhancement, with emphasis on prosthetics, is:

> Any addition to the body which qualitatively increases its power to act in specific circumstances in a way that the individual positively values.

This definition is derived from the joyful side of Spinoza’s theory of affects:

> By affect I understand affections of the body by which the body’s power of acting is increased or diminished, aided or restrained, and at the same time, the ideas of these affections. (Spinoza 1996:70)

> The more the body is rendered capable of these things [affecting external bodies and being affected in a beneficial way], the more the mind is rendered capable of perceiving. And so what disposes the body in this way, and renders it capable of these things, is necessarily good, or useful (ibid:137)

Prosthetic enhancements are, in a sense, or at least produce ‘affections of the body by which the body’s power of acting is increased’ (ibid:70), and too, often increase the capacity to be affected, and render the mind more capable of perceiving, for example by providing sensory feedback. But with this increased power to act, especially in the cases with which I am concerned (i.e., weapons), comes an increased power to affect *other*

bodies who will *not* positively value the manner in which they are affected by those enhancements, and indeed, may be diminished, even 'destroyed' by them (ibid:137).

In general: With relation to *any* kind of body, in any situation, the BCIUAV provides first a quantitative increase in capacity — the simple but profound fact of the prosthetic as an ontological addition, supplement to and of the body. Given a corresponding qualitative increase in some sort of power, some capability to act, we could describe the BCIUAV as an *enhancement*.

More specifically, in combat settings, when thinking about BCI-sUAVs, and where presumably the enhanced body already has the use of two organic hands, that body has gained *more* power capability wise. The additional capability afforded by the new control output through BCI — which allows the soldier to *simultaneously* control a drone with brain waves and operate an assault rifle with their hands — is the fundamental advantage, or competitive edge that BCI control could bring to combat sUAV systems for ground troops.

Further, the UAV as enhancement in itself, and thus however controlled, has certain qualities that must be considered. In the combat setting, even if the drone in question is not armed and serves in its extension of the body as a purely sensory supplement,[187] the qualities of this quantitative increase in capacity brought by a sUAV system used by ground troops, are the same. They amount to a likely increase in the overall capacity of not only the team, but in principle the individual soldier's body to affect in such a manner as to dominate and destroy other bodies.

At the same time, in both imagined BCI and actual non-BCI versions, by preserving one of the fundamental qualities of even minimally remotely controlled drones — the very same

[187] E.g., visual feedback from a remote airborne prosthetic, up the stairs, round the corner.

extension of vision[188] beyond the line of organic sight (i.e., expansion of sensory feedback) — a defensive advantage is enacted. This might well save troop's lives on the using side. And yet, even without being armed in itself, it appears as though the offensive and defensive capacities of the system are basically indistinguishable.

In terms of imagining BCI control of small *armed* drones like Songar and TIKAD, all of the above applies from the outset.[189] On the one hand, analytically nothing much has changed in this scenario, in the sense that even if not armed, the drone is part of a (hybrid) weapons system. On the other hand, in practical terms everything has changed. The capacity to destroy other bodies has increased again, this time much more pointedly, the BCI-sUAV becoming a weapon in the strongest sense, in itself. Up until now in the BCIUAV research articles I have reviewed, BCI 'control' has referred almost exclusively to the *flight control* of the drone. The actuation of another, non-flight control related function is present in only a very few instances across the entire collection of BCIUAV research. For example, Yu et al. (2012) have a command to take photos, and Wang et al. (2019) have a command that operates a water-spraying module for fire extinguishing. But it is clearly not inconceivable that, for example, an armed SSVEP-BCI-sUAV might have among its flickering stimuli in the HMD, one corresponding to a command for the actuation of a trigger, or to release a payload.[190] At the level of BCI design it would be a minor technical modification. The BCI control would then also be of the actuation of lethal force, not only flight control. However, to focus overly on the actual BCI control of

[188] And perhaps other senses.

[189] Operated hands free, extends the senses as well as the body and thus likely increases the individual's as well as any team's capacity to dominate and destroy enemy bodies.

[190] Although perhaps not for an active e.g., motor imagery based BCI given the unpredictability of endogenously produced commands, and their proximity to 'thought'. Philosophers Steinert et al. (2019), who think primarily about active motor imagery BCI, consider the possibility of BCI users having to develop meta-cognitive skills to *not think* certain things that become mapped to commands in a device. Reactive, visual BCI like SSVEP might pose its own type of problems in this regard. However, I think the opportunities for safeguarding things like trigger features are greater in this latter modality, given the opportunity for multiple command menus and thus also levels of authentication (e.g., 'are you sure you want to select X?').

lethality, 'brain on the trigger' as it were, is to risk diminishing the sense of importance that must be given to BCI control 'only' of flight, and thus the *specific complexity* of this imagined future weapon system and its development. The point is that even working on flight control in such an instance is to work on a weapons system, and this species of weapon system is *nothing without flight*.[191] In every single case of BCIUAV research, red flag or not, the central function being developed is the BCI control of flight, which as defined in an earlier chapter is the primary purpose of BCIUAV technology, and thus is central to any and every variety of the BCIUAV as artefact, including beneficently purposed ones. What this reinforces is that in the current context, *all* instances of BCIUAV research are dual use, because it is possible that any useful advances in flight control could be used to improve combat BCIUAVs in future.

5.6: Conclusion

In this chapter I have argued that that it is sUAVs that are most relevant to combat BCIUAV technology at present, and that these sUAVs will likely be used by ground troops. This does not exhaust possible uses and contexts of use. The BCI-sUAV may indeed ameliorate an 'induced disability' for soldiers, but as an addition to the body which quantitatively and qualitatively increases its power to act in in specific circumstances, it is better conceptualised as an *enhancement*.

Two of the combat sUAV videos I have considered involve the deployment of an aesthetic of invisibility when dealing with the human targets. However, this still evokes the human target, without which the technology loses its *raison d'etre*. The invisible human target emerges in between the frames of each video, and between the videos as I assembled them,

[191] Looming on the horizon are semi-autonomous swarms of such drones (with and without BCI control), which I will address in future research

as the excess that cannot be contained and gives the videos meaning. As I will discuss in the following chapter, there are resonances between this aesthetic of invisibility and both the optics of BCIUAV research and the ethics of BCI research, where the user of BCI systems are foregrounded while the non-user is backgrounded.

Finally, simple though it sounds, the BCIUAV as weapons system or indeed in any other guise, relies on *flight control* for its operation. This is the primary purpose of the technology. Now, any team working on flight control are conducting dual use research whether they know or like it or not.

6: Knitting with Dr Huggins

6.1: Introduction

This chapter is based on an interview with BCI researcher, Dr Jane Huggins in 2020. I focus on an excerpt in which we discuss dual use and weapons research with relation to BCI. Taking as a challenge Huggins's comments on what BCI researchers are interested and not interested in when discussing ethics, I identify how a possible window of concern might be opened onto the issue of electronic neuroweapons. Then, I consider a small selection of BCI ethics literature related to the BCI Society, which allows me to identify a near blind spot in the moral vision of BCI research: that it is predominantly user focused and tends to ignore the non-user. Subsequently I identify the incipient Principle of Social Impact'(Pham et al. 2018:107) which runs counter to the usual focus in BCI ethics on the BCI user. The Principle of Social Impact, cast in the existing ethical language of BCI research, does not yet appear to have dual use and WR in its sights. But it may allow for the window of concern to be opened on the issue of electronic neuroweapons and provide a basis for conversation to proceed in future.

6.2: Putting People Together/ Taking People Apart

Dr Huggins is a clinically oriented BCI researcher, a senior member of the BCI society, and serves on the editorial board of *Brain-Computer Interfaces* journal.[192] When I interviewed her over Skype, she sat doing her knitting for the whole two and a half hours, which I felt produced a bizarre juxtaposition with some of the topics we discussed (see below). Behind her was a rack containing different coloured balls of yarn. Both she, in Michigan, USA, and I in Oxford, UK respectively, were enduring lockdown restrictions

[192] This is where Meriño et al's (2017) paper was published.

due to the COVID-19 pandemic. We talked about all sorts of things, but I think we both knew what I was most interested in. I asked her about the dual use/WR issue in the BCI community. Taking a deep breath and putting down her knitting for a moment, she stared off camera into the distance. Returning her gaze to the video call, she compared the issue to a bunch of BCI researchers arguing with each other about what to have for dinner. They would never come to an agreement. Likewise, they would never come to an agreement on whether WR should or should not go on. Anyway, she told me:

> *I'm much more interested in putting people together and improving them, than taking them apart*.

Interestingly, however, she followed up on this remark by saying that she had no problem with the latter. On the issue of dual use, which as we know entails weapons innovation, Dr Huggins said:

> *Having an unmanned device that could go into dangerous situations, whether it is a combat situation or a search and rescue in an earthquake catastrophe or building collapse or something…the technology for the two is pretty much the same. So, you know, doing those things is a good thing to have happen.*

I felt this was a somewhat predictable answer that skirted round the real issue. When pressed on the question of ethics Huggins commented that BCI researchers probably don't talk about ethics enough — but that when they do, they want to talk about ethical issues that are '*unique to BCI*.' Dual use and WR, or rather, '*military solutions*', Dr Huggins thought, were *not* ethical issues *unique to BCI*. She is not alone in holding this view (see Schneider, Fins and Wolpaw 2012:381).

Subsequently, Dr Huggins asked me what possible advantage would BCI control bring to the way that existing, HALE fixed-wing military drones are controlled anyway? For EEG-based BCI, without going down the route of implantation and the use of ECoG which holds the potential for much clearer signals and faster information transfer rates — non-

invasive BCI would just slow them down. Relatively speaking, and in either case, BCI is still pretty slow, and really only brings advantages to those who actually need to use it because they are disabled. I had to agree. We even chuckled about it between us. Things might eventually speed up, but for now there wasn't much to see. Aside from the question of speed, Dr Huggins pointed out that standard aircraft controls, designed specifically for that purpose, including those used to pilot unmanned aircraft, were obviously a better candidate for the job than any current BCI. They had been in development for over a hundred years and are continuously proven to be up to be the task.

However, at this point in time (mid December 2020) neither of us had considered the possibilities outlined through analysis of the promotional videos for small combat UAV systems in the previous chapter.

Although non-invasive BCI is still relatively slow, in the previous chapter I suggested a unique (albeit theoretical) advantage that could be achieved by introducing it to combat sUAV systems in the near future (i.e., hands-free). To identify even one, albeit theoretical advantage that it might bring to combat UAV systems — which, as discussed, relies on the primary purpose of the technology which is flight control — strengthens the argument that BCIUAV research of any kind, even that which is benignly intended, is dual use and may therefore entail weapons innovation. And, as discussed, this advantage occurs on top of the other advantages that BCIUAV systems could confer on users in combat situations, whether the drone is armed or not. Although the latter are mostly to do with the drone itself, the fact remains that BCI control would be involved in the BCIUAV.

Moreover, contextually, we also know that some instances of BCIUAV research are openly dual use and some are funded by military agencies. The potential for BCIUAV technology to feature in future warfare is hardly a secret. It's not so much a question of what the technology can do now, but what it will be able to do in future. This all poses a

challenge to Dr Huggins' assumption concerning potential advantages to BCI control of UAVs — although now of course my understanding of the kind of UAV in question has changed, and I am not thinking in the same way as her concerning information transfer rates and so on. Nevertheless, albeit without grasping the computer science, I assume that these latter aspects can and will be ironed out as time goes on. No doubt, a muscular injection of military money from DARPA will produce the desired results, which as Tullis (2019) reports, is already happing under the auspices of the N3 programme announced in 2018 (see also DARPA 2019).[193] But this is only possible because the groundwork was laid by largely non-militarily funded university based BCIUAV researchers, which was in turn made possible by several decades of diverse and well-meaning work by BCI researchers just like Dr Huggins before that. Not that these latter works were (all) necessarily dual use in the sensible, contextually sensitive, and relatively complex way that we mean it (although presumably some were). But perhaps more so in the unhelpful sense that scissors, or the production of certain grades of steel or other metals generally, can be said to be 'dual use', where everything becomes dual use, so that eventually the category loses all utility.

6.3: Opening a Window

I take Dr Huggins's remarks on ethical issues that are '*unique to BCI'* as an intellectual invitation. On the one hand, she is right that WR itself is not an issue unique to BCI. It is an ancient practice that has spanned technological domains for millennia in some form or another. Here we encounter more of the same. On the other hand, perhaps certain kinds of dual use and/or WR, are, if not unique to BCI, then specific to its involvement in certain types of weapons systems. If so, then a window for concern *might* be opened through

[193] https://www.darpa.mil/news-events/2019-05-20 (https://perma.cc/WD9D-JQH6)

which to modify the appreciative system ('a set of readinesses to distinguish some aspects of the situation rather than others and to classify and value these in this way rather than that' (Vickers 1965:67)) currently in operation by the BCI Society. I think this is actually quite (almost *too*) simple to demonstrate. As already established, the future weapons which we are concerned with are categorizable as 'neuroweapons' because of the involvement of *neuro*technology in them. The neuroweapons in question —'combat BCIUAVs' (although 'combat' is too restrictive a term) are only 'neuroweapons' *because BCI technology is involved*. So, there may be grounds to argue that, even in these simplistic terms, the creation of neuroweapons that rely upon BCI for their control is an issue not just specific but *unique* to BCI. But even if BCI researchers, as individuals and as a diverse community of practice can see the logic of this, the crucial question will still be whether this is perceivable as an *ethical* issue relating to BCI and, most importantly, to BCI researchers.

6.4: Social Impact: Expanding the Moral Vision of BCI Research

Dr Huggins is a co-author on several papers explicitly addressing ethical issues pertaining to BCI (e.g., Pham et al. 2018) but also neurotechnologies more broadly (Goering et al. 2021), and indeed, the intersection of these with artificial intelligence e.g., Yuste et al. (2017). The ethical issues pertaining to BCI raised in Yuste et al. (2017) and Pham et al. (2018) (see also Nijboer et al. 2011) are on the whole *internal* ethical issues. By this I mean they concern *users* of BCI and the treatment of research subjects. There is no doubt that these internal, largely user centred matters are important. Nevertheless, my interest is, on the contrary, directed towards those ethical questions pertaining to BCI that would be considered *external* (Forge 2008:17). The latter concern in this case *non-users* of BCI

technology who may nevertheless be affected negatively by it when the application in question has the potential to harm and kill them.[194]

In future work, I will conduct a wider review of the BCI ethical literature. Here, I concentrate on the paper by Pham et al. (2018) along with its linked predecessor (Nijboer et al. 2011). These two papers are both based on surveys done with members of the BCI Society at two BCI Society conferences (International BCI Meetings). Although I say *on the whole* these ethical discussions are internally focused, the proposed ethical 'Principle of Social Impact' which 'emphasizes the importance of recognizing that BCI technologies can have broad social effects' (Pham et al. 2018:107) has an external ethical focus. However, this principle is not much elaborated and has not yet, to my knowledge, been extended to dual use or NWR, nor deleterious effects on *non*-users. As signalled in the previous chapter, this indicates a near blind spot in the moral vision of BCI research. The topics raised in relation to a Principle of Social Impact include 'a commitment to democratic representation and transparency in BCI research development (such as soliciting public import on future BCI research)' and 'to mak[ing] BCI data more available to others in the field (such as through shared databases)' (2018:107). With the aim of eventually engaging with the BCI Society on the issue of dual use and NWR in mind, being able to frame the problem of electronic neuroweapons involving BCI as coming under the Principle of Social Impact, and thus in the Society's own ethical language, will surely be helpful.

There is, however, already possible evidence that some BCIUAV researchers do appreciate that the dual use possibilities of their own work pose ethical issues, possibly

[194] When I raised the idea of considering external ethical issues pertaining to non-users with Professor Kübler (another highly experienced BCI researcher) during one of our interviews, it was clearly quite alien to her. This anecdotally suggests that thinking about external ethical issues in BCI research is not common. Once the idea had taken hold, however, Kübler affirmed her appreciation of its importance (particularly in light of my research topic) and seemed keen for us to investigate it collaboratively in future work.

even with relation to the notion of social impact and the non-user; or, at least, that it could be perceived by others as an ethical issue in this regard. But this is not made evident by open discussion of harmful uses. Rather, possible evidence of their recognition of ethical issues is found in the ways they appear to try to manage perceptions of the harmful uses to which it could be put — in other words, what might be seen to appear as efforts to favourably frame, and even dissemble them in certain ways, and to varying degrees. This is central to the discussion in the next chapter, which is a speculative inquiry into the optics of BCIUAV research as it appears in several published articles.

6.5: Conclusion

In this chapter, selective insights from my interview with Dr Huggins have been discussed. I took her remarks on what BCI researchers are interested in when they talk about ethics to be a challenge. By defining the problem of electronic neuroweapons of the BCI type as being one unique to BCI, I argue that a window for concern might be opened. Further, by identifying the extant Principle of Social Impact as an incipient category of *external* rather than internal ethical import — the moral vision of BCI research, but more specifically, of the BCI Society — might be expanded in future to include electronic neuroweapons involving BCI and a more concerted focus on the *non*-user, both of which appear to be near blind spots at present.

7: Optical Dissolution

> In future, these integrated systems could serve more practical purposes—some conceivable applications are as follows: in hospitals where patients with severe disabilities could use them for transporting objects; in battle fields where wounded soldiers could use them to proceed with the combat; and in space where they could assist astronauts to accomplish multitask missions outside the spacecraft. (Nourmohammadi, Jafari and Zander 2018:338)

> One agenda of visual anthropology is to analyse the properties of visual systems, to determine the properties of particular visual systems and the conditions of their interpretation and to relate the particular systems to the complexities of the social and political processes of which they are a part. (Banks and Morphy 1999:2)

> (W)illingness to place ourselves under the spell of all manner of works of art, though it contributes very much to the richness of our cultural experience, is paradoxically the major stumbling block in the path of the anthropology of art, the ultimate aim of which must be the *dissolution* of art, in the same way that the dissolution of religion, politics, economics, kinship and all other forms under which human experience is presented to the socialized mind, must be the ultimate aim of anthropology in general. (Gell 1992:41 emphasis added)

7.1: Introduction

BCI researchers may find it odd that an anthropologist concentrates on what in relation to their high-tech practices may seem to them an irrelevance. But at least in some cases, the bodies of possible future users figured by text in research papers become portals allowing access to the visual imaginary of the BCIUAV which I described in Chapter 2 as a 'visual system' (Banks and Morphy 1999:2). This chapter expands the more critical side of the optical theory introduced in Chapter 2 concerning 'the optics of BCIUAV research', by first addressing the figure of the 'wounded solider(s)' posed as 'conceivable' future user of the BCUAV by Nourmohammadi et al's (2018) seen in the first epigraph above.

After briefly discussing Nourmohammadi et al's paper and some important contextual details, I introduce Judith Butler's concept of framing. Then, focusing on the work of human geographer Leila Dawney (2019, 2020) (who draws in part upon Butler) and

recalling Alfred Gell's (1992:41) emphasis on 'dissolution' in anthropological theorization, I dissolve the optics that the wounded soldier projects into the imagination of the reader. Inspired by Banks and Morphy's (1999:2) thoughts about how anthropologists should deal with 'visual systems', I conduct optical dissolution first in 'social' and then in 'political' terms. Building upon Achille Mbembe's (2019) neologisms of 'necropower' and 'necropolitics', and in eventual synergy with Eric Wolf's (1990) definitions of four kinds of power, I give a philosophical anthropological account of the power that KDU and weapon researchers wield. I argue theirs is a *transversal necropower* to kill *anyone, anywhere,* and in special cases *everyone, everywhere*. It is thus also a *cosmopolitan power*. Subsequently, it is argued that Nourmohammadi et al's wounded soldier is 'necro-optical', in that it attempts to morally persuade the reader as to the nature of the proposed future use, which in turn reflects back on perceptions of the research in question.

I then take what is learned from the wounded solider and loop back to the ALS patient figured by Meriño et al. (2017) discussed in Chapter 4, showing how the wounded solider and the ALS patient —— although very different kinds of body —— in fact share certain notable characteristics. By conducting a thought experiment involving a plausible scenario in which Meriño et al. share our analytic understanding of the significance of criteria A (military funding), and with reference to the work of John Austin (1979b) on *pretending*, I explore the notion of 'necro-optics' further, finding that the ALS patient is potentially playing a similar role to the wounded solider. Evoking an initial comparison between Merino et al's paper and another BCIUAV paper by Vishwanath et al. (2018), I then move on to compare Meriño et al's (2017) ALS patient with Nourmohammadi et al's (2018) wounded solider. On the surface, I liken the role being played by the wounded solider and the ALS patient to *human shields*, which here, following Austin, involves dissemblance. I then speculate as to the underlying logic that might be shared by both bodies in their roles

as human shields, despite their radical difference. Following Christopher Davis (2012), it is hypothesized that this logic involves the dissemblance of one kind of wound with another.

7.2: 'A Survey on UAV Remote Control Using Brain-Computer Interface' (Nourmohammadi et al 2018)

In their review article of BCIUAV research in which they also make suggestions for improvements in future BCIUAV systems,[195] Nourmohammadi et al. (2018) present perhaps the most interesting example of the tendency to non-normatively express the dual use possibility of BCIUAV technology, as seen the first epigraph above. Recalling section 2.11 of Chapter 2, this means that the paper triggers criteria B: *explicit mention of harmful derivative purposes (e.g., battlefield / combat uses)*, and thus constitutes an instance of KDU research. It is unarguably the case that Nourmohammadi, Jafari and Zander are aware of the possible weaponization of BCIUAV technology. From the analyst's perspective, by including this short paragraph in their review article, Nourmohammadi et al. simultaneously frame the BCIUAV as a future combat technology — with implications for all future research — *and* gather up all the previous BCIUAV research into the dual use category: although they do not use the latter terminology themselves.

The article in question appears in *Transactions on Human-Machine Systems*, published by the Institute of Electrical and Electronics Engineers (IEEE), 'the world's largest technical professional organization for the advancement of technology'. The IEEE's inspiring motto is 'Advancing Technology for Humanity'. Their Mission Statement clarifies the latter: 'IEEE's core purpose is to foster technological innovation and excellence for the benefit of humanity'.[196] Thorsten Zander, the senior author of Nourmohammadi et al. (2018), is a

[195] So far, the only review dealing exclusively with BCIUAV research.
[196] https://www.ieee.org/about/vision-mission.html (https://perma.cc/Z6DM-7YH9)

prominent BCI researcher affiliated with the BCI society. His company Zander Labs specializes in the intersection of passive BCI technology and artificial intelligence (AI) development, and provides consultancy services to other companies and organizations concerning the integration of such systems into their own operations.[197] Zander Labs is partly a 'defence' contractor. Their website cites the US Air Force as a partner, and both US Air Force and US Army Research Laboratories as 'much-appreciated references'.[198] Oddly, Nourmohammadi et al. (2018) do not reference Meriño et al. (2017). The publication histories of each reveal that the former should have been able to know of the latter (see Appendix 1). Later in this chapter I will bring them into some kind of dialogue.

7.3: Enchanted Wounds

'(T)here are conditions under which war is waged, and we have to know them if we are to oppose war' writes Judith Butler (2010:i). These conditions extend beyond physical battlefields and the primary sites of military activity. The distinction made possible by the remoteness of wars conducted on foreign soil, between 'the destruction of the bomb and the framing of its reality' (2010: xiii) plays out in the visibility of domestic public spaces through various media communicating carefully crafted narratives. Certain elements of war's visibility are made prominent and even exploited by states to garner public support for war. At the same time, the function of framing is to place other elements outside the frame, making them invisible. Frames are inherently conceptual and ideological in nature, but clearly the sense in which the metaphor is meant here carries over quite literally the

[197] Passive BCI refers to the use of BCI to monitor brain signals rather than using them directly for control. The idea is that these monitored signals can be used to improve, for example, the control of an external device and the performance of human-machine systems in indirect ways, as well as giving insight into the mental and emotional states of users (see Zander and Kothe 2011).
[198] https://zanderlabs.com/ (https://perma.cc/9HYZ-ZEKK)

(‘picture’, as it were) ‘frame’s’ connection to visual culture, and the role of imagery in the selectivity of seeing. Ideological and visual frames are lesser-known parts of the weaponry deployed by warring states not so much in the first instance against ‘the enemy’, but on their domestic publics and allies: forming aspects of propaganda aimed at conscripting civilian subjects into supporting, and thus, in an important sense, participating in wars. However, even dominant frames are in a state of ‘perpetual breakage’ (2010:10) as they travel between contexts. ‘The conditions are set for astonishment, outrage, revulsion, admiration, and discovery, depending on how the content is framed by shifting time and place’ (2010:11).

It is along these lines that Leila Dawney (2019) theorizes regimes of public visibility orchestrated with and through encounters with actual wounded bodies. Specifically, those of (living and dead) British soldiers post-conflict. Butler’s concept of framing and the concept of ‘substantiation’ (see below) coined by Elaine Scarry in her classic work *The Body in Pain* (1988) form perhaps the two most important components of Dawney’s own proposal for a ‘critical politics of substantiation’ (2019:59). Here, the wounded body, and its image, is taken to be a ‘material affective entity’ (2019:52). Although characteristically unruly in their visceral appeal to the ‘incontestable reality of…the body in pain’ (Scarry in Dawney 2019:58), there is ‘an openness and potential reversibility’ (Dawney 2019:60) to the wounds caused in war. The affective force of the wound is an indeterminate excess that can be put to work in variously politicised regimes of visibility — those promoting anti-war sentiment as much as those perpetuating the very war that caused the wound itself:

> Substantiation in Scarry’s work, refers to the way in which the matter of wounded, maimed and dead bodies works to enflesh ideas. The damaged or altered body functions in war as a vehicle for substantiation: the making material of immaterial beliefs and values. The concept of substantiation thus holds that the material altering of matter is necessary to the political work of war, since it brings into the world the ideas over which war is fought. In other words, wounding inscribes power relations in and through bodies and makes ideas (e.g., the idea of ‘the nation’ or ‘the people’) visible and palpable to publics. The dead and

> maimed bodies produced in warfare thus make political claims solid and in doing so materialize language and ideas. (Dawney 2019:50).

Dawney proposes a critical politics of substantiation that analyses the work that wounded bodies as affective technologies do, and the work that is done with them. *How*, for instance, in the substantiation of certain political claims and their associated imaginaries, are the wounded bodies of British servicemen used (or rather, *deployed*) to produce certain forms of response in spectators, simultaneously hoping to supress others? (2019:58, 2020:1107). Through analysis of the 'aesthetic strategies' (2020:1109) of militaristic spectacles such as the Invictus Games (2019), or repatriation ceremonies of British war dead in otherwise sleepy English towns (2020), Dawney argues that control is leveraged over and through war-wounded bodies in the interests of generating support for the British military and its wars. Her work reveals a tendency toward the engineering of emotional, but she thinks 'post-political' (2020:1100) responses in spectating publics identifying the 'figure' of the wounded soldier as 'hero-victim' (2020:1113) or 'soldier-as-victim' (2020:1108) as the locus of the operation.[199] In contrast to the more traditional figure of the soldier as a fearless warrior, the solider-as-victim is a framed as a 'vulnerable family man' (2020:1109). Whilst still a hero for serving his country, he is dispossessed of authority, as a victim maimed or killed by enemies of the state. And yet, this very same dispossession of authority stemming from the wound can also become the force of authority by which his body, dead or alive, becomes used by others to silence the critics of war. After all: *Who is going to have the cheek to come out here amidst this eye-popping pageantry, and analyse, let alone criticise, the optics that this patriotic wounded or even dead body is tangled up in?! Anyone?* Well, at least for some, the very sight of war

[199] 'Post-political' here in the sense of cultivating a public atmosphere of indisputable silent respectfulness in which counter narratives are thus excluded.

damaged bodies, images of conflict and the uncontrollable destruction in its wake, provokes not only sympathy with those grievable lives highlighted gloriously by the frame. It may even cause an identification with the apparently ungrievable 'enemy'[200] framed as target populations for the violence meted out in war. A counter recognition of *all* grievable life can lead some spectators to respond by rejecting militaristic rhetoric (Butler 2010). Suppressing this kind of resistant response, making it difficult to speak out against militarism and war, is essential to keeping up the appearance of legitimacy of militaries and their immensely profitable industrial complexes, while actively manufacturing public support for wars.[201] However, the inherent unruliness of the wound mentioned earlier, is precisely one of the things being insured against by the 'augmentation and channelling' (Dawney 2020:1112) of its potentially disruptive excess through aesthetic strategies. It is always threatening to break out of its framing. The figure of the wounded soldier, then, is an extremely potent device to deploy in a visual system: but one with attendant risks.

7.4: A Critical Politics of Insubstantiation

Examining the imaginal iconography evoked by Nourmohammadi et al. (2018) in closer detail, important questions must be asked about *how* but also *why* these authors have deployed a 'wounded' soldier? Why have they gone to the lengths of wounding their own solider? Why is this soldier a 'wounded' soldier rather than a fighting fit one? Why, have these science-artists fabulated a wound? What are the intended social and political functions of this wounded body?

[200] Sufferers, too.
[201] A form of domestication

Here it is a matter not of actual bodies gathered under the figure of the wounded soldier as 'material-affective entities' (Dawney 2019:52), but the figured body of a wounded soldier as *immaterial-affective entity*, so to speak. The term 'substantiation' obviously lends itself to the phenomena Dawney describes but doesn't quite make sense unless used in relation to giving actual weight to an idea with material bodies. Therefore, the term I will use with relation to the present case concerning the optical deployment of bodies figured via ekphrasis that are *immaterial-affective entities*, and thus to mark an ontological difference, is *insubstantiation.* Nevertheless, the logic of substantiation in the most important respects still stands. This is still a strategic deployment of a wounded body in the service of a particular politics (see below), geared towards producing certain responses and not others in relation to what it frames, and too, hopes to exclude from the frame. '(A) way of worldmaking oscillat(ing) between the registers of affect and subjectivity' (Dawney 2019:58): a choreographed encounter wherein control is leveraged over the witness via the power of the wound as a sort of 'affective technology and armament' (2019:57). But now, the body in question inhabits the imaginary layer of the BCIUAV conceptualized as a visual system, carried in text, sustained in the imaginal corporeality of those readers who encounter it. While the reader sustains the figure of the wounded solider, they are 'ceaselessly becoming-other (while continuing to be what they are)' (Deleuze and Guattari 1994:177), drawn in by this monument to a possible future carried by just 'a few marks' (1994:165). But what skilful marks they are, displaying an 'affective Athleticism' (Artaud quoted in Deleuze and Guattari 1994:172).

The affective tonality of the desired and quite natural response to the imperative of defence found in the appeal to the 'incontestable reality of…the body in pain' (Scarry in Dawney 2019:58) is sympathetic. However, as Forge (2008) (2013b) (2019) makes eminently clear, and this should be asserted repeatedly: there is really no such thing as a defensive weapon.

But there are conceivable defensive *uses* of weapons in certain situations. And defence is in principle a good (even the best) candidate for the justification for the design, manufacture and use of weapons. Sure enough, Nourmohammadi et al's *wounded* soldier(-as-victim) is figured in one such situation. It's a good thing the wounded soldier has a BCI helmet and an armed sUAV strapped to his backpack, then, we should suppose — and perhaps also that it was only now he came to use it? *After* being wounded, the soldier, perhaps otherwise *defenceless*, may now proceed with combat and thus defend himself against the unspecified enemy other who is excluded from our view. After spinning this tale of an otherwise vulnerable body, is the derivative purpose in question (combat BCIUAV) actually a beneficent one? Alas, the figuring of a fleeting defensive use does not a beneficent derivative purpose make, because 'a combat drone that does not put [other] humans *in* harm's way would be useless.' (Allinson 2015:121 emphasis added). Proceeding with combat, the wounded soldier as much as the freshly deployed soldier takes lives so that he may live. This is 'the relationship of war' (Foucault 2004:255).

Thus, following the method of optical dissolution, I see that the wounded body's function as an ideal 'technology of enchantment' (Gell 1992) aimed at the reader, is not only a realist prospection as to the BCUAV's militarized future uses. It is to frame the prospect of combat use *in a beneficent way* by insubstantiating the idea of (self)defence in future wars, as a moral justification for NWR in the present.[202] And — having made the cut, having cultivated a subtle moral atmosphere — exploiting the openness of the wound's force, Nourmohammadi et al. hope to silence critique concerning the inherently *offensive* tendencies of the system presently under development: in battlefields where soldiers could use it to proceed with combat. The wounded body of the future solider is a key player in the optics of the BCIUAV conceptualised as a 'visual system' (Banks and Morphy 1999).

[202] Lethality often appears under the auspices of defence (Davis 2012).

Recalling the discussion of the optics of BCIUAV research in Chapter 2: the wounded solider is a domesticated fiction in the Latourian (2013) sense but deployed in a process of insubstantiation that is in itself geared at domestication in the Gellian (1988, 1992) sense, of an audience with relation to their perceptions of the combat BCIUAV and research developing it.

It seems that a form of non-kinetic affective/psychological war is being waged via science fiction, on the reader now, precisely because the article indexes originary conditions under which future kinetic wars will be waged. After all, this article contains notes toward designs for what is certainly in part a neuroweapon system.[203] The latter transcends any particular conflict, any particular moral or legal justification for use, and makes a mockery of the attempt to distinguish in the abstract the offensive and defensive, if both are ultimately lethal uses of force against other human beings (see below). Simple as it sounds, the imaginary wound inflicted on the future soldier appears to attest to Nourmohammadi et al's *anticipation of criticism* concerning the creation of the means to harm. This is one example, then, at least as I interpret it, of possible evidence that some BCIUAV researchers might appreciate that the dual use possibility of their own work raises ethical issues. By this I mean it could be evidence that they recognise that others may perceive this to be the case, and that these others may otherwise disapprove.

7.5: Every Strike Begins in the Clouds

In this chapter so far, I have attempted to analyse the 'social processes' (Banks and Morphy 1999:2) in which the image of the wounded solider plays a part, having been

[203] I write 'notes toward designs for a weapons system' because it is a constructive review article: no actual practical work is undertaken, but in reviewing many of the previous practical BCIUAV studies, suggestions are made as to the improvement of the technology in future. Still, it might be too weak a term that I have used, because these 'notes towards designs' are still very much active efforts to improve future designs for what is, by their own admission, a weapons system, implicit in the use of the term 'combat'.

identified as a property of the BCIUAV conceptualized as a visual system. Dawney's work stresses the importance of the political dimension of this particular insubstantiation. Not that the 'social' can ever be disentangled from the 'political', but theoretically, at least, there are angles from which to interrogate the latter in relatively distinct terms. I will now present a philosophical anthropological account of 'politics' and thus 'power' germane to the contexts of KDU and WR. Through this, we will deepen our capacity for critical vision and sharpen our understanding of the possible optical function of Nourmohammadi et al's wounded soldier.

Foucault writes: 'the body is directly involved in a political field; power relations have an immediate hold upon it; they invest it, mark it, train it, torture it, force it to carry out tasks, to perform ceremonies, to emit signs'(1984:173). On this basis I broadly define 'politics' in its most rudimentary theoretical form, as pertaining to 'power relations'. What's more, Foucault usefully stresses the centrality of the body in the exercise and methods of power and political technology. So, when I speak of politics here, I speak not specifically of governance, but of those constellations of asymmetric (but not necessarily static) power relations which imply and indeed, seem to require, that there be agent and patient bodies. In service of what politics, then, do Nourmohammadi et al perform their insubstantiation? To exercise '*necropower'*, (Mbembe 2019:79) the power to kill, is '(t)he ultimate expression of sovereignty' (ibid:66). At its extremes, Mbembe's necropower (and correspondingly the varieties of 'necropolitics' through which it is wielded) is really just the sovereign right to kill as Foucault (2004/1976) theorizes its jarring presence in biopolitical forms of state governance, and filtered through Giorgio Agamben's (1998) intervening body of work (amongst others). I take necropower to be the new name for the

active death function of (bio)power,[204] which is directed toward a particular population; a rhetorical inversion 'marking the point at which the decision on life becomes a decision on death, and biopolitics can turn into thanatopolitics' (Agamben 1998:72). [205] Of particular relevance here is Joanna Bourke's (2017) reference to Mbembe's neologisms in her feminist history of ballistic science. She uses necropower and necropolitics in a way that straightforwardly chimes with my own use of them, and what's more, also with relation to weapon design. Bourke argues that history has tended not to record weapons scientists as 'violent individuals' (2017:136), citing factors that may have affected this judgement such as 'class, status, education, whiteness, and emotional comportment' (ibid:135). Nevertheless, as key players in the 'necro-political complex' (ibid:136) weapon designers have been 'heavily implicated in the major forms of wounding and killing in modern history' (ibid:138). Although, as discussed via Forge in Chapter 2, they are rarely if ever the ones using the artefacts that result, which have the potential to massively proliferate beyond them in space and time. Later it will be others, many being more comfortably categorizable as violent individuals,[206] who incorporate the technology into apparatuses of domination and massacre with relation to various cultural logics and imaginaries.

Considering the 'kill-chain', as 'a dispersed and distributed *apparatus,* a congeries of actors, objects, practices, discourses and affects' (Gregory 2011:196) culminating in the

[204] Thus, in the interests of clarification — and assuming the reader has some familiarity with this stock Foucauldian concept referring to modern state governance of human life at a population level, which also entails techniques of regulation exercised over individual bodies, seen for example in public health initiatives that aim to sustain a workforce that will drive a state's economy — not simply to 'let die', which is the passive function of biopower, and certainly not the active function of biopower to 'make live': but rather to actively 'take life' and thus *make die* (Foucault 2004:247).

[205] The conditions of the concentration camp are taken by both Foucault and Agamben to be the ultimate demonstration of the wretched flipside of biopolitics when racism becomes involved, racism being the mechanism by which biopower justifies its wielding of the sovereign death function. This is a power to keep people in a condition somewhere between life and death, in a state of exception from the normal laws governing men, but also and importantly, to *make die*. It is re-historicised by Mbembe via European colonialism in Africa and the slave trade, providing a major corrective to the accounts of both Foucault and Agamben. Mbembe also recontextualizes this sort of power as seen in the era of the war on terror, and neo-colonialism in Palestine.

[206] Although not all.

death of a human being, it not only includes but in a causal sense is dependent on the activities of those who design the weapons that are eventually used, by someone else, in the terminating link. Weapon designers do not decide *who* dies; rather, they decide only *that someone will.*[207] Resonating with Bourke's choice of subject matter, it is not the necropolitics of (brain-computer interface) drone *warfare* (cf. Allinson 2015, Zulaika 2020:16-19) that I am referring to here (although that is of course entailed): but rather the necropolitics of ('combat') brain-computer interface drone *research*. It is my view that weapon designers establish a relation of enmity to a planetary population. By extension, this also stands for KDU researchers, like Nourmohammadi et al. Indeed, I argue that as knowingly and openly dual use researchers, Nourmohammadi et al (2018) are, at least *in part*, neuroweapon researchers/designers.[208] Accordingly, the application of necropower/politics with relation to the present case — that of weapon designers — does not concern the involvement of the weapon technology in the domination of a *particular* human population sectioned off as being '*less than life*' (Allinson 2015:117). To my mind no classificatory schema or differential notion such as race or culture is in play; no specific (or perhaps rather, no 'secondary') 'necropolitical logic' (ibid.) is *yet* at work.[209] It is simply, purely, the power to kill that is at stake. To design weapons is the ability to massacre without and before the influences of culture, bureaucracy, or racism on the decision concerning who dies. It is necropower as knowledge and technical skill transformed into potential, possibility, affordance: *technology*. In this way it is the power to kill *anyone, anywhere,* with complete impunity. An indiscriminatory, supra-regional,

[207] Thus, what is also decided from the very beginning in the act of weapons design is that *no body matters*.
[208] Even though in this specific case no practical, and only theoretical work is undertaken.
[209] Although it must be acknowledged that these individuals do not operate outside of national systems of power entirely, and certainly one of them has multiple state military industrial complex connections – albeit as a private 'defence' contractor – and so in that capacity counts as a commercial weapons researcher. What I am homing in on is the power that the researchers wield for themselves, a product of their specialist knowledge, skill, and thus future making capacities, which can be exploited by states or others.

potential violence: simmering. Its absolute indiscriminateness, its disregard for the symbolic categorizations of identity and the accidents of communitarian affiliation, its ultimate detachment from the 'defence' of any particular person, nation or idea, in any specific conflict: mean that it is by nature a *cosmopolitan* power. Glimpses of a *Necropolitics of the Human Race* (cf. Foucault 2004:243), [210] lethal power over man as both body and species wielded in the first instance from a quiet place, not by tyrannical kings or post-modern states: but by scientists and engineers. A contracted sort of sovereignty that nevertheless reminds us of our 'capacity to be killed' (Agamben 1998:68), reduced to sentient meat in an asymmetrical relation of careless enmity.

Forge's '*Unknowability Thesis*' (2013b:78) is crucial to grasping what is at stake in the wielding of this terrible power. The long-view problem with designing weapons is that the designs outlive any specific justification connected to the anticipation or occurrence of a specific conflict from any, at the time, *just* perspective, or even any foreseeable specific use. Indeed, 'future uses may be 'bad' uses, uses that would not be condoned or accepted either by the original designers or on any reasonable moral standard' (Forge 2013b:59). The weapon designer 'cannot have good grounds for believing that [their] work will be only used in just wars' (ibid:305). They *can* know that their work will be used to harm and kill human beings. But in what circumstances, and in what context, in which futures — in other words, the particularities of use: they simply *cannot* know. In this respect, even war time WR is difficult if not impossible to justify let alone commercial WR in peace time, because 'an activity that gives rise to unknowable and unlimited potential for harm cannot be justified. This, in a nutshell, is the case against weapons research.' (2013b:34). What the Unknowability Thesis highlights is the sense in which beyond their exercising it in the

[210] Taking the long-view, whenever a new weapon of any kind is designed the population under threat, is always 'Us'.

act of research and design, this exceptionally potent form of power wielded by the weapon designer spirals out of their control and becomes radically distributed. Its potency is in large part attributable to precisely this uncontrollable capacity for proliferation. But even though such researchers do not entirely control the effects of their actions and their power, this does not mean that they are not still ultimately responsible for them, nor that they are not in some sense present where those effects occur.

To deepen and reinforce these insights from a material anthropological perspective, I return to the work of Alfred Gell. Rather than the technology of enchantment here I want to draw upon elements of his theorization of the ontological constitution of the materially distributed person (i.e., the prosthetic body, cf. Chapter 5).[211] The example given to illustrate the theory of materially distributed personhood in the passage below bears direct relevance to the present discussion:

> A soldier is not just a man, but a man with a gun, or in this case with a box of mines to sow. The soldier's weapons are *parts* of him which make him what he is. We cannot speak of Pol Pot's soldiers without referring, in the same breath, to their weaponry, and the social context and military tactics which the possession of such weaponry implies. Pol Pot's men were capable of being the kind of (very malign) agents that they were only because of the artefacts they had at their disposal, which so to speak, turned them from mere men into devils with extraordinary powers. Their kind of agency would be unthinkable except in conjunction with the spatio-temporally expanded capacity for violence which the possession of mines makes possible. (Gell 1998:20-21)

Armed with the logic contained in this passage and tracing the chain of causal relations backwards — while they might never be present in their organic bodies, in battlefields where soldiers proceed with combat, or in cities where terrorists attack innocent civilians: the materially distributed cognition and agency of the weapon designer or KDU researcher, as a social entity, is present at and implicated in every act of violence done with their work:

[211] At least where these two tiers of his broader theory in *Art and Agency* (1998) can be heuristically separated.

> (A)s social persons, we are present, not just in our singular bodies, but in everything…which bears witness to our existence, our attributes, our agency. (Gell 1998:103)

This is to describe the social ontology of the prosthetic bodies of such researchers, which in virtue of the designs they produce and the artefacts that follow, multiply via mechanical reproduction and reach across the planet. One solider, or one terrorist may kill tens, maybe even hundreds of other human beings in their own lifetime. But weapon designers afford all soldiers, all terrorists, potentially for all time, the power to kill. Ultimately, weapon designers may kill thousands, hundreds of thousands, even millions of human beings without ever seeing, or being held responsible for the effects. Further, due to the enduring qualities of designs but also artefacts themselves, these researchers can continue to harm and kill human beings even after they themselves are 'dead'. This is what I mean when I write that this is the power to kill *anyone, anywhere*.

> After the war, I worked long and very hard, day and night, labored at the lathe until I created a model with better characteristics…I cannot bear my spiritual agony and the question that repeats itself over and over: If my automatic deprived people of life, am I, Mikhail Kalashnikov, ninety-three years of age, son of a peasant woman, a Christian and of Orthodox faith, guilty of the deaths of people, even if of enemies? (Mikhail Kalashnikov 2012)[212]

When I make this claim concerning the power to kill *anyone, anywhere*, I do not speak specifically of nuclear weapons or their designers, to which and to whom such a claim may have until now seemed almost uniquely appropriate (see below). Nor, recalling Chapter 1, nearer the opposite end of the weapon scale, do I speak specifically of military HALE drones when making this claim, as Fish and Richardson (2021) do when they write that 'drone warfare becomes the humanitarian alternative to mass death and indiscriminate bombing, but it does so only through the capacity to render anyone, anywhere, killable' (2021:13). While Fish and Richardson are basically correct, my view is that their argument represents a stunted formulation of a more profound and generalizing argument that goes

[212] https://harpers.org/archive/2014/05/automatic-for-the-people/ (https://perma.cc/BD3J-MK5K)

beyond a focus on any single weapon technology, but also beyond (behind) weapons themselves to the power that creates them. I will now clarify my claim concerning the capacity to kill *anyone, anywhere*, which here applies to all weapon designers rather than the people who use the weapons or the weapons themselves. To do so requires a brief detour to discuss nuclear weapons rather than drones.

On the artefactual level, a high death toll can be achieved by a single nuclear weapon strike in an instant, and the blast radius can cover a very large albeit not unlimited geographical region. Hence why nuclear weapons are classified as weapons of mass destruction.[213] Here, the claim still stands that to *design* a nuclear weapon is to wield the power to kill *anyone*, *anywhere*. However, this implies a view of nuclear weapon *use* that corresponds to the only way we have ever actually known it. Nuclear weapons have only been used twice in war, both times by the United States of America on the cities of Hiroshima and Nagasaki, Japan, in 1945.[214] Each time, a single warhead was deployed, and importantly, without retaliation. This was a version of *localized* nuclear war, conducted in a completely asymmetric fashion. The response of the world's bearing witness to these horrific crimes against humanity was to aggressively stockpile nuclear weapons. It is estimated that by 1985 there were up to seventy thousand warheads in existence. Today, according to the Federation of American Scientists there are thought to be more like thirteen thousand (and, unfortunately, rising).[215] Even though there are fewer individual warheads in existence now than during most of the cold war, the size of the warheads used over Hiroshima and Nagasaki pales in comparison to the warheads

[213] This is to ignore the recent development of tactical (low yield) nuclear weapons supposed to be more akin to non-nuclear bombs, at least in the reach of their effects.

[214] Although they have also been tested many times, with horrific and long-lasting effects for the people and places where these tests took place. Bikini Atoll being a prime example, where the native people were essentially used as lab animals by the US Government to test the effects of radiation on human physiology, and who still live in exile from their subsequently uninhabitable islands.

[215] https://fas.org/issues/nuclear-weapons/status-world-nuclear-forces/ (https://perma.cc/G346-X4UE)

stockpiled by major nuclear powers today. The latter's force is measured in megatons rather than kilotons as the earlier versions were, and deployment capabilities are far more advanced. In the event of a *total* nuclear war, most, potentially even all life on earth could be extinguished in a relatively short space of time. The immediate human and animal death toll of millions, possibly even billions, would rise further when soon after, broader environmental effects ensued. Multiple life forms and entire ecosystems would be destroyed, agricultural systems would fail, and the various radiation induced illnesses, burns and blast wounds afflicting surviving humans and animals would all contribute to a rising death toll. However, as the cold war drew to a close, and at the quantitative peak of the global war head inventory, Jacques Derrida considered part of the paradox of the prospect of *total* nuclear war to be that:

> Nuclear war has not taken place, it is a speculation, an invention in the sense of a fable or an invention to be invented in order to make a place for it or to prevent it from taking place (as much invention is needed for the one as for the other), and for the moment all this is only literature. Some might conclude that therefore it is not real, as it remains entirely suspended in its fabulous and literary *epoché*. But we do not believe, such is the other version or the other side of the same paradox, *in any thing except the nuclear referent*. (Derrida 1984:28)

And, in the final analysis:

> (N)uclear war — as a hypothesis, a phantasm, of total self-destruction…would be a war without a name, a nameless war, or it would no longer share even the name of war with other events of the same type, of the same family. Beyond all genealogy, a nameless war in the name of the name. That would be the End and the Revelation of the name itself, the Apocalypse of the Name. (ibid:30-31)

There is hardly anything left to say about the possibility of *total* nuclear war. It is a catastrophe beyond comprehension in which no life and thus no thought as we think it can any longer sustain itself. All that we can usefully say is that to design, make and stockpile (let alone actually use) nuclear weapons, when taken to the extreme in number and collectively amongst nations, to the point of making possible *total* nuclear war: is an

expression of the power to kill *everyone, everywhere,* destroy everything, in a very short space of time.

The thing about designs is that they make possible many artefacts. So, in an important sense, given the reproducibility of artefacts, the power to kill *everyone, everywhere*, almost certainly applies to any and all nuclear weapon designers today. The two possible outcomes discussed — *localised* nuclear war and *total* nuclear war — are confined to the artefactual and use level, and are determined finally by choices made by politicians, actions by military personnel and in extremis amongst warring states. But the nuclear weapon designers as individuals and collectively, afford warmakers *both* of these options. At the level of the nuclear weapon designer's operation, distinctions on the ground are irrelevant. *They let the tiger loose in a pre-school and walk away*.[216] There is no longer any individual nuclear weapons designer who can claim not to court the possibility of total nuclear war, even though this possibility remains, for now, a fable.

> Oh, we will all fry together when we fry
> We'll be French-fried potatoes by-and-by
> There will be no more misery
> When the world is our rotisserie
> Yes, we all fry together when we fry.
> (Tom Lehrer, *We Will All Go Together When We Go*, 1959)

So here, the *anyone, anywhere / everyone, everywhere* distinction, serves to differentiate the power weapon designers wield, either (a) in accordance with the reality of war involving anything other than nuclear weapons[217] or (b) making possible (the paradoxical

[216] Like any weapon designer, in fact.

[217] Admittedly, the development of *some* biological weapons could also entail the power to kill everyone, everywhere (e.g., highly transmissible viruses with high rates of mortality). However, at present, nuclear weapons seem to represent the very worst of what have to offer as a species. The sheer speed at which they can destroy life is unrivalled, which in comparison to biological agents, makes mitigation of their effects very difficult. So nuclear weapons perform the function in this argument of the ultimate extreme — although, unfortunately, they may not be the only type of weapon with the capability reap death on such a macro scale.

fable of) *total* nuclear war where necropower implodes upon itself and becomes species suicide.

Nevertheless, and now to perform a non-absurd reduction, I argue that whether it is localizable or total nuclear war, or war conducted via smaller arms that eventually ensues, the *species* of power wielded by all weapon designers at the core remains the same. Because even if even *one* human being might or will die because of a design for any weapon, in any context, then necropower is being exerted by the designer.[218]

Further, 'war' is too narrow a focus when dealing with weapons. Here the categories of 'soldier' and 'civilian' break down. So, in the present philosophical anthropological mode: it is not the differences between types of weapons at the artefactual level and in use that interests us, but rather what it is that makes them weapons at all (that they harm and kill) — and moreover, the nature of the necropower involved in the *design* of weapons in general.

This is all especially relevant to the present thesis because the weapon we are concerned with (the combat BCIUAV, which as we saw in Chapter 5, if armed, would likely be equipped with small arms, at least in its first versions) in artefactual form is for now, but not for long, a futural 'fable' in its own way. Therefore, we are concerned here necessarily with its *designs,* which stand in a potentializing relation to the artefacts they will eventually make possible. A design for *any* weapon, at least in its virtual part, 'is a temporally dispersed object, an object at no specific time or place, but moving through time and place, like a thunderstorm' (Gell 1998:226).[219] Metaphorically speaking, the necropower that all weapon designers and KDU researchers wield through their designs is thunderstorm-like. Every strike begins in the clouds.

[218] Including but not limited to nuclear weapons, chemical weapons, biological weapons, neuroweapons, explosive weapons and small arms.

[219] Here I repurpose Gell's words pertaining to New Ireland Malangan carvings, which are artefacts, and indeed, not weapons: but I think the idea transposes quite beautifully to describe weapon designs.

7.5.1: Transversal Necropower by Proxy

Anthropologist Eric Wolf (1990:586) defines four kinds of power:

> 1: 'power as the attribute of the person, as potency or capability'
> 2: 'the ability of an ego to impose its will on an alter, in social action, in interpersonal relations'
> 3: 'power that controls the settings in which people may show forth their potentialities and interact with others'
> 4: 'power that not only operates within settings or domains but that also organizes and orchestrates the settings themselves, and that specifies the distribution and direction of energy flows'

With relation to these four kinds of power, how does the cosmopolitan necropower of the KDU researcher and/or weapon designer to kill *anyone, anywhere* sit? Their power is certainly of the first kind, an 'attribute of the person, as potency or capability'. But as has been discussed, this is a capacity not only to conduct research and to produce technologies and artefacts; it is also a capacity to provide a technological affordance to someone else, which in turn translates into the first kind of power again, for that someone else, and thus subsequently becomes the second kind of power for them too. But the power of the weapon designer is also the third kind of power; by, if not controlling, then potentializing other actors in other settings to express certain qualities, perform certain kinds of action. This all surges into the fourth kind of power, which Wolf terms 'structural power'. The power to design weapons — although not identical to, is *integral* to the power of, say, states to deploy them — and so does potentially structure the possibilities of action in all possible violent contexts: 'shap[ing] the social field of action so as to render some kinds of behaviour possible, while making others less possible or impossible' (1990:587).[220] So, the necropower of the weapon designer as the capacity to provide technological affordance, seems to thread through all the kinds of power Wolf defines. It is a *transversal* necropower

[220] This fourth level of power is the one at which Mbembe's necropower sits as a theoretical entity, but just like Foucault's biopower, it penetrates down to the microphysical level of bodies and affects everything in-between.

which begins with an individual (albeit usually as part of a team, so individuals), and ultimately, ends, or rather terminates (with) another. Importantly, these individuals on either end of the kill-chain who are without doubt causally connected, never meet: which, further, serves to show how the first and importantly the second kind of power defined by Wolf, as wielded by the weapon designer manifest at several removes, *by proxy*.

7.5.2: A Break in the Clouds

Having diagnosed the kind of power that these researchers wield, and the kind of politics that they participate in, the possible optical function of Nourmohammadi et al's wounded soldier can be understood with increased clarity. The wounded soldier embodies a necropolitical optics, is *necro-optical*, in that it functions to shape the reader's perceptions of necropower being exercised toward the creation of '*death-worlds'* (Mbembe 2019:92), as something other or less than that. By 'necro-optical', I do not mean that the optics at work attempt to make visible death worlds, but on the contrary that they function to *distract* from and thus *dissemble* them (see below). Next, and following up on this theme, I want to attempt comparison between Nourmohammadi et al. (2018) and Meriño et al. (2017; discussed in Chapter 4), which entails an experimental re-analysis of the latter. To that aim, an initial comparison is made between Meriño et al. (2017) and one other BCIUAV paper from the same two-year period (Vishwanath et al. 2018).

7.6: Human Shields

Indian team Vishwanath et al's (2018) paper 'A Real-time Control Approach for Unmanned Aerial Vehicles using Brain-Computer Interface' was funded by the Government of India's Defence Research Development Organization (DRDO) and thus

triggers criteria A. The system itself is a motor imagery paradigm EEG-based BCI.[221] Vishwanath et al. give a short summary of the development of the BCI research field, which was 'initially confined to only medical applications' (2018:1). But it seems that medical applications are not their aim, as they make no reference with relation to their own work, of any, even potential use for disabled individuals. Rather, it is their intention to 'solve the complexities involved in the implementation of a BCI controlled fixed wing aircraft.' (2018:2) which requires 'high-speed…control' (ibid.).

Not only do they test their system with a quadcopter in a gymnasium, but they take what they learn and apply it to the control of an actual fixed-wing 'delta configuration' (2018:5) UAV: a variety not mentioned before in other BCIUAV research.[222] They do not give any further specifications of the UAV. In any case, '(t)his work can be further extended to control other kinds of UAV and complexity can be increased and customized based on the requirement.' (2018:7). In terms of other attempts to use BCI for flight control of fixed-wing UAVs, although Vishwanath et al. claim this has not previously been attempted it was done by the very first BCIUAV study Akce, Johnson and Bretl (2010). Akce et al. used motor imagery paradigm EEG-based BCI to control the flight of a fixed-wing glider located above an airfield several miles away, albeit only with two-dimensional control. Vishwanath et al. do not reference Akce et al, instead referring to LaFleur et al's (2013) ground-breaking quadcopter study.

Returning to optical dissolution, I now compare Vishwanath et al's and Meriño et al's (2017) papers. What differs, really, between Vishwanath et al's and Meriño et al's papers, in terms of the kind of research being undertaken in each case? Vishwanath et al. do no not make any beneficent claim, as Meriño et al. do in relation to their own work. Nor indeed,

[221] Vishwanath et al. believe that practicing Yoga makes for a better BCIUAV pilot, as the most successful individual of the 14 subjects involved was an experienced practitioner.

[222] This demonstrates that at least one military believes there to be merit in fixed-wing BCIUAVs.

just like Meriño et al., do Vishwanath et al. describe any kind of military use of the BCIUAV. The implications of military funding are that one can reasonably assume that Meriño et al. and Vishwanath et al., whatever else it is they do, likely contribute to the development of a neuroweapon system. Vishwanath et al., like Meriño et al., are in a position to know this, but we cannot say whether they do. Both are military funded BCIUAV research, but unlike Meriño et al's, Vishwanath et al's is not, at least on the surface of things, dual use research. Vishwanath et al. (2018) is categorizable as NWR (whether they know or intend it or not) — because in the presence of DRDO funding they do not claim any derivative purpose whatsoever, although most importantly: because there is not even a potentially beneficent derivative purpose posed.

It was remarked at the end of Chapter 4 that Meriño et al's research was perceived as 'at best' dual use research because, if Meriño et al. *hadn't* figured the ALS patient to frame a possible future of their research and technology, then, from the outside, in terms of optics, and as cynical realists we would surely be inclined to categorize their research, quite simply, as NWR (whether they know or intend it or not). Such is the force that emanates from military funding. Similarly, we *could* argue of Vishwanath et al's work that even though they don't make any beneficent claims, they could, with their system framework, still in theory be contributing to efforts to create a general controller, and thus might somewhere down the line benefit disabled patients (see Chapter 4). But this is true in so far as it is true for any BCI system whatsoever, and so it has very little force indeed, certainly when compared to strong proof of concept studies with relation to people with disabilities, or actual patient studies. Nevertheless, we have no compelling reason to make this argument because Vishwanath et al. do not suggest it. Whereas the main reason we are guided towards charity in Meriño et al's case, is that *they say it could be so.*

For legal reasons, before going on I must make clear that I am about to engage in a thought experiment. This experiment involves imagining the quite plausible scenario in which Meriño et al. are not just in a position to know about the weaponizable possibility of their BCIUAV research, but that they do know this. In that scenario, while applying for funding from the ARL they will have interpreted paragraphs such as the following from the ARL's website (let alone all the other far more detailed information at their disposal) in a way that resonates with our common-sense understanding of criteria A:

> ARL is the Army's sole fundamental research laboratory focused on cutting-edge scientific discovery, technological innovation, and transition of knowledge products that offer incredible potential to improve the Army's chances of surviving and winning any future conflicts.
>
> From human sciences to networking we are always in search of world-class talent ready to provide innovative science and technology to the warfighter.
> https://www.arl.army.mil/ (https://perma.cc/M8XU-C9UZ)

In this imagined, but highly plausible scenario, from one possible angle of interpretation, like the wounded soldier in Nourmohammadi et al's paper, the vulnerable, *mortally* (Davis 2012 – see below) wounded body of the ALS patient *may* have been deployed by Meriño et al. in the interests of framing their research, in not just a futural but a *moral* way too. And I say, 'may', because even in the imagined scenario, this is a speculative, highly subjective, partial interpretation of the way things look. A good portion of the analysis of Nourmohammadi et al's (2018) soldier concerning the affectivity of the wounded and thus vulnerable figure, with its subtle sympathetic pull silencing critiques of the offensive tendencies of the system, could potentially be applied to Meriño et al's ALS patient. However, as a radically different body,[223] the ALS patient might help reveal more about a

[223] Civilian, completely physically incapable, unlikely to be found engaging in combat of any sort. And so on. It's hard to imagine two more differently capacitated bodies than the serving soldier and the severely paralyzed patient – albeit, when the former is 'wounded', their bodies minimally converge through the vulnerability that this entails.

shared role these bodies play in the visual system, and further lead us to discover the underlying logic that connects them.

It matters crucially that there is a vulnerable body as potential beneficiary being figured in the case of Meriño et al. (2017). As I have argued, in light of the triggering of criteria A, in optical terms the function of the body of the ALS patient in Meriño et al's article is to make the research appear as something other than just NWR; and instead appear as, at best, dual use research, at least in the perceptions of the careful, critical reader.[224] Interpreted thus, in the new context of the thought experiment, it suggests an engagement in one of the most primitive acts in which humans nevertheless specialize. In order to explain myself on this matter, I turn once again to J.L Austin whose thoughts on the nature of *pretending* are invaluable:

> And first for that goddess fair and free (fairly fair, frailly free), divinest Etymology**.** *Prae-tendere* in Latin never strays far from the literal meaning of holding or stretching one thing in front of another in order to protect or conceal or disguise it: even in such a figurative use as that in Ovid's 'praetendens culpae splendida verba tuae'[225] the words are still a façade to hide the crime. In English, we do not any longer explicitly refer, in the construction used with 'pretend', to that which the pretender is hiding or dissembling, which in Latin does appear in the dative case. Nevertheless, it seems clear that it still is an important feature of pretending, in classic cases if not in all, that the pretender is concealing or suppressing something.
> In a case of pretending, then, there will typically be:
> (PB) The pretence-behaviour, the actual public performance gone through in pretending, indulged in, as of course it is, for the sake of dissembling.
> (Rd) The reality-dissembled, about which the audience is to be hoodwinked. This *may* on occasion include in part, or be wholly identical with
> (RBd) Some real-behaviour-dissembled, as for instance when I am really engaged in biting the carpet but disguise this fact by pretending to be kissing it. (Austin 1979b:259-260)

This is by no means the sum of Austin's vexations regarding different types of case of pretending. However, 'if we do not care for precision' (1979b:268) but are earnest,[226] the

[224] I recognise that the mediating influence of the journals in question might have some effect on these subtleties of phrasing. Future research may shed light on this.
[225] 'Hiding your weakness behind fine words' (Batchelor 2012:13)
[226] Which as anthropologists dealing with philosophers, is often the case (cf. Rees 2018) (cf. Zeitlyn and Just 2014).

simplicity of this initial account concerning the centrality of dissemblance to any case of pretending, provides the insight needed to make a quick and dirty diagnosis (EASA future anthropologies network 2017:2). Austin wrote this piece with a Mr Errol Bedford's position in mind, and unlike the latter, takes it to be the case that one can *actually do* the thing one is only pretending to do, in the process of *hiding* something else. Perhaps most relevant is the example Austin gives of the man cleaning the windows. He takes his soapy cloth to the pane but is in fact only pretending to be cleaning the windows, whilst dissembling the reality of the act that he is *really* engaged in: casing the joint. His 'heart' is not in it (1979b:262) but he *is actually* cleaning them — at least as far as we can see from over here, and thus to the degree necessary to support the deception.

In Chapter 4, the carelessness of the figuring of the (CLIS) ALS patient's body by Meriño et al. in terms of its place in the wider context of BCI research, was revealed. This was done via the analytical review wherein the body figured via ekphrasis was extracted, magnified and juxtaposed with the actual, individual BCI system they present, as well as with the example of Khan and Hong (2017) who were more *careful* about what they wrote. However, following the comparison with Khan and Hong (2017), in a quite different sense, it could be argued that Merino et al *have* demonstrated an awareness of the complex role responsibility attributed to BCI researchers, by figuring this body. In the present sense, it wasn't careless at all.[227] It *appears* as though it was quite *carefully placed* as part of the organization of the(ir) BCIUAV as a visual system. However, they have done it in a way that could easily be interpreted as exploiting the very idea of that responsibility. According to the most cynical interpretation possible, then, the body of the ALS patient figured by Meriño et al. is an instance of pretending to be being beneficent by figuring a

[227] For clarification's sake, I am saying that the figuring of the body of the ALS patient could be perceived as being careless in one sense (i.e., following the analysis conducted in Chapter 4 concerning translational gaps) but simultaneously careful in another (the sense being discussed in this chapter i.e., carefully placed).

vulnerable body, in order to hide the reality of their conducting (public) NWR. In this way, the ALS patient is also a necro-optical device. Although, in further accordance with Austin's account of pretending, and as discussed in Chapter 4: with relation to the system framework and the general controller, Meriño et al. are in *some* conceivable way, *actually* doing work that could benefit ALS patients (of some description). Vague and weak as this claim is, Merino et al. do provide a minimally felicitous utterance in terms of the idle brain state detection feature for BCI for control, and its potential future utility for ALS patients, in the reconfigurative imaginary of the general controller. And so, to a degree, they do *actually* clean the windows. What I mean is that to the absolute minimal degree — which is the minimal degree seen in *any BCI study whatsoever* — Meriño et al. do work that could benefit ALS patients *somewhere* down the line. There is something of a resonance between the previous statement, taken in concert with the imaginary image of the ALS patient in Meriño et al's article, and the notion touched upon by E.H. Gombrich (1978:8) of the 'minimum image'. The latter is an image which although rudimentary and lacking in detail in terms of resemblance to the thing it becomes a *substitute* for, nevertheless in its capacity as substitute functions as a key that 'fit(s) into a psychological lock' (ibid.).

Moving back into the orbit of Austin's account of pretending, an only quasi-metaphor that emerges in terms of an apparently shared optical role being played by Meriño et al's and Nourmohammadi et al's figured bodies, is that of *human shields.* The use of non-combatant human bodies as shields from attack by and from parties to armed conflict is covered in the list of war crimes defined by the Rome Statute of the International Criminal Court (ICC Statute 1998, Article 8 (2) (b)(xxiii).[228] However, here, in a different but certainly related way, by the use of 'human shields', I mean the deployment of the figure of an imaginary vulnerable and/or wounded body (combatant or non-combatant) in order

[228] https://www.icc-cpi.int/sites/default/files/RS-Eng.pdf (https://perma.cc/6LRV-LB86)

to dissemble a potentially *wounding reality*. The underpinning logic of the figured bodies in both Nourmohammadi et al. (2018) and Meriño et al. (2017), involves the evocation of one wound to dissemble another.

> Mortal—death from within, the vulnerabilities of the flesh
> Fatal—death from without—accident, blow, etc.,
> Deadly—likely to cause death, but not necessarily designed to do so (as in the way a wrench or hammer can be a deadly weapon)
> Lethal—certain to cause death, though death may not always result (a gun is an obvious example of a lethal weapon). (Davis 2012:509)

Using Davis' terminology: the ALS patient, *mortally* wounded by disease from within, and the soldier wounded *fatally* from without, could both be seen to dissemble the *deadly* and/or *lethal* wounds that the application of the technology in question will be used to inflict on *non-user* others in futures. It is the underlying logic that unites them in their functioning as subtle optical devices, in their radical difference as kinds of bodies with very different capacities. The use of human shields is only a quasi-metaphor because it refers to an optical phenomenon involving figured vulnerable and/or wounded human bodies, functioning as a protective lens or camouflage, within a necro-optics specific to the BCIUAV as a visual system, found at work in both Meriño et al. (2017) and Nourmohammadi et al. (2018).[229] Recalling Dr Huggins's remarks quoted in Chapter 6, we now see more clearly the possibility that they are not really (or, at best, not only) interested in *putting people together*. They are (also) interested in *taking them apart*.[230] With relation to both the cases discussed, appearances can be deceiving. In this respect, two questions remain open: Do my perceptions deceive me? Or, as the speculative hypotheses advanced appear to suggest, are we readers being manipulated, maybe even

[229] And potentially others, who I will not discuss here.
[230] Admittedly after putting the body of the future soldier together with their neuroprosthetic weapons system.

deceived? Whether what I have pointed to bears any resemblance to reality or not, it would seem that body work of this nature is not unique to the BCIUAV. There is an uncanny resemblance to be found in remarks made by neuroscientist Curtis Bell, in an essay introducing the rationale behind 'The Neuroscientist Pledge', in which he asks neuroscientists to agree not to engage in research that is likely to be used in aggressive war and/or torture.[231] In the following quote, Bell manages to sum up in a few words what has just been speculatively outlined with relation to the BCIUAV:

> Almost every application of neuroscience can be used for benign peaceful uses as well as for military purposes. As pointed out by Nagel, the potential for beneficial uses is often used as a means to silence those who raise fears of misuse (Nagel 2010). Such critics pose the question, "Surely you are not against helping quadriplegics with BMI devices or finding earthquake victims with robots?" (Bell 2014:235)

Bell refers to the presence of the dual use problem in neuroscience, and to the manner in which those who want their technical exertions of necropower to be viewed more favourably use as *cynical* moral bargaining chips, the figured and actual bodies of vulnerable others. By subjecting these bodies to optical dissolution, taking account of the futures they gesture towards, or indeed, dissemble, and the ways this is done, we may better understand the moral landscape of this situation. Seemingly, it is populated, here and there, by 'empathic predators' (Davis 2012:509) and centred around what might in some (or even now *all*) cases be called, if we are feeling brave, 'experiments of concern' (National Research Council of the National Academies 2004:5).

[231] It seems impossible for (neuro)scientists to do what Bell asks and this is why it isn't good enough. Following from Forge's Unknowability Thesis, there can be no guarantees about the nature of the war that a weapon is used in because weapons and designs extend beyond the specific conflict, and beyond any particular agent's use of them.

7.7: First Assault

Now consider what brazen looks like. Sawarkar et al. (2016) perform unabashed necropower in scholarly form in a non-peer reviewed article found on the same site (arXiv.org) as Vishwanath et al. (2018), and also funded by the DRDO: not involving BCI but combining small UAV and unmanned ground vehicle (UGV) technology:[232]

> Tele-operation capabilities, or the ability for an operator to manipulate and control a robot remotely from a safe location through radio link offers the possibility of controlling the robot in hostile environment with no human casualties. These capabilities reduce or remove operator's risk in highly stressful and dangerous environments. The human operator based on a wireless location, away from the danger, receives the data wirelessly from the robot in real-time. This data is processed and presented upfront such that it does not overload the operator. This project proposes a robotic solution for handling terrorist situation in conjunction with human assistance. The machine can be used for *first assault* in hostile environment. (Sawarkar et al. 2016:1 emphasis added)

No pretence, no reality dissembled

No defence, no pre-existing wound

No vulnerable bodies figured out in front or dragged behind:

First assault

[232] Notably, they include an artificially intelligent combatant recognition feature. This kind of work might challenge, to some degree anyway, the idea put forward earlier that weapons designers don't decide *who* dies. In any case, they still decide *that someone will*.



Fig. 2: Dix, Otto (1891-1969). Wounded Man (Autumn 1916, Bapaume) – [Verwundeter (Herbst 1916, Bapaume)], from 'The War' (Der Kreig), 1924. Etching and aquatint from a portfolio of fifty etching, aquatint and drypoints, plate 7 3/4 x 11 7/16' (19.7 x 29 cm); sheet: 12 3/4 x 18 11/16' (35 x 47.4 cm). Publisher: Karl Nierendorf, Berlin. Printer: Otto Felsing, Berlin. Edition: 70. Gift of Abby Aldrich Rockefeller. Acc. No.: 159.1934.6. Artwork location: Museum of Modern Art (MoMA), New York, USA. Credit: Digital image, The Museum of Modern Art (MoMA), New York/ Scala, Florence. 2022 © Photo Scala, Florence.

7.8: Conclusion

This chapter has speculatively examined two special cases in which the optics of BCIUAV research appear to be working in more-than-futural ways, where, on my interpretation, moral persuasion can be detected in the images of bodes of future users conjured by authors. In this critical politics of *in*substantiation, the body of the wounded solider in Nourmohammadi et al. (2018) could be seen as an optical device that through its wounded vulnerability, functions to make the reader sympathise with its plight, and thus support the

use of the BCIUAV in future wars. This in turn is a device that tries to make us perceive the research article in which it appears as something other or less than a contribution to designs for a neuroweapons system that can be used in any number of belligerent situations, including, it should be recognised, the killing of innocents. A philosophical anthropological account of the kind of power that KDU and weapon researchers wield has been offered, amounting to a transversal cosmopolitan necropower to kill *anyone, anywhere* (and in special cases, *everyone, everywhere*). Subsequently, Nourmohammadi et al's wounded soldier was diagnosed as a necro-optical device functioning to make the reader perceive the future combat use of the technology, and the research which gives rise to it, as something other and/or less than the creation of death-worlds. The experimental re-analysis of Meriño et al's ALS patient, first encountered in Chapter 4, revealed the common characteristic of vulnerability shared with Nourmohammadi et al's wounded soldier. Given Meriño et al's military funding source, their evocation of the ALS patient makes their research, at best, dual use, rather than simply NWR. In this way, and in the plausible scenario of my thought experiment in which they share our understanding of criteria A: Meriño et al's ALS patient is also necro-optical. Common to both necro-optical devices, in Nourmohammadi et al. (2018) and Meriño et al. (2017) is their role as (visually rhetorical) human shields, which I have defined here as the deployment of an imaginary vulnerable and/or wounded body (combatant or non-combatant) to dissemble a wounding reality. This led me to speculate that there was an underlying logic uniting these two radically different bodies playing the role of human shields. One wound (mortal or fatal) suffered by the body of the future BCI user, appeared to distract from and thus dissemble the wounding reality that it is *non-user* others who will suffer the deadly and/or lethal affects of the BCIUAV in its warring guise. And so, a double dissemblance is revealed. The fact is that this technology in a combative context is meant just as much for first

assault as it is for defence. Certainly, if the BCIUAV is armed, any defensive capability supervenes on the offensive capability. Attempts to separate these capabilities can only ever be rhetorical.

In all this we have learned something of the possibility that scientists who *know* that their research and the technology they develop is dual use or *maybe* even that it is really just WR, *might* try to dissemble their knowledge concerning either the nature and extent (Nourmohammadi et al. 2018), or simply the fact of its lethal tendencies (Meriño et al. 2017). If so, they do this while moving through public space, by which I mean peer-reviewed journals, but more importantly, the world we all share. '(S)cientists publish papers', as Forge (2008:18) reminds us, citing Latour and Woolgar's *Laboratory Life* (1979). And so, it would be a mistake to write off such delicate matters as discussed here as mere irrelevances, if papers, as much as substantive outcomes and in many cases patents, are the things through which they aim to produce and define themselves *as* scientists.[233] This chapter has produced a speculative anthropological *insight* (see Leach 1982:52) concerning a real, ongoing case study of dual use research and technology. However, it seems that what has been hypothesised via attention to these specific cases may be part of a wider social phenomenon, whose claim for inclusion within a general theoretical, but more *anthropological* account of dual use in future, is bolstered initially by Bell's remarks above.[234] I will discuss the optical dissolution conducted in this chapter further in Chapter 9 through the lens of Susan Buck-Morss's (1992) work.

[233] Whether 'pure' or 'applied' scientists, in fact.
[234] 'The translation of event into generality is the hallmark of science' (Firth 1958:13).

8: Human Conservation: A Moral Vision

> Everyone has the right to life, liberty and security of person.
> (Universal Declaration of Human Rights 1948/2021)

8.1: Introduction

How should anthropologists respond to practices that threaten human life and thus the human right to life? What, if any, is our duty to not just the people we study directly, but humanity at large? Here I provide necessarily partial answers to these questions. The first part of this chapter involves a critique of Nicolas Langlitz's (2020a) polemic proposal for an 'amoral' anthropology. A common feature of academic polemic is that the reader grasps implicitly that the polemicist is taking a strong position that they are 'not fully committed to' in the manner they rhetorically suggest (Langlitz 2020b:1033). What follows is conducted in the spirit of polemic responsivity, but with the caveat that I do mean what I say. The reader should imagine, however, that this discussion concerns not insipid, mundane 'moral breakdowns' (Zigon 2007, cf. Taylor-Green 2020), interesting as these are: but rather those of the order in which there is real and unnecessary human suffering at stake, at its extremes involving 'malevolent destructiveness' (Csordas 2019:35) and/or neglect, 'careless turning away' (ibid:41) by others. The issues that I am most concerned with are those presenting a threat to human life, and thus the human right to life. First, I explain why I take Langlitz's perspective to be an ethological rather than anthropological one. Against his position, I argue that anthropology is humane when it retains the possibility of critique and intervention on moral grounds, and potentially inhumane when it does not. Langlitz's amoral anthropology, when faced with threats to human life, risks becoming an *immoral* anthropology. The moral vision of *human conservation* is introduced as an alternative to Langlitz's amoral anthropology. Second, contrary to

dispassionate views such as Langlitz's: inspired by Ted Stolze's (2019) writings on Spinoza's political philosophy, I argue that there is wisdom in compassionate activity propelled by indignation, and that anthropology can benefit from an embrace of the passions rather than repressing them in the name of science. Drawing on the work of Phillip Fisher (2002), I recognise that in my own work a fear for others leads to pity for those others, and subsequently anger emerges in the form of indignation directed towards those engaged in KDU research or WR — the latter being prime examples of human practices that threaten human life.

The second part of the chapter explores how this indignation — a potentially harmful passion — can be positively redirected towards compassionate activity through and by *love* (as *agape*) whose role in a cosmopolitan anthropology is discussed by Nigel Rapport (2019a). Rapport's thoughts on how reminders of death provoke a potent 'loving recognition' of Anyone, facilitate reflections on an artwork by Otto Dix (1891-1969). It is then argued that the spectrum of conditions within which human life can be sustained is incompatible with the cosmopolitan tyranny of weapon designers, whose activities constitute cardinal examples of *bad manners*, as opposed to the 'good manners' (Rapport 2012:195) of a cosmopolitan politesse that aims to ensure the 'safe passage' (2019a:6) of Anyone. With love, the moral vision of human conservation is set out as a loving but critical look — ultimately concerned with identifying practices that threaten Anyone's right to life, and subsequently finding ways to intervene in the hope of protecting that right. In the interest of epistemological sobriety, following Dorothy Emmet's (1994) work on Kant's concepts of Regulative Ideals and Regulative Principles, I explore how the moral vision of human conservation is an example of the former, while the conservational imperative that follows from it is an example of the latter. Finally, the human conservation work that remains to be done with relation to my own research is outlined.

8.2: Anthropology is not Ethology

The first angle of my critique concerns what I take to be the ethological, rather than anthropological nature of Langlitz's amoral anthropology. Throughout, it must be remembered that I have constructed this critique with practices that threaten human life in mind, which at no point does Langlitz explicitly address. In this way, I push his proposal for an amoral anthropology to extremes — the kind that most anthropologists will never encounter, and thus my critique may seem somewhat fringe. I acknowledge that Langlitz's proposal — which in fact, represents huge swathes of existing and traditional anthropology — may be perfectly acceptable in the majority of cases. However, just because I think with rare and extreme cases, my argument should not be considered eccentric. Rather, it should be considered an argument about a fundamental moral value judgement in the practice of anthropology broadly — a judgement representing *the lowest bar* of moral rectitude, which Langlitz's amoral anthropology does not recognise. This thesis flows toward a consideration of the right to life because it concerns dual use research which leads to weapons innovation. It is from the encounter with the subject of dual use research that the general argument here has been developed. However, a crucial qualification concerning the most general level of the argument must be made before continuing, in order to avoid being dragged unnecessarily into debates around abortion. By human life, I mean strictly *individuated* human life.[235]

I begin with this revealing quote from Langlitz, appearing at the end of his proposal for an amoral anthropology where he summarizes his argument — which he means to apply to anthropology in general — by means of analogy with a specific example:

[235] Further, euthanasia or assisted suicide (by someone suffering from a terminal illness making a choice to die with medical assistance) is not what I mean when I speak of practices posing a threat to human life. Euthanasia along with any other kind of self-chosen relinquishing of one's own life, is not the target of my argument precisely because it is an individual's choice to die — and not the imposition of the will of another. Nor is what I am arguing anything to do with the creation of life.

> Based on my own ethnography of chimpanzee ethnographers I can say this: As conservationists, primatologists certainly take action in the human world to protect their research subjects against poaching or deforestation, but it does not occur to them to chastise chimpanzee males for systematically killing members of neighbouring groups, beating females into submission, or playing an orphaned mangabey baby to death, even though it is thought the animals are not just following a genetic program. Nor would it ever occur to primatologists to take sides in a conflict, even if an inferior individual turned to them to solicit support (see Langlitz 2020:116; Strum 1987:37). From the primates' point of view, primatologists must appear like flaneurs who look at their existential struggles in a holiday mood. Perhaps cultural anthropologists would come to understand human life more accurately if they renounced critique and activist research**,** adopted a contemplative attitude, and attended to Homo sapiens' not always pretty behaviour from a nonjudgmental angle instead. (2020a:1000)

Ethology is 'the scientific zoological study of the evolution of the behaviour of wild animals in their natural environment' (Leach 1976:177). There is, of course, a field of contemporary scientific inquiry, linked to anthropology but perhaps more so now to the biological and evolutionary branch, called 'human ethology'. Writing as a philosophically inclined social anthropologist in the British tradition, while it isn't anthropology as I understand it, human ethology is clearly a legitimate field of study. In what follows I will use the terms 'ethology', 'ethologist' and 'ethological', and will not be prefixing them with 'human'. A combination of my own anthropological outlook, the moral position to which I subscribe, and deep reflections on the subject addressed in this thesis — which concerns extreme human behaviour with serious moral implications — create the conditions under which for an 'anthropologist' to be described as an 'ethologist' becomes something of a slur. One of the defining features of ethology, even when its methods are carried over into the study of human behaviour is 'structured non-interfering observation' (Havlicek and Blazek 2012:4). This should be kept in mind as we begin to approach Langlitz's proposal for an amoral anthropology, first via relevant anthropological sources.

The now famous debate around moral(izing) anthropology as found in the opposingly positioned papers by Roy D'Andrade (1995) and Nancy Scheper-Hughes (1995) revolved precisely around the question of whether structured non-interfering observation was or was

not the limit of professionalized academic anthropological endeavour. D'Andrade, a self-proclaimed man of science, squirmed at the prospect of critique of, and positively writhed at the possibility of intervention in the social worlds anthropologists come to study. His position was a culturally and, importantly, morally relativistic one, extolling the virtues of disinterested observation of human affairs. It is unscientific to criticise or intervene, thus it is considered unprofessional, improper, *bad*, even, for anthropologists to be swept up by for instance, indignation, which is an artefact of subjectivism. The professional anthropologist should never give in to the pull of moral outrage, and ought to leave the humans they study to be whatever they are and do whatever it is they do or undergo. Preferably, one simply describes, understands and explains (Fassin 2008, Stoczkowski 2008). Langlitz also appears sympathetic with this view, and with his amoral anthropology presents, in my opinion, what amounts to a morally relativist position.

Scheper-Hughes, on the contrary, advocated for a 'barefoot anthropology' (1995:419), moralizing and capable of intervention on the basis that we are all human beings thrown into a world that can be less than kind, and sometimes we need a helping hand. Anthropologists, on this view, are specially positioned in social situations as 'witnesses' (ibid.), in that they obtain a perspective which might facilitate the identification and analysis of problems, with a view to helping better human lives: precisely the sort of approach that Langlitz's amoral anthropology exists in opposition to.[236] Stoczkowski (2008:351) identifies the inclination towards a political and activist anthropology with social transformation in mind, as the 'fourth aim' of anthropology', beyond describing, understanding, and explaining. In the context of the present work I want to draw attention to the resonance between the position advocating for non-interfering observation, and the

[236] This seems a simple idea, but for many anthropologists it is terribly complex. Due to vexatious relativist worries, my general argument cannot, at this time, be extended wholesale to the prevention of *harm*. The preservation of human life is the form of betterment with which I am primarily concerned here.

concept that permeates Langlitz's proposal for an amoral anthropology, that of 'second-order observation' (2020a:997) taken from German sociologist and philosopher Niklas Luhmann:

> While first-order observers ask *what* is and maybe what should be the case, second-order observers want to know *how* these determinations are made. They recognize the contingency and the blind spots that both enable and delimit competing points of view. Yet their position is not privileged: it does not provide a view from nowhere and from everywhere, but comes with its own blind spots. (Langlitz ibid)[237]

Langlitz takes second-order observation to be a way to 'step-back' (2020:998) in order to scan all possible alternative perspectives on a given issue, avoiding taking any one side. Nevertheless, adopting this approach, Langlitz reports that Luhmann denied that humans had any real effect on the natural environment (in the face of mounting empirical evidence to the contrary) and denied that scientific research could be judged to be 'good' or 'bad, only true or false.[238] On Langlitz's account Luhmann was a dedicated contrarian and Langlitz models himself in his image.

As seen in the quote at the beginning of this section, in deploying a specific example to serve as an analogy for his vision of an amoral anthropology generally, Langlitz refers to a special population of ethologists he has studied as an ethnographer: *primatologists*, who study non-human primates. Primatologists, Langlitz says, *will* act against humans (e.g., poachers) who threaten their non-human primate subjects' existence, because primatologists perceive themselves to have a *conservationist* duty towards those subjects — a moral duty, it must be said. But in the ethological frame of mind, when they observe primates engaging in lethal and harmful behaviour, they *won't* 'chastise' (2020a:1000) the animals they study for their failure to behave morally towards one another, *won't* pass

[237] In my view, none of this is incompatible with a *moralizing* anthropology.

[238] To say that 'research' itself is either 'good' or 'bad' is very difficult in most cases, but the outcomes or likely outcomes of scientific research are much easier to judge in this way, given context. Much scientific research done by the Nazis *was* very easy to judge as 'bad' in itself. Strange, perhaps, that Luhmann managed to sustain such attitudes concerning morality given that during the 1950s his day job was 'to process restitution payments to victims of the Nazi regime' (Langlitz 2020a:997).

judgement in a truly moral sense, and certainly *won't* intervene in their goings on. Presumably, they will not pass judgement because ultimately (even if they show what look like incipient tendencies towards what humans recognise as 'moral' behaviours, and 'even though it is thought the animals are not just following a genetic program' (ibid)), they are not capable of being moral agents: at least not in the same way that a human being could be said to be or have the capacity to be a moral agent.[239] So, it would seem that — not unreasonably — primatologists as ethologists assume that it is pointless to try to reason with their subjects and present them with opportunities to act in less or non-lethal ways. Likewise, it is not their business to help their subjects when the latter's lives are threatened by others of their own kind, whether they solicit support or not. We have here, then, the two sides of the primatologist's attitudinal coin: the *conservationist* and the *ethologist.*

However, looking at the quote above it seems Langlitz is being rather selective. He appears to only draw upon the ethological side of the coin, this being the side that he finally rests his argument by analogy concerning exclusive adherence to non-interfering observation in an amoral anthropology on. And yet, I think that if he had decided to integrate rather than ignore the conservationist side of the coin, he might have recognised that his analogy — which he means to apply to anthropology proper, and in general — is fatally flawed in its selectivity. Specifically, in the context of my critique, where amoral anthropology is tested to its limits by witnessing instances of human activity that threaten the lives of other humans.

I think that when viewed in this light, in its selectivity concerning the ethological side of the primatologist's coin, Langlitz's analogy imports several hidden assumptions into his model of an amoral anthropology. These hidden assumptions, risk seeping into the

[239] Neither are they even really first-order, let alone second-order observers, which is perhaps one way of describing why they are not capable of being moral agents.

methodological infrastructure of amoral anthropology, and thus into the amoral anthropologist's engagement with other humans, (metaphorically but perhaps even epistemologically) transforming the anthropologist into a different kind of scholar, and the humans they study into different kinds of creatures. However, I must emphasise that what I am about to write concerns the dangers of hidden, unnoticed assumptions and certainly not any anthropologist (Langlitz or otherwise) actually, consciously holding these assumptions.

In the social anthropological case there are usually no non-human primates involved: only humans. And this is where the problems begin with Langlitz's selective analogy. Most human subjects are capable of being moral agents, just as they all are vulnerable to the cruelty of others. Leaving aside debates on the status and rights of non-human animals for now — humans are certainly all deserving of efforts to protect their life: something profoundly recognized in the Universal Declaration of Human Rights (1948/2021). However, in selecting only the ethological side of the primatologist's coin for its foundations, when tested to its limits by the kinds of extreme cases I am concerned with, Langlitz's amoral anthropology was built to deal with the beings that ethologists study, and who cannot be said to share the same crucial qualities, nor be afforded the same rights and responsibilities as human beings. I think the very same assumptions are imported into Langlitz's amoral anthropology, hidden though they are, when it comes to witnessing practices that pose a threat to human life. With threats to human life in mind, I argue that by importing those assumptions, the amoral anthropology proposed by Langlitz may entail denying the humans under study their own humanity. By this, I mean both the element of humanity located in their capacity (via a combination of first and second-order observations, it should be said) to consider whether or not it is right to kill others in their capacity as (im)moral agents *and* that located in their liability to die as victims (Rapport

2010b - see below). But it also risks anthropologists themselves losing an element of their own humanity, because by abstaining from critique or intervention, they would not have treated those others, whether perpetrator or victim, in a human or *humane* way. If we witnessed practices by some that led to the killing of others and did not at the very least attempt to reason with the former in the interest of providing them an opportunity to reconsider their ways — and failing that — did not call them out, criticize, chastise, and even attempt to stigmatize their actions (Rappert 2013), then we would be ethological voyeurs rather than fully co-humans; and would risk acting as though the lives of those under threat were not equal in value to our own. Talking with our subjects and understanding why they do what they do is clearly a crucial component in all this, but it is still *only part* of what I argue is required (see below). In this respect, the oft assumed separation between 'academic' and 'applied' anthropologies must break down.

In the encounter with practices that threaten human life, Langlitz's amoral anthropologist becomes an ethologist. Therefore, I argue — metaphorically, but also methodologically, and perhaps therefore, epistemologically — amoral anthropology turns its human subjects into *mere animals*, whether playing the role of victim or aggressor. Who, in the latter case, cannot be expected to respond to reason and act in less or non-lethal ways, and in the former, are somehow not deserving of our responsivity to protect their life. With relation to concern for the latter but also therefore in relation to engaging with the former; when substituting the term '(amoral) anthropology' for 'philosophy', the following words from Rousseau's *Discourse on the Origin and Basis of Inequality Amongst Men* ring true here:

> it is reason that makes man shrink into himself; it is reason that makes him keep aloof from everything that can trouble or afflict him; it is philosophy that destroys his connections with other men; it is in consequence of her dictates that he mutters to himself at the sight of another in distress, You may perish for aught I care, I am safe. (2002:107)

If we are to remain anthropologists and not become ethologists, we must believe in and preserve the humanity of our subjects. This means retaining the possibility of critique and intervention, especially where this concerns practices that threaten the life and thus the human right to life of others. The assumptions of ethology as applied to non-human primates and other animals cannot be carried over to anthropology in the face of such threats. Indeed, in the face of human threats to human life, an amoral anthropology that rules out critique and intervention in the human worlds we study, as ethology would with animals in animal worlds: risks becoming an *immoral* anthropology through a form of methodologically instituted negligence. That is, if any given anthropologist can, in principle, agree that killing other humans is 'wrong', which I don't think is too lofty an expectation.

Primatologists might not directly intervene in the worlds of their non-human subjects, but as Langlitz observes, as conservationists they clearly do intervene to protect them from human actors who threaten them. In this latter sense, they do, albeit indirectly, intervene in the worlds of their non-human primate subjects by directly intervening in human affairs. To my mind, this elevates the primatologist above the ethologist, and frankly, above Langlitz's amoral anthropologist. Why, then, if primatologists as conservationists can intervene in human worlds to protect animals, should not anthropologists intervene in human worlds to protect humans, whether that means critiquing and/or taking action against and/or giving a helping hand?

Rather than perceiving critique and intervention as transgressing the professional bounds of our discipline, the moral vision of *human conservation* I outline towards the end of the chapter perceives it as part of our professional duty to respond in these ways, in an attempt to preserve the life of Anyone. We ought to offer our services where they might apply (sometimes solicited, others unsolicited): whether the threat be actual or potential,

occurring in the present or nascently simmering in the present with relation to futures. The latter is most relevant to my own research and will be discussed in due course. Of course, even *seeing* into those spaces more clearly is a good thing, and in many instances can even count as intervention. But I am also calling for something more if it is within the realm of the possible.

8.3: The Indignant Sage

The editorial note to the issue of *HAU* containing the special section in which Langlitz's article appears, claims with relation to Langlitz's amoral anthropologist that 'such a role should not be seen as a form of disengagement from the world, but rather of a different form of engagement' (Kipnis et al. 2020:711). While on the one hand I understand what they mean, on the other hand I'm afraid this description mischaracterises the essence of Langlitz's position, captured again by his remarks on flânerie and the 'holiday mood', a term drawn from Robert Musil's novel *Man Without Qualities* (1930-1943). In a holiday mood, one assumes a 'mystical quality' (Langlitz 2020a:1000) allowing the vexatious world to wash over without letting it perturb a detached, care free, composure. Where Langlitz uses the term 'holiday mood' to capture the spirit of second-order observation, and in turn, to conceive of 'anthropological fieldwork as a spiritual exercise' (ibid), I am reminded of the notion of *ataraxia* familiar to Hellenistic philosophies, describing a state of unperturbedness. The Stoic conception of a 'reasonable man' (Rabinow 2008:97) who is ultimately a sage, was of one who could train themselves to become immune to their own emotional and psychological states, and also develop an 'immunity to situations', but which 'if it becomes the core of a way of life…seem(s) shrunken in its vehemence and perhaps even its care' (ibid). As we have already seen, and as I will go on to discuss from

another angle, in Langlitz's amoral anthropology this immunity clearly extends to the states and situations of *other* people.[240] I wish to present an alternative perspective on what it is to be sagacious in the face of moral quandaries as a concerned and moral(izing) anthropologist — rather than an unperturbed, amoral 'anthropologist'.

Indignation has received bad press in 'moral' anthropological discourse. According to the Cambridge dictionary, indignation is 'anger about a situation that you think is wrong or not fair'.[241] Didier Fassin explicitly warns against indignation, something that 'younger researchers or students' (2008:338) are especially prone to and which risks confusing 'anthropological interpretation and moral evaluation'(ibid). Likewise, Wiktor Stoczkowski is 'unhappy when [he] sees anthropologists shirking their duty to describe and to explain, preferring vain rhetorical exercises satisfying a moral indignation infatuated with its own uprightness' (2008:351). Langlitz also speaks of indignation with a negative valence when he writes of his annoyance — or is it indignation?— that 'American cultural anthropology firmly sides with progressives, partaking in and fuelling a sense of indignation about the immorality of conservatives and reactionaries' (2020a:990). It would seem that indignation has been marked out by these men (and they are all male) as one of the cardinal sins for the anthropologist. Strange that in their fervour, these anthropologists appear to be indignantly making normative judgements, chastising their colleagues, moralizing about their profession, its professionals, and by implication, beyond. It looks like from their perspective, anthropology's new 'Savage slot' (Troulliot 2021:54) is filled by well-meaning anthropologists who in their own indignation dare to critique inhuman practices and move toward fulfilling the fourth aim of anthropology involving social transformation.

[240] Nevertheless, I do appreciate something of the spirituality, as it were, of Langlitz's position as far as second-order observationalism goes. Cultivating a certain level of detachment, learning when to deploy it strategically and for how long to maintain it is worthwhile: here with specific relation to the moral *indignation* which certain issues may provoke in the anthropologist (see below).
[241] https://dictionary.cambridge.org/dictionary/english/indignation (https://perma.cc/MVJ7-AVDW)

It so happens that the key to reimagining anthropological sagaciousness is the same passionate state which inspires the amoralist's critique of the moralist. Philosopher Ted Stolze writes of the role of indignation in Spinoza's political philosophy. The structure of indignation is found in a tripartite relation in which a bystander *hates* an oppressor who *harms* a victim. The bystander feels indignant and hates the oppressor because he affectively identifies with and recognizes himself in the victim. If the victim happens to be someone the bystander loves in a personal capacity this hatred for the oppressor is of a greater intensity. Problematically, because it involves anger (here as hatred), indignation is a destructive, sad passion which is harmful to the indignant one. But whether indignation remains a form of affective self-harm or not depends upon how we manage our passions according to reason. Stole identifies in Spinoza's thought three kinds of 'affective transition' (Stolze 2019:117) which are in themselves varieties of knowledge, and which follow from the advice to 'pay attention to what good there is in each thing, so that in this way we are always determined to act from an affect of joy' (Spinoza quoted in Stolze 2019:132). With indignation in the forefront of our minds, the three affective transitions Stolze identifies, in this sequence, are:

1: 'transition from instrumentally bad to instrumentally good passions' (2019:117)
2: 'redirect bad affects' (2019:131)
3: 'the philosophical cultivation and expansion of 'wise persons'(sapientes)' (2019:134)

Here, a very different image of the sage emerges. '(T)he sage… doesn't allow himself to be carried along by the flow of events, as if the latter constituted a blind fatality' (Macherey quoted in Stolze 2019:135), and as Langlitz's sage trains himself to do in the holiday mood. Rather, having made the first two affective transitions, in his cultivation of wisdom he turns the sad affect of indignation into a 'rebellious serenity' (Stolze ibid.). In

direct opposition to Langlitz's figuring of a wise anthropologist, we arrive at the realization that 'serenity has nothing to do with mysticism, contemplation or isolation but instead implies a continued active engagement in the passionate life of human beings' (Stolze 2019:136-137). It is in a commitment to *compassionate activity* that the greatest wisdom and even serenity lie. The politics of the bystander, then, who as an anthropologist is skilled in second-order observation, involve engagement in activity related to that higher, third order of knowledge, no longer simply observing but compassionately intervening in the world. In turn, this knowledge of the third kind involving compassionate activity seems to correspond with the 'fourth aim of anthropology' (Stoczkowski 2008).

Despite Langlitz's complaints, most specifically about the bleeding-heart of American anthropology — which does seem to be more morally strident than its British counterpart — I cannot imagine that any serious thinker in Great Britain or the United States would suggest that the *only* aim of anthropology is the fourth aim: for if nothing else without the first, second, and third, the fourth has no ground upon which to build, as Stoczkowski (2008) understands. It would be churlish not to agree with D'Andrade to the extent that 'one can be an anthropologist simply because one is interested in human life and still be a good person' (1995:402). But beyond this, we needn't support the concerted and regressive de-passioning of anthropology at all costs, ultimately in the name of 'science'. There must remain the possibility of 'blended models' (1995:405) which combine the (supposedly) objective and the subjective moral inclinations of the researcher, as long as a sufficient degree of reflexivity is applied, and along with the checks and balances provided by academic collegiality.

I wrote earlier that Langlitz's amoral anthropology, with its aspiration to the holiday mood, appears to be undergirded by *ataraxia*, that concept found somewhere in all Hellenistic philosophies, denoting a state of unperturbedness. This makes more sense when

we recognise, as Rabinow does when drawing upon Phillip Fischer's magisterial book *The Vehement Passions* (2002) (see below) that it was the last of the Hellenistic philosophies, Stoicism, to which *ataraxia* was crucial, that launched the most significant 'assault on the passions' (Fisher 2002:146). My contention is that indignation needn't be an unruly, thoughtless passion that harms the inquirer and irretrievably compromises inquiry. Along with other passions it has the potential to play a vital role in anthropology as a compassionate and transformative social science, albeit when tempered by reason and redirected in a wise manner. Our task, when faced with passions such as anger during the course of academic inquiry, that may in turn provoke moralizing sentiments, concerns 'how to find forms in which such passions could be made to make specific practices flourish, strengthen excellence or virtue' (Rabinow 2008:100).

8.4: Fear, Pity, Anger, Love: An Affective Transition

> Make me a decent reflexive anthropologist and I will make you a gift of the free spirit. (Langlitz 2020a:993)

The tripartite structure of indignation outlined above by Stolze applies to my case, but requires some modification. As indignant anthropologist I am in the 'bystander' role. Assuming the role of the 'oppressor' are the KDU and (neuro)weapon researchers. In the role of the 'victim' stands no particular, nor any actual person *yet*. Rather, the 'victim' is *Anyone* (Rapport 2012), a figure combining at once the human species at large and each and *any* individual human, here recognized both as 'empathic predator (Davis 2012:509) and potential target. In the description of the structure of indignation given by Stolze there are other adjustments to be made with relation to the case being worked upon here. By this I mean that in the original model the victim has no passional directedness: they are only *harmed* by the oppressor and *loved* by the bystander. Their passional indirection remains a

curious omission, for is it not conceivable that the victim *fears* their oppressor and the potential harms caused by them? Given the nature of the case, fear is a passion we cannot overlook. However, it is also the bystander's affectivity that is under-described in the basic model of indignation. The bystander hates the oppressor, but may they not also experience fear in relation to the oppressor? Further, may not the bystander experience fear in a special relation to the victim: a *fear for* them, accompanied by *pity*?

The Vehement Passions (Fisher 2002) prized by Rabinow (2008), is useful here. Fisher discusses the workings of a range of (Euro-American) passions in great detail, including anger, grief, fear, and rashness. He argues that in the West it can seem that we live in a de-passioned world, where over time the triumph of reason over the impulsivity of the passions has entailed the development of techniques to manage and repress the latter. Nevertheless, Fisher contends that the passions always were and are still crucial to the discovery of knowledge, the identification of injustice, the creation of social solidarity, political action, and far more. Fear is such an important passion that Fisher dedicates two chapters to it. His reference to philosopher Robert Nozick's (1974) concept of 'general anticipatory fear' is profound. The latter stands in opposition to the 'classic model of fear' (Fisher 2002:82) which focuses on the individual's experience of and reaction to fear — a fear, moreover, that is of someone or something in particular at a particular time in a particular place, confined to a moment or a range of successive moments, with a distinct beginning and end. Instead,

> Nozick lets us imagine a model where the state of fear of those in no imminent danger at all is placed at the center. This fear is general rather than individual, and its object is any possible other person...It is also any possible time, not a specific now moment, which after all is an exceptional moment, one that will come to an end. This fear never ends, never starts, is always present like gravity. (2002:79)

In Chapter 7, the power of the KDU and/or weapon researcher/designer was diagnosed as not being directed towards a specific person, a specific human population, nor a specific time or place. Rather, their necropower, cosmopolitan and transversal by proxy, targets the entire human species and thus *anyone*, *anywhere*, at any future time or place.

Put to work here, the concept of general anticipatory fear can be used to describe, at least conceptually, the corresponding psychological/affective state of Anyone in the abstract, with relation to the power wielded by the KDU researcher and/or weapons designer As an example of general anticipatory fear, Fisher suggests 'the ambience of rape' (2002:78). What this queasy juxtaposition of terms shows us is that general anticipatory fear can be of something in particular (e.g., rape). It's not the specific anticipatory fear of rape, which occurs, for example, when we are being chased by a specific person, in a specific place, at a specific time. It's when the anticipation of this specific *type* of event hangs over us in a general sense, walking at anytime, anywhere.

So, stemming from, yet moving beyond the most general element of fear concerning the nature of the necropower of weapon designers, there is also an acute element that I am getting at with the use of general anticipatory fear: the future combat BCIUAV and the fear of lethal attacks. But this fear remains until an as of yet unspecified future moment, *generalized*. We will only know who will die when they are struck down: but we know already with a degree of surety, that someone will die. I identify this general anticipatory fear of something as the experience of a potentially 'shared fear' (2002:97). Shared fear is rooted in the capacity to imagine the inner states of others. In shared fear we become 'part of a group like the passengers on a falling airplane… a group where each person is at the same time threatened identically, but where some will survive and others will not.' (2002:166). Taking us beyond the solipsistic experience of our own fear, 'the solidarity of terror' (2002:97) generates a *pity*, which is 'a secondary derivative, product of fear'

(2002:93) for the other emerging from our affective identification with them. In shared fear there is a 'civic energy' (2002:107). The pity stemming from shared fear in turn can be channelled into another social solidarity: the kind that might spur collective action, if, indeed, the nature of threat is compatible with action (to which, despite their illustration of the initial solidarity of terror, examples such as the falling plane may not lend themselves particularly well).

In the present case, the extent to which the fear is actually shared is important, for 'we cannot desire or fear anything, but in consequence of the ideas we have of it' (Rousseau 2002:97). With relation to the weaponized BCIUAV, this fear is restricted at the present time to relatively few individuals. Most people do not even know of the threat which nevertheless exists, even if only via a virtual-becoming-actual way posed by the research and design of BCIUAV technology. Because this potential fear is presently so restricted, the 'civic energy' which emerges from 'the solidarity of terror' and the pity for others in the same boat remains potential too.

Given what has been said, a crucial aspect of general anticipatory fear is that it is not only a fear *of* a certain lethal power and a future technology as design and artefact on the way to being given. It is also a fear *for* the future safety of others in relation to this power, this technology, that artefact, and the species of event they summon. In this sense, I both 'anticipate, and volunteer' (Fisher 2002:100) fear *for* the potential victims of the threat. Gathering these thought-feelings together, in this affective transition it is *fear for* others, that leads to experiencing *pity* for those others, which in turn provokes the passion of anger as found in *indignation* directed toward the oppressor. So, how to make the first transition in Stolze-Spinoza's model from instrumentally bad passions to instrumentally good ones? I believe that this indignation must be transformed into and through *love:* which here is not

divorced from reason. The stage is already set for this transformation because in the structure of indignation the bystander loves the victim, who here is Anyone.

8.5: Rapport in Love

In *Cosmopolitan Love and Individuality: Ethical Engagement Beyond Culture* (2019a) Nigel Rapport embarks on an ambitious, idealistic philosophical anthropological project: a 'quest for the conditions of moral human engagement' (2019a:xii). This is a project that stretches beyond anthropology as an academic discipline, to a normative program for how humans might live in harmony in a global civil society. However, *Cosmopolitan Love* is an invaluable source for the contemporary anthropologist when conceptualizing anthropology as a potentially 'moral social science' (Rapport 2019b unpublished essay). Throughout this thesis, I have referred to 'Anyone', the human figure conjured by Rapport in *Anyone: The Cosmopolitan Subject of Anthropology* (2012). *Cosmopolitan Love* (2019a) follows directly from *Anyone* (2012), and they comprise two major parts of one philosophical anthropological project. After a brief introduction to key themes of *Anyone*, I will focus on *Cosmopolitan Love.*

Of all the formulations that have emerged since, there is no need to deviate from the 'precise and ethical' (2012:40) vision of cosmopolitanism as set out by Kant (2006) intertwined with his programme for anthropology itself:

> a scientific and moral programme which deployed that [global] knowledge [of the human] in the securing of universal betterment for humanity, both in its collective (that is species-wide) manifestation and in its local (that is individual) manifestation. (Rapport ibid.)

Rapport's own summation of what a cosmopolitan anthropology might be today is very similar to Kant's:

> The cosmopolitan project of anthropology is empirically and objectively to elucidate the nature of human capacity, the workings of individual consciousness, creativity and accomplishment; morally to clarify the conditions whereby individuals may live out their potential for experience and expression to the fullest; and aesthetically to promote an appreciation of the dignity of human identity and individual integrity. (Rapport 2012:40-41)

As noted in Chapter 2, central to the project of *Anyone* is the concept of 'cosmopolitan politesse' (2012:72). By this Rapport means a set of moral behavioural norms that facilitate the optimal conditions of social interaction whereby Anyone is afforded the recognition of their individuality free from the impositions of socio-cultural symbolism and categorization as a member of particular groups. They are also afforded the respectful distance required for the envisioning of their own life projects, which they must be allowed to freely pursue in so far as they do not infringe on those of anyone else. Cosmopolitan politesse describes 'good manners' (ibid:195) on a global scale. As a universal moral standard, it is an affirmation of Kant's categorical imperative to act as though your actions would be universally done by every actor, and thus to pre-judge the rightness of acts in light of that eventuality (Rapport ibid:194). Ultimately, politesse as the liberal ethic of a global civil society, melds with national, international and supranational legal structures and the political institutions which would uphold it. In this respect, the discourse of international human rights, 'the world's first universal ideology' (Weissbrodt quoted in Rapport 2012:62) offers 'cosmopolitan hope' (Rapport ibid:63). At the very least, cosmopolitan politesse attempts to open up a space of democratic discursive exchange in the inevitable (actual) situation of disagreement between parties upon the liberal ideals (such as individual, human rights and freedom of expression) which undergird its principles and the aspiration for its global export. While Kant was under no illusions about the idealism inherent to the notion of a future '*cosmopolitan society*', he argued that it was still in our best interests to strive for it:

> In itself it is an unattainable idea, but not a constitutive principle (the principle of anticipating lasting peace amid the most vigorous actions and reactions of human beings). Rather, it is only a regulative principle: to pursue this diligently as the vocation of the human race, not without grounded suspicion of a natural tendency toward it. (Kant 2006:236-237)

Rapport, too, is cautiously optimistic about such a prospect becoming reality, but clearly also believes it to be a worthy regulative principle that ought to guide our actions as a species.

Cosmopolitan Love (2019) addresses a question that haunted *Anyone*:

> what might be the motivation for taking up such politesse as general practice and for recognizing its virtue? (2019a:230)

Rapport suggests that love 'might be the motivational force by which cosmopolitan politesse is *understood* as virtuous, and *welcomed* as an ethos and interactional code' (ibid:45). Proposing a notion he thinks is alien to most social anthropologists, he contends that society might be structured at its core by 'emotional bonds' (Oz quoted in Rapport ibid:9) rather than by laws or norms: the latter usually assumed to be determined by the former in a Durkheimian paradigm. It is on this affective assumption that the project of *Cosmopolitan Love* builds, in attempting to imagine how love might be a 'culturally transcendent—and politically efficacious—kind of emotional and compassionate engagement'(ibid.)

Rapport insists that '(o)nly the human and the individual are true' (ibid:235), and that '(c)ultural symbology' consists only of fictions which 'present(s) a threat to human ontology: to the individual determination of world-views…that reflect an individual creativity...and gratify an individual life (ibid:4). Indeed, he goes so far as to conceive of "civilization" as 'those intervals between category thinking' (ibid:219). Tyranny, on the contrary, is conceived of in terms of the homogenizing, stereotyping, and thus deleterious

effects of a culturalist world-view and culture itself on the individuality of human beings. Nationalisms, religiosity and other forms of imagined communitarian belonging serve to establish and enforce illusory differences between individuals and subsequently groups, that can become naturalized and seemingly insurmountable, as if, from an extreme relativist perspective we were almost different species (ibid:31).[242] There is a tyranny in the way certain illiberal cultures and their traditions oppress their members, by supressing their capacity to choose their own belongings and to express themselves in whichever way they see fit, according to an idiosyncratically formed, freely chosen world-view. Rapport's faith in the freedom of expression and association afforded to the individual by civil society in liberal democracies is profound.[243]

Nevertheless, the project of *Cosmopolitan Love* is one that must sit 'alongside' (ibid:219) the seemingly unshakable human (and academic anthropological) propensity to perceive the Other primarily through the fictionalizing lenses of cultural, symbolic categorization. These lenses may well obfuscate an 'ontological truth'(ibid.) concerning our shared humanity, and may hinder our capacity for a 'loving recognition'(see below) of the individual human Other as a truly unique, precious 'ipseity'(Levinas quoted in Rapport ibid:20) who deserves to be respected *as* an individual, seen, engaged with in their own way rather than as a member of (and indeed, according to) some culture, ethnic group, class, religion etc. But the tragedy remains that the individual must both express their own subjectivity through the external means and forms which culture and/or society provides

[242] Anthropology itself risks being a tyrannical endeavour in this regard, too

[243] Indeed, it could be said that Rapport has become intoxicated by the Kool-Aid of liberalism. My aim here is not to review or even to invent critiques of his project stretching across the two works focused on here (nor his work more generally) but rather to elucidate it in a way befitting the almost utopian manner in which he proposes it — and subsequently to build upon it. Readers seeking a more critical take on Rapport's work than I intend to give here, might refer to Bridgette Lewis (2016, 2017) who from a feminist perspective, questions the purportedly androgenous figure of Anyone and critiques the eschewal of identity politics that Rapport's universalizing cosmopolitan project entails. The theoretical and methodological priority placed on the individual in Rapport's anthropology more broadly, is critically addressed to great effect by Roger Just (2004).

and perceive others through socio-cultural 'distortions' (Simmel quoted in Rapport ibid:30). And yet, there still might be moments of experience —specifically those moments when we *fall in love* — in which we break through fictive distortions, realizing the individuality of the other and affording them the recognition and respect they deserve. By attuning to these revelatory moments of deep emotional understanding, and through the subsequent exercise of reason, we might find ways to routinize the insights they bring us via certain practices.

It is '*Agape:* a selfless, altruistic, patient, gentle, even dutiful, giving'(ibid:10) that best describes the kind of love Rapport feels holds promise for a philosophical anthropological program, in which a universalizable form of moral human engagement can be defined: ultimately characterized by 'benevolent concern for all fellow human beings.'(ibid:14). Importantly, this love is of a *non-reciprocal* kind, asking nothing in return from the beloved, and is independent of the beloved's actions toward the bestower. However, there is a desirous component— albeit an 'unerotic' one (ibid:6) — experienced as an emotional attraction to another human being, and without which the kind of 'loving recognition' Rapport is keen to promote would be difficult to get off the ground:

> Loving recognition is a process, a complex of behaviours comprising attraction, appreciation, and respect. An emotional attraction gives on to a rational appreciation and then an ethos of respect, a training and an organization in caring. (ibid:50)

8.6: Loving Recognition as Affective Transition

Ultimately, Rapport becomes interested in how we might conceptualize and subsequently practice loving recognition, in both an *indirect* way that may not even explicitly involve 'love' (but facilitates a loving recognition and inclusion of Anyone), and as a *process*. My main interest here is in the processualism of loving recognition. Earlier I detailed my affective transition from fear, to pity, to indignation, the latter involving anger and

therefore a potentially harmful passion to harbour. Following Stolze's reading of Spinoza, I suggested that as well as being tempered and redirected by reason, this indignation must be transformed through and into *love*, for which the stage was already set because in the structure of indignation the bystander loves the victim: who here is Anyone. In thinking the processualism of loving recognition, Rapport sets out an affective transition involving both emotion and reason.

1: Love begins with a 'moment(s) of vision'(Hardy quoted in Rapport 2019a:6), an emotional epiphany concerning the unique wondrousness of the individual Other who in themselves is another interior world. This moment of 'loving looking' (Rapport ibid:53) is tantamount to 'the discovery of reality' (Murdoch quoted in Rapport ibid:19). Intuitively attracted to the Other, torn away from ourselves and the cultural conventions that usually dictate our perceptions: we *fall in love* with them.[244]

2: The next part of the movement is a rational one: an 'avowal'(Rapport ibid:225) to stay true to the emotional force of the original epiphany, to reflect upon and learn from it (ibid). Even what may in some cases begin with a sexually charged erotic desire directed towards a specific individual, grows through the exercise of reason to become a 'more purely "erotic" (ibid:137) philosophical form of desire in which *'eros* [is] abetted by *sophia'* (ibid:19). Rapport idealizes this 'ascent of a loving kind' (ibid:224) as moving through reason beyond the specific individual, who was the object of the epiphanous moment of vision, and whose particular qualities attracted us to them: 'to qualities independent of particular individuals…for example, toward beauty in the abstract' (ibid:137). The loving ascent may extend further to an appreciation of the abstract quality of individuality itself,

[244] The moment of vision is one of 'metanoia' (ibid:55). I put more emphasis on this term in my concluding remarks in Chapter 9 via reference to Stade and Rapport (2022).

and beyond to a loving recognition of 'Anyone and Everyone' (ibid:225), and thus the human species as a whole. However, we may also progress beyond the appreciation of a sort of abstract quality of individuality inhering in Anyone, who becomes the object of our loving recognition, which in turn becomes loving recognition of Anyone and Everyone — 'rationally…to a recognition and respect for Life [itself], for Nature, for the conditions fated to befall any organism *sub specie aeternitatis*' (ibid:226). I will return to this crucial theme below.

3: From then on, it is one's responsibility to maintain an ' "ironical" performing of that [epiphanous] moment' (ibid:224) which entails keeping in mind the fictitiousness of the cultural symbology and category thinking that shrouds our everyday apprehension of the Other: while always holding on to the emotional force of that original moment of vision, in the hope of achieving what may amount to a 'lasting spiritual understanding'(ibid:138). Nevertheless, such understanding is not something we can hope to achieve once and for all, as though having made the first ascent we would achieve Enlightenment. Loving recognition takes constant work and renewal — an 'ongoing dialectic: a continual zigzagging between loving as emotional and as rational; between an engagement with "individuality" as an abstract phenomenon and "humanity" as a species whole' (ibid:226).

More broadly, Rapport considers 'Three Possible Ways to a Universalized Love'(ibid:85-114), which are complementary rather than mutually exclusive (ibid:112) and constitute important elements of his own rationally powered 'transformation of loving recognition into a political project' (ibid:47). The first concerns the unilateral ethical duty of the individual towards others, seen in the affective transition of loving recognition above; the second involves the establishment and maintenance of a 'global civil society'(ibid:99) through legal means; and the third encourages the formation of institutions that through teaching and learning, uphold an 'ethics of care' (ibid:105) towards Anyone. Instead of

discussing these possible ways to a universalized love, at this juncture, I must continue on my own quest. To do so requires a discussion of the role of art in Rapport's vision of loving recognition.

8.7: Art and Love

Drawing upon psychologist Kaja Silverman, Rapport argues that one of the ways we might learn to look lovingly and see beyond the shroud of symbolic categorizations when encountering other humans, is to consume artistic representations of Otherness. This latter term is to be understood here, I think, in the sense familiar to cultural anthropology, but also in keeping with Rapport's corpus more broadly, the sense of Otherness that exists between every individual, and thus in the relation between any individual recipient of art and any (fictional or non-fictional) human subject of art. Silverman emphasises the process of 'idealization', the 'psychic activity at the heart of love' (Rapport ibid:25) where ego identifies an Other as 'able to fill a void at the core of its own sense of self' (ibid.), a form of appreciation in which the body of the Other is key and whereby ego 'hop(es) for the health and happiness of the beloved Other.' (ibid). As we continue to view aesthetic representations of the Other, we can come to idealize them in some sense too, and thus we may gradually learn that our moral responsibilities reach beyond those we experience in the romantic, friendly, familial, or other more immediately experienced loving manners. This is a promising theorization of the moral role of art in social life, and something of a reassurance that a wider public are being continually exposed to 'love's devices' (ibid:181-213) (see below). I now want to discuss a work of art bearing relation to the topic of this thesis, that demonstrates the grandest kind of loving ascent mentioned earlier, in which the infinity of the cosmos meets with the finitude of Anyone in the contemplation of or event of their death.

8.8: The Art of Dying

Surely, the famous artwork we saw in Chapter 7 created from memory by the German artist Otto Dix after having been in the battlefields of World War 1, is not the image Nourmohammadi et al. (2018) wanted to put in our mind's eyes when they figured a wounded solider as 'conceivable' future user of BCIUAV technology. But this is, without doubt, a war wounded solider: although one who seems anything but ready to proceed with combat, let alone use any modality of brain-computer interface unmanned aerial vehicle to do so, were he in some future battlefield.[245] Stare into the terrified and terrifying eyes of the wounded solider as long as you can before being forced to avert your gaze anywhere else in that wretched frame, only to be met by more bodily horror. Then, dragged back into his desperate gaze, repeat the dreadful movement like a trapped animal until you can no longer bear to see the image, which anyway, now, cannot be unseen. I feel a strange kind of shame for my species when viewing this work of art, but also fear, pity and anger. Something to do with 'the very secret of mimesis' (Gell 1998:31). The shivers, the fight against recoil, the futile and yet ever so real desire to help this nameless man: reduced to a tangled mess of clothed flesh waiting to be sludged into the crater he lies in under thundering tank tracks, or by aerial bombardment. Perhaps he wishes for death? Or perhaps he is clinging to life, in vain. In either case, his expression is beyond words and is, in itself, a scream (Taylor-Green 2020). An ethical summons before and beyond culture, 'a demand for acknowledgement' (Rapport 2019a:93, cf. Taussig 2009), a request to make ourselves 'available' (Rapport ibid:87). He is 'Anyone, like me' (2012:94). In receipt of Dix's harrowing vision, it is not simply the black irony of Nourmohammadi et al's wounding of their own imaginary soldier in what appears as an attempt to dissemble

[245] cf. Kim et al. (2014) who note that even mild anxiety makes it very difficult to control the drone in the confines of a scientific experiment, so it seems unlikely that someone in terrible pain would be able to carry out this task in a battlefield.

necropolitical activities under the beneficent auspice of (self)defence; for, as is eminently clear, no reasonable person would expect this wretched figure to proceed with combat in any form.[246] It is also the equally blackening and no less ironic recognition that this image depicts what the necropolitical activities of KDU and/or WR would *lead to*. However, as I mentioned in the previous chapter, thinking only of soldiers or battlefields and thus 'war' with relation to the use and effects of (neuro)weapons is too narrow. Although Dix's print is often referred to as 'Wounded Solider', and does indeed portray one, it is important to recall that the title of the piece is actually 'Wounded Man', eschewing any reference to war, but also social categorization or structural role. From a cosmopolitan anthropological perspective, it is not a *German* man depicted by Dix, but *a* Man: *Anyone.* The Wounded Man silently screams at us from the past. *Looking* and *listening lovingly* through an imaginative multimodal ekphrasis, his scream is the same cacophonously silent scream that I 'hear' in my mind's ears in the process of researching the research and development of BCIUAV technology: resounding from future *death-worlds*.

> Ultimately an individual life is nothing: ultimately, against the infinitude of death, an individual life is everything. (Rapport 2019a:226)

'Wounded Man' is a '*memento mori'* (ibid:203) a reminder of death; a reminder that we mortal human beings die, somehow, somewhere. It is, therefore, a cosmic reminder 'rescaling' (ibid:207) us and our understanding of the ultimate *insignificance* and ephemerality of human life within the vastness of the universe, a moment of vision that, yet, in the same flash points to the precious *significance* of each and every human life on Earth. Seeing this image is akin to seeing images of Earth from space (ibid:204-205), a testament to our shared vulnerability as fleshy entities that rely on certain conditions for

[246] **'**(I)f I thoroughly understand this term *wretched*, it is a word that either has no meaning, or signifies nothing but a privation attended with pain, and a suffering state of body or soul' (Rousseau 2002:104)

our flourishing, but more fundamentally, our continued existence (see below). Within each one of us, in turn, a world. 'Wounded Man' is one of 'Love's Devices' (ibid:181-216) an artistic channel provoking an emotional epiphany, a moment of vision with both Earthly and cosmic resonations: a 'cosmo-politan' love of Anyone (ibid:213).

8.9: Good Manners and the Right to Life

> Anyone is recognizably human in terms of the spectrum between whose poles life is sustainable, and yet irreducibly themselves in the expression which human life achieves in them. 'The spectrum', as a model, combines a common range of possibilities with unique actual location. (Rapport 2012:159)

In *Anyone,* Rapport discusses the universally shared but individually lived and thus specific nature of human embodiment in terms of its materiality, spatiality, temporality, and capacities. 'The spectrum' constitutes an attempt to 'model a universal relationship between individual and human totality' (2012:159). Here by spectrum, I mean particularly the 'environmental range' (ibid:160) within which an individual human life (taken wholistically as an organism — a body possessing consciousness in an environment — but therefore also in species-wide terms) can continue to exist and even flourish within. What I am keen to argue here, with emphasis on the universal, is that anything that wholesale threatens the environmental range within which Anyone can survive, specifically those human practices and humanly created things that threaten the bare fact of bodily existence — life itself — must be defined as phenomena that constitute the most fundamental assault on the 'safe passage' (2019a:6) of Anyone, and that represent the absolute antithesis of cosmopolitan politesse. Therefore, in terms of human rights, those same practices and things threaten the *right to life* of Anyone.

Prime examples of such practices are the acts of KDU research and WR. Thinking about Anyone 'in terms of species-wide capacities: capabilities for action and imagination…

[and]… liabilities for suffering and cruelty'(Rapport 2010b:2): weapons are external threats in the environment, imagined, designed and used in such a way as to target the body of Anyone as a living organism, to harm, make suffer and even destroy it. The capacity for imagination and action as cruelty of one human causally infringes on the liabilities to suffer and die of any other. Contrary to the 'good manners' (2012:195) of cosmopolitan politesse, with KDU research and WR, we have cardinal examples of *bad manners*, to put it mildly.

The power that KDU and weapon researchers wield amounts to a *cosmopolitan tyranny*. Its absolute disregard for human difference as well as its planetary reach is what makes it cosmopolitan; its absolute, impersonal and violent disrespect for the health and life of Anyone anywhere (not least with complete impunity) makes it tyrannical. It is therefore a negative counterpart of a cosmopolitan anthropology motivated by love. I believe cosmopolitan love in theory and, importantly, as I will now discuss, action — emerging here in the moral vision of human conservation, which takes cosmopolitan politesse as it pertains to the right to life to be paramount (see below) — is well suited to the task of meeting the cosmopolitan tyranny of neuroweapons innovation.

8.10: Human Conservation as Love

What does love, as elucidated above, mean for anthropology in general, with relation to encountering practices that threaten human life and thus the human right to life? Primatologists in a conservationist mode will act to protect their non-human primate subjects from poaching, and thus from threats to their lives. Likewise, it is incumbent upon the anthropologist as human conservationist (see below), having identified people and practices that pose threats to human life, to, if possible, understand what they do and why, but more controversially, develop strategies to discourage those practices and the ideas and

attitudes that perpetuate them. This suggestion is contrary to the aspiration to neutrality that anthropology in many quarters has long maintained to be best professional practice, and thus also contrary to the reassertion of this position by Langlitz in his amoral anthropology. But I argue that — when it is possible — to critically engage and even intervene when human life is under threat, is to *act out of a love for Anyone*, to *act lovingly*: as a *professional* anthropologist. None of this is inconsistent, however, with the 'noble goal of understanding others in their own terms' (Rapport 2002:156). It is simply an attempt to avoid the 'morally nihilistic, politically conservative and quietist consequences' (ibid) of moral relativism at the extremes of anthropological witnessing.

At the heart of our theoretical and methodological understanding of anthropology, ought to burn a loving recognition of Anyone as both individual and species. A recognition of ourselves in every other, and of the precious significance of every human life and human existence itself: faced, in the sprawling infinity of the cosmos, with the inevitability of our individual and collective entropy. This ought to be accompanied by an awareness of, and feeling for, the moral responsibility that flows from this loving recognition: both personally and *professionally*. Building on Rapport, I argue that anthropology, when *theorized* with love, yearns to rationally *act* upon and thus *apply* the fundamental insights of loving recognition, and thus, to at the very least attempt to preserve Anyone's life. And so, here, the oft separated theoretical and applied elements of anthropology must blur. Even hard relativists who would find the notion of exporting cosmopolitan politesse writ large problematic: could surely agree, at least in principle, that all humans deserve to be sheltered from threats to their life. To argue that anthropology, the discipline concerned with 'the human', ought to be concerned for and in relevant cases even attempt to preserve

the very existence of its own subject of study[247] (which is, after all, the very species to which all anthropologists also belong) is hardly a radical idea, nor an unreasonable aim. What I have written above describes the moral vision of human conservation for anthropology in general. With relation to this moral vision, the principle or maxim that may help guide the practice of anthropologists in relevant situations, I call the *conservational imperative*:

> *Any practice that threatens the (right to) life of Anyone, whether it is technically legal or not, is a fundamental contravention of cosmopolitan politesse: bad manners. A cosmopolitan anthropologist, therefore, who loves Anyone and desires to ensure their safe passage, has a unilateral duty to turn their idealistic stance into reality, however modestly, by attempting to find ways to understand and if possible, transform the appreciative systems which facilitate those breaches of politesse, thus promoting good manners, in the interests of conserving human life.*

However, a dose of epistemological sobriety is required. Dorothy Emmet's *The Role of the Unrealisable* (1994) explores Kant's related concepts of Regulative Ideals and Regulative Principles.[248] Recall that Kant, in his *Anthropology*, framed the diligent striving towards 'a *cosmopolitan society*' (2006:236) as a 'regulative principle' (ibid:237). Correspondingly, within the context of his philosophy — and although he does not make this explicit in the section of the *Anthropology* quoted above — this means that as an 'unattainable idea' (ibid), it is possible to treat 'a *cosmopolitan society*' as a Regulative Ideal:

> To say that something is unrealisable is to speak with reference to a goal or standard which may be approached but which cannot be attained. Nevertheless, practice may be orientated towards it. This relation is not the type-token relation of a universal to its particular exemplifications: it is a teleological relation of an ideal to its approximations… a Regulative Ideal is unrealisable, but to entertain it is to give orientation to a practice. (Emmet 1994:2)
>
> A Regulative Ideal is 'a *focus imaginarius*, an ideal which we can never reach, though we can approximate to it through the reflective use of Regulative Principles (ibid:12)

[247] As long as this doesn't in itself involve causing harm or death.
[248] Emmet capitalizes these two terms throughout her book, so in this section I follow suit.

Following Emmet: The moral vision and thus, in a sense, overarching goal of human conservation for anthropology is a Regulative Ideal, because it sets an unrealistic universal standard, and can never be achieved in any totalizing sense. There will also be sound objections and warranted exceptions to it in many circumstances. The conservational imperative is therefore a Regulative Principle that in many, perhaps most cases, cannot be followed, but importantly, in some cases *can*: hence the qualification 'if possible'. However, it is not within my power to specify the relevant conditions for judging whether intervention is possible: this will always be relative to the individual anthropologist and their situation, and one hopes that thoroughgoing debate between anthropologists can be had on such matters in future. Nor can I be sure that in every case perceived to be relevant from the perspective of a future anthropologist, intervention is 'right'. Again, this will be something tested and even constrained by the crucial checks and balances of academic collegiality. For now, it is the task of this philosophical anthropology to assert this Regulative Ideal and its Regulative Principle, as subjects for future research, debate, and in the hope that they will inform practice. Unrealizability hangs over human conservation and the conservational imperative, and 'it is a delusion to think they can be *fully* attained' (Emmet 1994:11 emphasis added). But there is still value in holding the former as a 'a guiding thread' (Kleingeld 2008:526) because it is conceivable that cases will arise in which it is both right and possible to act according to the conservational imperative and thus *partially* (cf. Zeitlyn 2009) live up to the ideal. 'A Regulative Principle can be pressed as far as it will go' (Emmet ibid). Allowing the conservational imperative to orient practice in relevant cases, may bring us closer (albeit always asymptotically) to the former.

8.11: Redirecting Bad Affects: Human Conservation as Conversation

What does it mean to act lovingly, from the perspective of human conservation, with relation to the case addressed in this thesis — that of KDU research and neuroweapons innovation in the international BCI research community? An early reader of this chapter objected to the claim made in the critique of amoral anthropology that it transforms its subjects into animals, on the grounds that anthropologists have always spoken to their subjects about morality and ethics and will always do. In this way we treat them as humans, essentially because we can converse at all. However, my critique points to the problems that arise in extreme cases if we *only* listen but never critically speak up or intervene. If there is a clear case for critique and intervention based on a fundamental moral argument concerning the importance of upholding the human right to life, and we do not take the opportunity to do so, then we risk, in my view, the denial of humanity. In the case of perpetrators, we risk the denial by missing the opportunity to give them a chance to consider acting differently, more compassionately, less lethally (see also Chapter 9). In the case of potential victims (even when dealing solely with perpetrators), we risk the denial by methodologically dismissing their lives as being unequal in value to our own. It is humanizing, and moral, to converse with participants — here, especially potential and actual perpetrators — to better understand why they do what they do (an 'anthropology of moralities' (see Zigon 2007)). But crucially, in line with human conservation: explicitly acknowledging the existence of, and appealing to their humanity, by at least asking them to consider the gravity of what they do in a (more) humane way. This is to act lovingly toward, and in the interests of, Anyone. In Chapter 2, I stated the conversational imperative, formulated in line with the conservational imperative:

> *In any situation in which the activities conducted by some or all members of a professional community have the (knowable and/or known) possibility of leading to*

> *weapons innovation, then this ought to be at the very top of the conversational agenda.*

I argue that at the minimum, an ethically focused conversation should take place within the BCI Society as to the (un)acceptability of KDU and NWR. Out of a love for Anyone, it is the anthropologist as human conservationist's responsibility to help instigate such a conversation. And, entangled with but hopefully beyond that to engage in modest advocacy whose aim is bring into being a world that is less brutal than it currently is, or might be (cf. Rabinow 2008:14). Because the task involves engaging with other scholars, I firmly believe that conversation is the most appropriate method of intervention in this case, and thus may even be the most effective. In Chapter 6, I set out the basic principles that might allow for a window of concern to be opened, and potentially to expand the moral vision of the BCI Society to include dual use and weapons research. These were the definition of electronic neuroweapons of the BCI type as being an issue unique to BCI research, alongside the incipient Principle of Social Impact (Pham et al. 2018) which has the potential to address external ethical issues that pertain to the non-users of BCI systems, rather than users. On this basis, and to begin with deploying surveys in the fashion of Pham et al. (2018): future research will investigate awareness of and attitudes to KDU and NWR among BCI researchers, the undertaking and publication of which should begin a conversation.

Then, all being well the task ahead involves considering possible ways to discourage research that leads to weapons innovation in the BCI Society, with the help of concerned members. This may fail miserably, but it is better to have tried than to have sat back in the holiday mood. I argue that to even have the BCI Society and perhaps the wider BCI community *thinking* and *talking* about dual use and weapons research, would be moral progress. What lies beyond, only time will tell.

8.12: Conclusion

In the first half of this chapter, Langlitz's proposal for an amoral anthropology was critiqued from two angles. First it was diagnosed as an ethological rather than anthropological perspective, suited to the study of animals rather than human beings. Tested to its limits by instances of human behaviour that threaten human life, amoral anthropology's insistence on the principle of detached, non-interfering observation reveals hidden assumptions built into the former. These concern the inability of perpetrators to respond to reason and potentially act in less or non-lethal ways, and of victim's lives not being equal in value to our own and thus undeserving of our efforts to help them survive. In such extreme circumstances, amoral anthropology entails the denial of the humanity of its subjects, and turns them methodological, metaphorically and perhaps even epistemologically, into mere animals. Inspired by the conservationist impulse of primatologists which Langlitz chooses to ignore, the moral vision of human conservation was introduced as a possible alternative, to be discussed later in the chapter.

Second, Langlitz's portrayal of sagaciousness in which the amoral anthropologist aspires to the holiday mood was diagnosed as lacking in care for others. An alternative portrayal of the indignant sage was offered via reference to Stolze's work on Spinoza, which I think more suited to anthropology conducted by concerned, moral anthropologists, unafraid of the fourth aim of anthropology where the wisdom of compassionate activity might be found.

Then, with the help of Fisher, the role of passions in my own positionality with relation to the research conducted in this thesis were identified as being characterized by an affective transition moving through fear, pity, and anger. A discussion of Rapport's work on love allowed for the redirection of the potentially harmful passion of anger as found in indignation, into the moral vision of human conservation as it relates to the identification

of practices that threaten human life, and thus the human right to life — that constitute fundamental contraventions of the good manners of an idealized cosmopolitan politesse. The qualifying practices in the context of this thesis are KDU and (N)WR, and so, finally, justified suggestions for future activist research in the form of conversation with the BCI Society were proposed. Where Langlitz writes that '(a)s an ethnographer it is not good to be good' (2020a:1000), I must disagree. As an anthropologist it *may sometimes* be good to be good and encourage goodness, especially when this goodness concerns, *the preservation of life.*

9: Conclusion

BCI is still an open question for anthropology. By studying the development of BCIUAV technology, I have moved towards a more general theme represented by it — the issue of dual use and neuroweapons innovation in BCI research. This is just one (potentially *negative*) aspect of a broad, exciting, and relatively new field of applied science. The focus has been on this particular aspect because having recognised it in the BCIUAV, I felt myself to be interpellated (Law 2000) in a way that called into question my professional responsibilities as an anthropologist towards other human beings. It might seem unfair of me to have myopically focused on this issue when there is so much other incredible and non-harmful/lethal work done by BCI researchers across the world. But as I have argued, the gravity of the issue cannot be understated. The seeming lack of attention to it in the BCI community is therefore both fascinating and concerning. As I mentioned in the Introduction above, US military funding has been declared at a number of International BCI Meetings. The head of DARPA's N3 project gave a presentation in the capacity of a 'funding officer' at the Seventh such meeting. This demonstrates that many members of the BCI Society are if not already aware, then in a position to know of the weaponizable possibilities of BCI research and technology.

Because my focus has been on 'Red Flag' cases identified by means of criteria A and B, which entail either being in a position to know (PTK) their research is dual use, or conducting knowingly dual use research (KDU) and/or neuroweapon research (NWR) (Chapter 2): what has been little discussed until now is the mass of what I call *unknowingly* dual use (UDU) research. UDU research is by definition dual use, but the papers in question satisfy neither criteria A nor criteria B. BCI research is almost always applied research —which according to Douglas (2014) is the kind of research for which it

is most difficult to justify adopting a position of scientific isolationism from moral considerations about the uses to which it might be put. A dual use *potential* is always there regardless of whether there have appeared, or will ever appear, any instances of research into X that are KDU or just NWR. The emergence of dual use *possibility* through the recognition — represented crucially by explicit, open acknowledgement but also by military funding — and subsequent exploitation of X's dual use potential and thus the emergence of the risk of weapons innovation, then affects the character and trajectories of the surrounding research into X. By default, any past research on X becomes dual use retrospectively. However, in many cases up to a certain point in the development of X, researchers will not even be able to foresee dual use possibilities at all. Any future research that sits in this context and unknowingly or knowingly contributes to X's possibilities for weaponization is born dual use (whatever is or is not said openly about it), or worse. I would argue that as time goes on it is increasingly unlikely that dual use research could be done unknowingly. It is incumbent on researchers to understand the surrounding social context of their work and consider carefully whether at a given time further research ought to be done on X, if it is known to be a possible contribution to weapons innovation.

All BCIUAV researchers, post- Zhang and Jackson (2015), have been and are in a PTK, although in a more general, weaker sense than those publishing criteria A papers. Despite being a modest and never officially published work — Zhang and Jackson (2015) is nevertheless referenced and discussed by the only review paper dedicated specifically to BCIUAV research (Nourmohammadi et al. 2018) at my time of writing, demonstrating that other researchers *were* able to find it…before it disappeared. Within the vast swathe of what I have defined here as UDU research, there *could* be a far higher proportion of researchers who are actually doing KDU research or even (veiled) NWR, but who just

haven't taken (or just haven't declared) military money or made the jump to openly speaking about the possible harmful purposes of their own work. The way I have defined the terms of the analysis in this respect, and the strict, perhaps over-cautious limits I have placed upon their scope, means that I have not pursued certain lines of inquiry that follow, for example, from the recognition that some UDU research papers *cite* Red Flag papers of both kinds: suggesting that some of them *might* indeed be aware of the possibilities of weapons innovation of the research and technology in question. Similarly, I have not pursued the fact that an author appears on two criteria B papers, as well as in a UDU paper. Notably, the latter is sandwiched temporally between the two formers. In Appendix 1 I provide a chronological bibliography of BCIUAV research that lists all internal citations between papers underneath each entry, with cited red flag papers marked in bold typeface.

In Appendix 2, I provide a full list of all future uses of BCIUAVs posed by teams developing the technology. While there are plenty of interesting suggestions, I have focused on what I take to be the two most important of those, framed here as moral and bodily opposites, and that exist in a stark juxtapositioning indeed — assistive neurotechnology for severely disabled persons, and a neuroweapon that could be used to disable and kill persons — albeit with most emphasis on the latter. At no point, however, do I challenge the wonderful idea that disabled persons might be able to benefit from either an assistive or recreational BCIUAV in future. Chen et al's (2016) paper reviewed in Chapter 1 demonstrated the possibility of the latter variety, and I would love to see the former being developed. Despite the numerous mentions of this kind of beneficent purpose in the literature over more than a decade, Chen et al. are the only team in the entire body of research to have even attempted to test a BCIUAV with disabled individuals. And, beyond

Chen et al's patient study, there isn't even one example, to my knowledge, of a proper proof of concept study with relation to future disabled users of the BCIUAV, which some may think brings into question the sincerity of the claims being made in this respect across the body of research.

However, when it comes *assistive* BCI technology, there is unquestionably a hierarchy of need. It is unlikely that a BCIUAV will feature anywhere near the top of that hierarchy — something I think Chen et al. recognise when they pursue a *recreational* rather than assistive version. Recreation is of as great importance to disabled persons as it is for anyone else and can massively improve quality of life, as Kübler et al. argued with their revolutionary Brain Painting application. But it is less essential that they are afforded this than much more basic capacities such as communication.

Indeed, in terms of assistive technology, in Chapter 4, we are reminded of how incredible and beneficent some of the work that BCI researchers do is, and where the BCI fits into what I termed a finalist scheme of human capacity and dignity. This is in great part what makes the BCI such a profound technology, and its utility for people with severely paralyzing but also other disabilities is only just beginning to be shown. And yet, the tangible risk of neuroweapons innovation lurks in the background of a minority of work, now in the context of real threats to use it. Meriño et al's (2017) ARL funded research — meeting criteria A and thus demonstrating that the team were in a strong PTK about the risk of neuroweapons innovation their work posed — was published in the BCI Society's journal, *Brain-Computer Interfaces*. So not only have the BCI Society taken US military money for their conferences, but they are also publishing work funded by the US military with clear contextual evidence surrounding it concerning the possibility of its harmful/lethal affects. The BCI Society and *Brain-Computer Interfaces* journal staff are also in a strong PTK, and seem to be disseminating work that poses the risk of

neuroweapons innovation. Furthermore, publishers such as *Taylor and Francis* and the *IEEE*, have a role in all this.

The quote from S5 in Chapter 4 demonstrates clear evidence of 'scientific isolationism' (Douglas 2014) — albeit in a contracted, non-philosophically voiced way — the attitudinal position holding that:

> in science, use assessments can be eschewed; choices about which scientific project(s) if any to pursue or promote may be made purely on the basis of scientific considerations, for example, whether a given piece of knowledge is intrinsically or theoretically interesting ... it holds that decisions about the directions of science can be made in isolation from certain moral, non-scientific considerations (2014:90)

It would not surprise me to find that some, even many journals in this sphere either implicitly or explicitly adopt a scientific isolationist position. I say this because the evidence discussed in this thesis suggests that a great deal of foundational work towards the development of a neuroweapon has been done by largely university-based researchers internationally, and subsequently their UDU, but most importantly, KDU and NWR has been published across numerous journals. The BCIUAV will be, to my knowledge, the first electronic neuroweapon of the brain-computer interface type in human history, and along with others of its type will no doubt go onto define, in part, how future wars are fought. All this, facilitated by individuals and organizations who seem anything *but* violent entities (Bourke 2017)

It is amazing what the prosthetic body can do, in both war and peace, and it was the spectacular nature of the prosthetic body as it appears with the BCIUAV that first drew me to it as a topic of study. The novelty has worn off, however. In Chapter 5, by examining promotional videos for existing combat SUAVs I theorized both futures of combat BCIUAV technology, and the nature of the prosthetic body as it will appear with the combat BCIUAV. The additional capacity that could be afforded to ground troops —

hands free control of a neuroweapon enabling the hands to control another weapon — represents a nascent advantage in the combat space: and thus, an expansion of the power to dominate and destroy other bodies. But what this emphasised in terms of BCIUAV research, was that whether the future combat BCI-sUAV is armed in itself or not, and whether used on its own or by already armed soldiers on the ground: BCI *flight control* of the drone (established as the primary purpose of BCIUAV technology in Chapter 3) is the essential function of this neuroweapon upon which all of its other violent affordances will rest. This happens to be the very function that all the instances of BCIUAV research work towards. Unfortunately, this is the very function that would facilitate any derivative purpose of the BCIUAV whatsoever, beneficent, neutral or warring. In this respect, and again, unfortunately: *all* BCIUAV research — certainly any that develops techniques for flight control, but perhaps now almost any aspect of BCIUAV technology (past, present and for the time being, future) — is dual use. For in the present context, no practical research into it can be done without risking neuroweapon innovation. Therefore, all BCI researchers should examine their consciences deeply before engaging in BCIUAV research, at the very least. It is probably now too late for a moratorium on BCIUAV research in the university sector to have much effect, nor a moratorium on the publication of BCIUAV research, because much damage on both fronts has already been done.[249] But in future, temporary or even permanent moratoriums on conducting and publishing research identifiable as risking electronic neuroweapons innovation should certainly be considered. Obviously, I am not arguing for a cessation of all BCI research on grounds of dual use potential. That would contradict the sensible theorization of dual use by Forge in which we need to be able to identify contextual factors (risks and threats) to justify

[249] see Douglas (2014:99) on the voluntary moratorium placed by some researchers on the publication of their work that made airborne H5N1 virus transmission in ferrets possible.

inclusion in the dual use category, indicating the real possibility that an item risks weapons innovation. As mentioned in Chapter 2 when introducing Forge's account, we cannot include research and technology in the dual use category simply because it *could* be used for harm. Otherwise the category would become so large as to be meaningless. But there are bound to be more instances of tangibly dual use BCI research involving particular applications that pose recognisable problems in light of relevant contextual factors, and that will require interrogation in a similar manner to BCIUAV. Learning to recognise *this type* of research is crucial for both BCI researchers and social scientists alike. These reflections bring us back to the social ontology of the prosthetic bodies of KDU and weapon researchers described in Chapter 7 — radically diffuse and multiplied across time and space, embodying awesome impersonal and transversal power. The strange thing, however, is that without education about their nature, even those who possess such monstrous bodies can remain ignorant as to their extent.

In Chapter 6, Dr Huggins veered toward scientific isolationism with her remarks on 'taking people apart'. No attempt was made to chastise or even express any concern about BCI research and technology that takes people apart. She doesn't take people apart — she puts them back together. But other researchers do take people apart and that's just how it is. Potential disagreements as to the rightness or otherwise of taking people apart were compared to a relatively petty amoral discussion about what to have for dinner.
But in the other quote from Huggins concerning how having a technology that can enter dangerous situations — able to engage in both searching for survivors of earthquakes and proceed with combat in battlefields — is 'a good thing to have happen': she offered a low-key, non-philosophical argument *in favour* of doing dual use research. Her remarks, I think, represent a more benign variation of the cynical formula Bell (2014) identified: the '*surely* you don't want to forestall beneficent purposes by halting work into the thing

which as it happens also affords harmful purposes?' formula. In Bell's example, the formula comes across as a sort of ransom note containing a rough moral calculus concerning perceived benefits that are framed as somehow irrevocably tied to and almost dependent on the simultaneous development of harmful outcomes: which may or may not be the case in reality.

I don't want to forestall beneficent purposes, but neither do I think we should sit back and allow harmful and lethal purposes to be freely developed, and what's more, to ride parasitically on the underside of, or even hide behind, beneficent purposes — without at least some semblance of open ethical discussion about the latter. Sometimes we may have to place temporary or even permanent restrictions on X to forestall harmful purposes, in the unfortunate knowledge that beneficent purposes will also be delayed or blocked entirely. That is if we can agree that causing harm and ultimately death is intrinsically wrong, and that justifying it takes much more than merely *suggesting* beneficent outcomes that *might* be perceived, in their beneficence, to outweigh and thus potentially justify the harmful ones.

In practical terms, with my focus on BCI type neuroweapons: I argue that *no new weapons need be created.* As a species we do not need any *more* ways to harm and kill each other. We have an excess of these already — although arms manufacturers and militaries, but also many scientists and engineers enthusiastically engaged in the ever-spiralling, ever-more profitable bonanza of arms races — will no doubt disagree. Surely, our brightest minds ought to be putting their heads together to improve the human condition, not working to continually worsen it by developing new ways to make others suffer and die. Even small efforts to resist this species-suicidal technological tendency are worthwhile. And so, those bright minds must also work concertedly to avoid doing harm. KDU researchers, as I argued in Chapter 7, are *in part* weapons researchers. Once this

sinks in, maybe BCI researchers will think more carefully about what their role as scientists is in the world from a moral, hopefully compassionate, species-wide, and future-looking perspective — which if every scientist did, we would have less to worry about overall.

'Dissolution' (Gell 1992:41) characterizes the work and process of anthropology. Gell's metaphor comes from chemistry, where the most common acts of dissolving involve the dissolution of a substance (solute) in or with a liquid (solvent). Dissolution thus refers to a relationally enacted process. The act/process of dissolution leads to the formation of a third substance termed the solution — a resulting mixture of solute and solvent — with its own unique properties. In dissolution, things are unmade but something else is made.

The act and process of dissolution in anthropology is conducted via the operation of *critical vision* — which in itself involves 'welding together the results of imaginative speculative reasoning and a body of systematically collected evidence in accordance with the procedures of logical inference' (Firth 1975:11). Here, as in chemistry, things are both made and unmade. But unlike in chemistry: how this happens in the art of anthropology — at the most fundamental level (and so beyond 'method') — remains opaque.

On the subject of anthropology as art, and as critical vision, more needs to be said with relation to *optical* dissolution. In Chapter 1 I mentioned Zulaika's (2014) thoughts on the technologically mediated aesthetics of drone pilot's experiences, which centred on Benjamin's assessment of the aesthetics of fascism and fascism's aestheticization of politics, and subsequently the possible role of art in resisting fascism. Zulaika's understanding of Benjamin here is influenced greatly by Susan Buck-Morss's exceptional essay 'Aesthetics and Anaesthetics: Walter Benjamin's Artwork Essay Reconsidered' (1992) where she unpacks a core insight from *The Work of Art in the Age of Mechanical*

Reproduction (Benjamin 1935). Her own optical dissolution can shed further light on the work done in Chapter 7 and Chapter 8.

Amidst the rise of fascism in Europe, in the last lines of his Afterword to the artwork essay, Benjamin wrote that communism politicizes art in response to the fascist aestheticization of politics which ultimately leads only to war. In doing so, he was 'exploding the constellation of art, politics, and aesthetics into which, by the twentieth century, [the] tradition [of modernism] has congealed' (Buck-Morss 1992:5) by calling for a return to the original meaning of the term 'aesthetics' as '*Aisthesis…* the sensory experience of perception.' (ibid:6). 'Aesthetics' had come in modernity to denote a philosophical discourse on 'art, beauty and truth' (ibid), which, spurred on by Kant's articulation of the sublime, centred around conceptions of a male body empowered by rationality but separated from nature and reality, and nearly impervious to sensory infractions from the outside world — except where the senses were subjected to cultural, rational domestication. *Aisthisis*, on the contrary, begins with the biological role of the senses in 'self-preservation' where they fade into irrational (thus threatening to modern philosophy) and ultimately untameable 'animal instincts' (Buck Morss 1992:7). Allying herself with aesthetics as *aisthisis:* in order to interpret Benjamin's remarks, Buck-Morss begins 'to trace the development… of the human sensorium itself' (ibid:10) in modernity. Neurophysiologically and cybernetically resisting modern philosophical aesthetics, Buck-Morss founds her inquiry in a recognition that the nervous system is a 'sensory circuit' (ibid:13); an open system including the environment of the body in which both sensory stimuli are found, and actions are undertaken. The inclusion of the external world in what becomes a sensory 'field' (ibid:12) renders the 'so-called split between subject and object… [pronounced in modern philosophical aesthetics]…simply irrelevant' (ibid:12-

13). Buck-Morss terms her preferred conception of the nervous system 'the synaesthetic system' (ibid:14).

In the 19th century, drug-type anaesthetics revolutionized the field of medicine. They transformed surgery in phenomenological terms for both patient and surgeon. Dare we even imagine the horror of amputation before the advent of anaesthetics? But the utility of anaesthetizing drugs for surgical purposes was only realized because the (ab)use of narcotics such as nitrous oxide, opium, and cocaine was already widespread. 'Drug addiction is characteristic of modernity. It is the correlate and counterpart of shock.' (ibid:21). Indeed, at the same time 'a narcotic was made out of reality itself' (ibid:22). Drawing on the Freudian theory of consciousness as a protective barrier against excessive stimulation and thus a form of adaption to stress — a theory developed while Freud was thinking about war neuroses — Benjamin argued that in modern conditions, consciousness had become deployed in this protective capacity in an everyday setting, the latter now sensorially akin to the battlefield. The everyday experience of modernity, particularly in cities where industrialization was on the march and technologies increasingly mediated perception, was one of *shock*. Brutalized by machines, the synaesthetic system in modernity underwent a 'dialectical reversal, whereby aesthetics [read *aisthisis*] changes from a cognitive mode of being "in touch" with reality to a way of blocking out reality [read *aesthetics*], [and] destroys the human organism's power to respond politically even when self-preservation is at stake' (Buck-Morss 1992:18). What emerges is an '*an*aesthetics'… whose 'goal is to numb the organism, to deaden the senses' (ibid.). But modern technologies as they constitute the environment of the human organism are both the driver of the reversal and crucial to the new role of the synaesthetic system. Technology becomes the defence against modern shock: '(t)he powerfully prosthetic sense organs… are the new "ego" of a transformed synaesthetic system.' (ibid:33) The term

‘phantasmagoria’ was coined at the beginning of the 19th century to describe ‘optical illusions produced by magic lanterns…an appearance of reality that tricks the senses through technological manipulation.’ (ibid:22). The urban and domestic environments we have increasingly inhibited since the industrial revolution — as examples of ‘technoaesthetics’ (ibid) — have phantasmagorical effects, functioning to manipulate our senses in ways that protect them from the shock of reality. They anaesthetize us, but through ‘sensory distraction’ (ibid).

Amidst the new technologies, metaphors of society as a ‘techno-body’(ibid:30) took hold in politics and the newly established social sciences, founded on conceptions of the divisions of labour and their contribution to the functioning of the whole. In the abstract, society resembled the body of the anaesthetized patient that could be operated on, as it were, without provoking cries of anguish. Within this society, one now racked by machinic violence manifesting itself in ‘industrial and traffic accidents’ (ibid:32), a ‘Second Consciousness’ (Jünger quoted in Buck-Morss ibid) was emerging for the modern worker which drew them towards a realization of their own object-hood — revealing their status under capitalism as an unfeeling commodity ‘outside the zone of pain.’ (Jünger quoted in Buck-Morss ibid:33).

> In the “great mirror” of technology, the image that returns is displaced, reflected onto a different plane, where one sees oneself as a physical body divorced from sensory vulnerability — a statistical body, the behaviour of which can be calculated; a performing body, actions of which can be measured up against the “norm”; a virtual body, one that can ensure the shocks of modernity without pain. (Buck-Morss ibid).

We see reflected a *fragmented body,* and it is here that the ‘dilemma of perception’ (ibid.) arises which fascist (an)aesthetics provide an illusory solution to by manipulating the synaesthetic system. The rational surface image of the social whole threatens to dissolve the individual’s unitary perception of their own body. At the same time, if they do acquire

a perspective from which to see themselves as whole, they lose sight of the social body, risking isolation from society. In answer to this dilemma, fascism produces 'a phantasmagoria of the individual as part of a crowd that itself forms an integral whole' (ibid:35). Buck-Morss explains this by reference to Lacan's (1936) "mirror stage" in developmental psychology, the point at which the infant recognizes its own reflection and 'identifies with it as an imaginary bodily unity' (Buck-Morss ibid:37) but which also precipitates the ego's lifelong narcissistic fear of disintegration; the same fear evoked in adulthood for the individual by the dilemma of perception seen in the mirror of technology. But in the stadium at a fascist rally:

> the surface patterns provide a pleasing display of the whole letting the viewer forget the purpose of the display, the militarization of society for the teleology of making war. The aesthetics allows an anaesthetization of reception, a viewing of the "scene" with disinterested pleasure, even when that scene is the preparation through ritual of a whole society for unquestioning sacrifice and ultimately, destruction, murder, and death. (ibid:38)

And so, where fascist aesthetics attempt to alienate the senses of the public by producing a socio-technical phantasmagoria that ***dissembles***, at once, the fragmenting shock of modern existence in order to give the individual members of the audience a sense of bodily/egoic integrity; *and* the future bodily horrors at the perihelion of fascist teleology — it is the task of art (communist or not) to reveal them through *aisthisis:*

> [Benjamin] is demanding of art…to *undo* the alienation of the corporeal sensorium, to restore the instinctual power of the human bodily senses for the sake of humanity's self-preservation, and to do this, not by avoiding the new technologies, but by passing through them. (ibid:5)

The general thrust of this theorization is transposable to my own understanding of the optical dissolution conducted in Chapter 7. When successful, by means of sensory distraction (although not in terms of overstimulation: quite the opposite), the optics of BCIUAV research — which are in their own way 'technoaesthetics' (ibid:22) — function

to *anaesthetize* readers to the future bodily horrors being caused by the research in question, when the technology developed through the latter becomes artefactual. The optical affects aim to dull the reader's awareness either partially or totally of the pain to be experienced by fellow humans in futures, where otherwise, being able to perceive the latter might lead to the 'political response' (ibid:5) of cosmopolitan resistance in the present. On the contrary — albeit partially, imaginatively, speculatively — the analysis in Chapter 7 breaks through the anaesthetic framings of the research and its futures to reveal the bodily horrors being generated by NWR. The bodies conjured by the authors are *splayed out* on the operating table of the eye's mind, with the aim not only to describe, explain and potentially understand their workings: but to restore an awareness to the reader of what is actually at stake in the acts of research they were connected to by their creators.[250] Overall I find {Buck-Morss's interpretation of} Benjamin's demand for art is satisfied by anthropology as it appears in the optical dissolution: where two fictional human figures are dissected 'for the sake of humanity's preservation' (Buck-Morrs ibid:5).

There are traces of anaesthetics in the optics and affects of (amoral) anthropology critiqued in Chapter 8, too. Moral relativism and the extreme detachment this requires at its limits, anaesthetizes anthropologists and anthropology to the pain of others. The amoral anthropologist is anaesthetist-as-self-administered-patient. Adopting a narcotizing methodological attitude, they make themselves professionally *unresponsive* to the pain of others. The *flaneur*, one of Benjamin's other subjects — and who Langlitz explicitly evokes when considering how primates might perceive primatologists acting in the ethological mode — is:

[250] The former (describe-explain-understand) being integral to the latter, however.

> self-trained in this capacity of distancing oneself by turning reality into a phantasmagoria: rather than being caught up in the crowd, he slows his pace and observes it, making a pattern out of its surface. He sees the crowd as a reflection of his dream mood, an "intoxication" for his senses. (Buck-Morss 1992:24)

Beyond skilfully placing oneself in such a state — methodologically and/or with other psycho-active substances: 'there is, and can be, no privileged position outside of the multitude from which to operate. Such a place was, and remains, merely a fantasy of elites' (Stolze 2019:138). At least where life itself is at stake, we should not allow human beings to become mere figures in the magic lantern show of anthropology.

> The term art is used at times for the application of skill to human affairs —for enquiry directed to serving some individual or public interest, as in the art of government. Here opinions as to the role of social anthropology differ. (Firth 1958:15)

In the dappled range of opinion regarding anthropological 'enquiry directed to serving some individual or public interest' (1958:15), my own falls into a certain camp. I have spoken of my indignation towards KDU research and WR in the BCI sphere and beyond, but Chapter 8 is also driven by a sense of indignation towards amoral anthropology. In a recent essay (which was published after most of the thesis had been drafted) anthropologists Stade and Rapport (2022) discuss the concept of cruelty as it appears in liberal political philosophy, by triangulating it with the cruellest act of all — torture — and its 'contradistinction' (2022:15): love. However, key to their essay is another concept, 'metanoia':

> metanoia, a change of 'mind' or 'heart', is fundamental to the tortuous act of cruelty. The torturer makes a choice and takes a decision to undertake a particular course of action…This decision then has consequences for his or her existential state: it entails, in Borges's phrasing, a transcending of compassion. The practice of love, it can be argued, equally involves the process of metanoia, the mind of the lover being existentially changed, even to the extent that love is experienced as an epiphany… (Stade and Rapport 2022:14)

Theoretically, in the encounter between the insistence on non-interfering observation, and people and practices that threaten human life: amoral anthropology's methodological denial of the humanity of perpetrators of violence and lethality, occurs in the refusal to engage with them as others, who — unlike animals — *can* be reasoned with and *can* have a change of mind or heart. 'Humanity', here, inheres in the capacity to reflect, to (re)consider, to feel and think differently, and subsequently to (re)orient once's choices regarding action that affects others. It is therefore potentially the opportunity to exercise the capacity for, and to have the experience of, metanoia, that is being denied to perpetrators by an amoral anthropology taken to its extremes:[251] and precisely what anthropologists as human conservationists ought to facilitate and even provoke if possible. To do so can humanize the perpetrator, and by extension, the victim,[252] but also, as I have argued, can humanize the anthropologist too. The anthropologist has a choice to make about the methodological and thus moral stance they take towards others in their research, and in terms of how to act next.[253]

In an externalist sense, love is little without action. I have twisted and continue to twist out of shape Rapport's cosmopolitan anthropology where it concerns love, bending it back towards anthropology itself to paint a picture that contains a movement from the theoretical to the applied: because I feel that such a philosophical anthropological stance *tends towards action, yearns to act* — and cannot be satisfied merely to document human action. To act in accordance with the conservational imperative, and thus collapse the

[251] Metanoia is crucial to moral agency.

[252] The recalcitrance of many humans to act compassionately will entail anthropological movements towards the legal sphere, in attempts to compel them to behave differently, and thus perhaps ironically, to *enforce* cosmopolitan love. But this is for another work.

[253] As mentioned in Chapter 8 (fn236), I have tried to restrict the scope of the general level of the argument concerning anthropology to the issue of lethality, and thus the preservation of human life. Relativist worries about cross-culturally defining 'harm', which cannot be dealt with here, obstruct a blanket extension of the argument to cover the prevention of harm at this time.

distinction between academic/theoretical and applied anthropology, is to embrace 'practical love' in the Kantian sense:

> Practical love is the disposition to act benevolently towards those in need *independent of any relation of partisan feeling*…practical love manifests will — an object of individual command — and its principles are not of 'melting compassion' but of action (Kant 2002 [1785]: 31) (Rapport 2018:135).

To knowingly pursue dual use or weapons research is also a choice: to act in a way towards *Anyone Else* that could destroy them. Certainly, in all Red Flag cases of BCIUAV research: we are *beyond* the consideration of whether to do research we (could, should, or do) know to be potentially harmful and lethal. If we take military funding, or, if we openly describe the harmful uses of our work (and what's more, without demonstrating any kind of moral reflection alongside such pronouncements) then clearly the *use assessment* (Douglas 2014) is over, may even have been skipped over; and whether consciously, explicitly, intentionally, or not: a decision has been taken. But this does not preclude the changing of our hearts and minds, and choosing to act differently in future.

In terms of future action stemming from this thesis: awareness of and attitudes to PTK, KDU and NWR ought to be interrogated and addressed among the international BCI research community; particularly in and by the BCI Society. For the sake of human conservation, a conversation ought to be begun where there appears to be none. Arguments from a *concerned* and *non-scientific* perspective regarding PTK, KDU and NWR, perhaps offered by an anthropologist, ought to feature in this conversation, representing impersonally loving efforts towards the 'social negation' (Stade and Rapport 2022:3) of lethality, and thus by extension harm and cruelty. This may be a misguided venture, and the anthropologist must always remain open to counter-arguments as to why it might be morally sound to engage in KDU and NWR. But for now, the project seems sensible.

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Yin, G. and Gong, L., 2017, "Direction Control and Speed Control Combined Model of Motor-Imagery Based Brain-Actuated Vehicle", *2017 36th Chinese Control Conference (CCC)*, 2017, Technical Committee on Control Theory, CAA, pp. 2210-2214. DOI: 10.23919/ChiCC.2017.8027685

Yu, Y., He, D., Hua, W., Li, S., Qi, Y., Wang, Y., Pan, G., 2012, "Flyingbuddy2: A brain-controlled assistant for the handicapped," in Proceedings of the 2012 ACM Conference on Ubiquitous Computing, ser. Ubicomp '12. Ne w York, NY, USA:ACM, 2012, pp.669-670. DOI: 10.1145/2370216.2370359

Yuste, R., Goering, S., Arcas, B.A.Y., Bi, G., Carmena, J.M., Carter, A., Fins, J.J., Friesen, P., Gallant, J., Huggins, J.E., Illes, J., Kellmeyer, P., Klein, E., Marblestone, A., Mitchell, C., Parens, E., Pham, M., Rubel, A., Sadato, N., Sullivan, L.S., Teicher, M., Wasserman, D., Wexler, A., Whittaker, M. & Wolpaw, J. 2017, "Four ethical priorities for neurotechnologies and AI", *Nature (London)*, vol. 551, no. 7679, pp. 159-163.

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Zafar, A., Khan, M.J., Park, J. & Hong, K. 2018, "Initial-dip Based Quadcopter Control: Application to fNIRS-BCI", *IFAC-PapersOnLine*, vol. 51, no. 15, pp. 945-950. DOI: 10.1016/j.ifacol.2018.09.072

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Zhang, D. & Jackson, M.M. 2015, "Quadcopter navigation using Google Glass and brain-computer interface*"*. [Online]. *Georgia Institute of Technology*. Previously available at: https://www.cc.gatech.edu/~dzhang95/ [Accessed 02/12/2019].

Zhang, J. & Wang, M. 2021, "A survey on robots controlled by motor imagery brain-computer interfaces", *Cognitive Robotics*, vol. 1, pp. 12-24. DOI: 10.1016/j.cogr.2021.02.001

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Defense Update, 2020, *SKYLORD XTENDER*. [Online]. youtube.com. Last Updated: 06/10/2020. Available at: https://www.youtube.com/watch?v=NsL0LHi8Xjs [Accessed 18/11/2022]. Archived at: https://perma.cc/P9QH-FZDK

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University of Minnesota. (05/06/2013). *Model helicopter guided by power of thought*. [Online]. Nature Newsteam You Tube. Available at: https://www.youtube.com/watch?v=VSTLHBrTgD4 [Accessed 17/11/2022]. Archived at: https://perma.cc/5BQP-SB2C

Films

Avatar. 2009. [Film]. James Cameron. dir. United States: 20th Century Fox.

Firefox. 1982. [Film]. Clint Eastwood. dir. USA: Warner Bros.

Surrogates. 2009. [Film]. Jonathan Mostow. dir. USA: Walt Disney Studios.

Music

Lehrer, T. 1965, Werhner von Braun, *That Was The Year That Was*, [Vinyl] United States: Reprise Records.

Lehrer, T. 1959, We Will All Go Together When We Go, *More of Tom Lehrer*, [Vinyl] United States: Lehrer Records.

Appendix 1: BCIUAV Bibliography 2010-2021 — Chronological

The papers are arranged chronologically primarily by year of publication. In turn, they are chronologically ordered within those years according to the earliest date given with them i.e., received, accepted, published; or in the case of conference papers, within their year of publication according to the date of the conference they were delivered at.

2010

Akce, A., Johnson, M. & Bretl, T. 2010, "Remote Teleoperation of an Unmanned Aircraft with a Brain-Machine Interface: Theory and Preliminary Results", *2010 IEEE International Conference on Robotics and Automation*, pp. 5322-5327. DOI: 10.1109/ROBOT.2010.5509671

Conference date: May 3rd-7th 2010

Team Location: USA

Cites: None

Cited by: (Akce et al 2013; Nourmohammadi et al 2018; Tezza, Garcia et al 2019; Tezza, Caprio et al 2020, Hekmatmanesh et al 2021; Belkacem and Lakas 2021)

Number of citations: 6

Royer, A.S., Doud, A.J., Rose, M.L. & He, B. 2010, "EEG Control of a Virtual Helicopter in 3-Dimensional Space Using Intelligent Control Strategies", *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, vol. 18, no. 6, pp. 581-589. DOI: 10.1109/TNSRE.2010.2077654

Date: Received 4th June 2010, Accepted 8th September 2010, Published 27th September 2010, Date of Current Version 8th December 2010

Team Location: USA

Cites: None

Cited by: (Doud, Lucas and He 2011; Doud et al 2011; Akce et al 2013; LaFleur et al 2013; Kim et al 2014; Kosmyna et al 2015b, Das et al 2016; Meriño et al 2017; Peining et al 2017; Nourmohammadi et al 2017; Duan et al 2019; López et al 2020a; Chen et al 2020; Mei et al 2020; Kapgate 2021; Hekmatmanesh et al 2021)

Number of citations: 16

2011

Doud, A.J., Lucas, J.P. & He, B. 2011, “Continuous 3D control of a virtual helicopter using a motor imagery based BCI”, *2011 5th International IEEE/EMBS Conference on Neural Engineering*, IEEE, pp.364-367. DOI: 10.1109/NER.2011.5910562

Conference date: 27th April – 1st of May 2011

Team Locations: USA

Cites: (Royer et al 2010)

Cited by: LaFleur et al 2013

Number of citations: 1

Doud, A.J., Lucas, J.P., Pisansky, M.T. & He, B. 2011, "Continuous Three-Dimensional Control of a Virtual Helicopter Using a Motor Imagery Based Brain-Computer Interface (Continuous 3D Control Using EEG Based BCI)", *PLoS ONE*, vol. 6, no. 10, pp. e26322. DOI: 10.1371/journal.pone.0026322

Date: Received 24th June 2011, Accepted September 23rd 2011, Published 26th October 2011

Team Location: USA

Cites: (Royer et al 2010)

Cited by: (LaFleur et al 2013; Kim et al 2014; Kosmyna et al 2015b; Das et al 2016; Meriño et al 2017; Peining et al 2017; Nourmohammadi et al 2018; Duan et al 2019; Yang and Hong 2019; López et al 2020a; Mei et al 2020; Hekmatmanesh et al 2021)

Number of citations: 12

2012

Yu, Y., He, D., Hua, W., Li, S., Qi, Y., Wang, Y., Pan, G., 2012, “Flyingbuddy2: A brain-controlled assistant for the handicapped,” in Proceedings of the 2012 ACM Conference on Ubiquitous Computing, ser. Ubicomp ’12. New York, NY, USA:ACM, 2012, pp.669-670. DOI: 10.1145/2370216.2370359

Conference date: 5th-8th September 2012

Team Location: China

Cites: None

Cited by: Peining et al 2017; Chiuzbaian et al 2019; López et al 2020a, 2020b)

Number of citations: 4

2013

Akce, A., Johnson, M., Dantsker, O. & Bretl, T. 2013, "A Brain-Machine Interface to Navigate a Mobile Robot in a Planar Workspace: Enabling Humans to Fly Simulated Aircraft With EEG", *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, vol. 21, no. 2, pp. 306-318. DOI: 10.1109/TNSRE.2012.2233757

Date: Received 22nd April 2012, Accepted 25th November 2012, Published 13th December 2012, Current version 7th March 2013

Team Location: USA

Cites: (Akce et al 2010; Royer et al 2010)

Cited by: None

Number of citations: 0

LaFleur, K., Cassady, K., Doud, A., Shades, K., Rogin, E. & He, B. 2013, "Quadcopter control in three-dimensional space using a noninvasive motor imagery-based brain–computer interface", *Journal of Neural Engineering*, vol. 10, no. 4, pp. 1-15. DOI: 10.1088/1741-2560/10/4/046003

Date: Received 10th March 2013, Accepted 2nd May 2013, Published 4th June 2013

Team Location: USA

Cites: (Royer et al 2010; Doud, Lucas and He 2011; Doud et al 2011)

Cited by: (Kim et al 2014; Khan, Hong, Naseer and Bhutta 2015; Kosmyna et al 2015b; Zhang and Jackson 2015; Das et al 2016; Song et al 2016; Meriño et al 2017; Khan and Hong 2017; Khan, Zafar and Hong 2017a; Peining et al 2017; Corichi et al 2019; Khan, Zafar and Hong 2017b; Nourmohammadi et al 2018; Vijayendra et al 2018; Wang, Li, Zhang, Li, Zhang 2018; Zafar, Ghafoor, Khan and Hong 2018; Vishwanath et al 2018; Mazumder et al 2018; Duan et al 2019; Christensen et al 2019; Chiuzbaian et al 2019; Kavichai et al 2019; Yu et al 2019; Yang and Hong 2019; Tezza and Andujar 2019; Paszkiel et l 2020; López et al 2020a; Chen et al 2020; Yan et al 2020; Choi and Jo 2020; Mei et al 2020; Chhabra et al 2020; Parikh and George 2020; Zhang and Wang 2021; Kapgate 2021; Wu et al 2021; Hekmatmanesh et al 2021; Brnestad and Vatsvag 2021; Dumitrescu et al 2021)

Number of citations: 39

2014

Kosmyna, N., Tarpin-Bernard, F. & Rivet, B. 2014a, **"**Bidirectional Feedback in Motor Imagery BCIs: Learn to Control a Drone within 5 Minutes", *CHI '14 Extended Abstracts on Human Factors in Computing Systems*, pp. 479-482. DOI: 10.1145/2559206.2574820

Conference date: April 26th – May 1st , 2014

Team Location: France

Cites: None

Cited by: (Nourmohammadi et al 2018, Tezza and Andujar 2019)

Number of citations: 2

Kim, B.H., Kim, M. & Jo, S. 2014, "Quadcopter flight control using a low-cost hybrid interface with EEG-based classification and eye tracking", *Computers in biology and medicine,* vol. 51, pp. 82-92. DOI: 10.1016/j.compbiomed.2014.04.020

Date: Accepted 29th April 2014

Team Location: South Korea

Cites: (Royer et al 2010; Doud et al 2011; LaFleur et al 2013)

Cited by: (Das et al 2016; Song et al 2016; Khan and Hong 2017; Peining et al 2017; Khan, Zafar and Hong 2017b; Nourmohammadi et al 2018; Vijayendra et al 2018; Duan et al 2019; Chiuzbaian et al 2019; Kavichai et al 2019; Yang and Hong 2019; Tezza and Andujar 2019; Shi et al 2019; López et al 2020a, Yan et al 2020; López et al 2020b; Kapgate 2021; Hekmatmanesh et al 2021)

Number of citations: 18

Kosmyna, N., Tarpin-Bernard, F. & Rivet, B. 2014b, "Drone, Your Brain, Ring Course – Accept the Challenge and Prevail!" *Proceedings of the 2014 ACM International Joint Conference on pervasive and ubiquitous computing*, pp. 243-246. DOI: 10.1145/2638728.2638785

Conference date:13th-17th September 2014

Team Location: France

Cites: None

Cited by: (Nourmohammadi et al 2018; Tezza and Andujar 2019; Zhang and Wang 2021)

Number of citations: 3

2015

Shi, T., Wang, H. & Zhang, C. 2015, "Brain Computer Interface system based on indoor semi-autonomous navigation and motor imagery for Unmanned Aerial Vehicle control", *Expert Systems with Applications,* vol. 42, no. 9, pp. 4196-4206. DOI: 10.1016/j.eswa.2015.01.031

Date: Available online 24th January 2015

Team Location: China

Cites: None

Cited by: (Song et al 2015; Yin and Gong 2017; An et al 2017; Nourmohammadi et al 2018; Rho and Jo 2018; Duan et al 2019; Tezza and Andujar 2019; Shi et al 2019; Lopez et al 2020a; Yan et al 2020; Mei et al 2020; López et al 2020b; Zhang and Wang 2021; Kapgate 2021; Hekmatmanesh et al 2021; Ramos et al 2021)

Number of citations: 16

Lin, J-S.,Jiang, Z-Y., 2015, "Implementing Remote Presence Using Quadcopter Control by a Non-Invasive BCI Device". *Computer Science and Information Technology*. 3(4), pp.122-126. DOI:10.13189/csit.2015.030405

Date: July 2015

Team location: Taiwan

Cites: None

Cited by: (Nourmohammadi et al 2018; Chiuzbainan et al 2019; Yang and Hong 2019; Tezza and Andujar 2019; López et al 2020a; Chhabra et al 2020; López et al 2020b; Hekmatmanesh et al 2021)

Number of citations: 8

Khan, M.J., Keum-Shik Hong, Naseer, N. & Bhutta, M.R. 2015, "Hybrid EEG-NIRS based BCI for quadcopter control", *2015 54th Annual Conference of the Society of Instrument and Control Engineers of Japan (SICE)*, pp.1177-1182. DOI: 10.1109/SICE.2015.7285434

Conference date: July 28th-30th 2015

Team location: South Korea

Cites: (La Fleur et al 2013)

Cited by: (Khan, Zafar and Hong 2017a, 2017b; Nourmohammadi et al 2018; Yang and Hong 2019; Tezza and Andujar 2019; López et al 2020a; Chen et al 2020; Choi and Jo 2020; Parikh and George 2020; López et al 2020b; Zhang and Wang 2021; Hekmatmanesh et al 2021)

Number of citations: 12

Kosmyna, N., Tarpin-Bernard, F. & Rivet, B. 2015a, "Brains, computers, and drones: think and control", *Interactions (New York, N.Y.)*, vol. 22, no. 4, pp. 44-47. DOI: 10.1145/2782758

Date: July-August 2015 edition

Team location: France

Cites: (Kosmyna et al 2014a)

Cited by: None

Number of citations: 0

Song, Y., Liu, J., Gao, Q. & Liu, M. 2015, "A Quadrotor Helicopter Control System Based on Brain-Computer Interface", *2015 IEEE International Conference on Mechatronics and Automation (ICMA)*, IEEE, pp. 1478-1483. DOI: 10.1109/ICMA.2015.7237703

Conference date: 2nd- 5th August 2015

Team location: China

Cites: (Shi et al 2015)

Cited by: None

Number of citations: 0

Kosmyna, N., Tarpin-Bernard, F. & Rivet, B. 2015b, Towards brain computer interfaces for recreational activities: Piloting a drone. *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 9296(Part I), pp.506–522. DOI: 10.1007/978-3-319-22701-6_37

Conference date: 14th – 18th September 2015

Team location: France

Cites: (Royer et al 2010; Doud et al 2011; LaFleur et al 2013)

Cited by: (Peining et al 2017; Nourmohammadi et al 2018; Chiuzbaian et al 2019; Tezza and Andujar 2019; López et al 2020a, 2020b; Kapgate 2021; Hekmatmanesh et al 2021)

Number of citations: 8

Zhang, D., Jackson, M.M, 2015, "Quadcopter navigation using Google Glass and brain-computer interface*"*. [Online]. *Georgia Institute of Technology*. Previously available at: https://www.cc.gatech.edu/~dzhang95/ [Accessed 02/12/2019].

No date given

Team location: USA

Cites: (LaFleur et al 2013)

Cited by: (Nourmohammadi et al 2018; Tezza and Andujar 2019; Zhang and Wang 2021; Hekmatmanesh et al 2021)[254]

Number of citations: 4

2016

Das, A.K., Tan, T.L., Suresh, S. & Sundararajan, N. 2016, "Meta-cognitive Interval Type-2 Fuzzy Controller for Quadcopter Flight Control- An EEG based Approach", *2016 IEEE International Conference on Fuzzy Systems (FUZZ-IEEE)*, pp. 2501-2507. DOI: 10.1109/FUZZ-IEEE.2016.7738008

Conference date: 24th – 29th July 2016

Team location: Singapore

Cites: Royer et al 2010; Doud et al 2011; LaFleur et al 2013; Kim et al 2014; Lin and Jiang 2015)

Cited by: (Duan et al 2019)

Number of citations: 1

Chen, Y., Chen, S., Zaeni, I. & Wu, C. 2016, "Fuzzy Tracking and Control Algorithm for an SSVEP-Based BCI System", *Applied sciences*, vol. 6, no. 10, pp. 1-11. DOI: 10.3390/app6100270

Date: 22nd September 2016

Team location: Taiwan

Internal citations: None

Cited by: None

Number of citations: 0

Song, X., Mann, K., Allison, E., Suk-Chung Yoon, Hila, H., Muller, A. & Gieder, C. 2016, "A Quadcopter Controlled by Brain Concentration and Eye Blink", *2016 IEEE Signal Processing in Medicine and Biology Symposium (SPMB)*, pp.1-4. DOI: 10.1109/SPMB.2016.7846875

Conference date: 3rd December

Team location: USA

Cites: (LaFleur et al 2013; Kim et al 2014)

Cited by: None

[254] Interestingly, all the papers that cite Zhang and Jackson (2015) are review papers.

Number of citations: 0

2017

Meriño, L., Nayak, T., Kolar, P., Hall, G., Mao, Z., Pack, D.J. & Huang, Y. 2017, "Asynchronous control of unmanned aerial vehicles using a steady-state visual evoked potential-based brain computer interface", *Brain-computer Interfaces*, vol. 4, no. 1, pp. 122-135. DOI: 10.1080/2326263X.2017.1292721

Dates: Received 30th July 2016, Accepted 6th Feb 2017, Published 5th March 2017

Team location: USA

Cites: (Royer et al 2010; Doud et al 2011; LaFleur et al 2013)

Cited by: (Yan et al 2020; Choi and Jo 2020; Parikh and George 2020)

Number of citations: 3

Khan, M.J. & Hong, K. 2017, "Hybrid EEG-fNIRS-Based Eight-Command Decoding for BCI: Application to Quadcopter Control", *Frontiers in neurorobotics*, vol. 11, no. 6, pp. 1-13. DOI: 10.3389/fnbot.2017.00006

Dates: Received: 25 October 2016 Accepted: 24 January 2017 Published: 17 February 2017

Team location: South Korea

Cites: (LaFleur et al 2013; Kim et al 2014)

Cited by: (Khan, Zafar and Hong 2017b; Zafar, Khan, Park and Hong 2018; Zafar, Ghafoor, Khan and Hong 2018; Zafar, Ghafoor, Yaqub and Hong 2019; Kavichai et al 2019; Yang and Hong 2019; López et al 2020a; Yan et al 2020; López et al 202b; Kapgate 2021; Hekmatmanesh et al 2021)

Number of citations: 11

Khan, M.J., Zafar, A., Hong, K-S. 2017a, "Hybrid EEG-NIRS based active command generation for quadcopter movement control," *2016 International Automatic Control Conference (CACS)*, pp. 200-205. DOI: 10.1109/CACS.2016.7973909.

Conference date: 9th-11th November 2016

Team location: South Korea

Cites: (LaFleur et al 2013; Kim et al 2014; Khan, Hong, Naseer and Bhutta 2015)

Cited by: (Kahn, Zafar and Hong 2017b; Hekmatmanesh et al 2021)

Number of citations: 2

Peining, P., Tan, G., Wai, P., Aung, A., 2017, Evaluation of consumer-grade EEG headsets for BCI drone control. *IRC conference on science, engineering, and technology*, pp.1-6. [Online]. Available at: https://oar.a-star.edu.sg/communities-collections/articles/13648 [Accessed 17 December 2022]. Archived at: https://perma.cc/TKZ2-PB54

Conference date: 21st – 22nd April 2017

Team location: China

Cites: (Royer et al 2010; Doud et al 2011; Yu et al 2012; LaFleur et al 2013; Kim et al 2014; Kosmyna et al 2015b)

Cited by: (Marin et al 2020)

Number of citations: 1

Yin, G. and Gong, L., 2017, "Direction Control and Speed Control Combined Model of Motor-Imagery Based Brain-Actuated Vehicle", *2017 36th Chinese Control Conference (CCC)*, 2017, Technical Committee on Control Theory, CAA, pp. 2210-2214. DOI: 10.23919/ChiCC.2017.8027685

Conference date: 26-28 July 2017

Team location: China

Cites: (Shi et al 2015)

Cited by: None

Number of citations: 0

Santos, A.R., Cordeiro, G.N., Becchi, G.C., Ayala, H.V.H., Mariani, V.C.,Coelho, L.S., 2017, "Quadcopter Control Based on Electroencephalogram Headset and Hybrid Fuzzy Classifier", In, Frasson, C. & Kostopoulos, G.K., *Brain function assessment in learning : first International Conference, BFAL 2017, Patras, Greece, September 24-25, 2017, proceedings*, Springer, Cham, Switzerland, pp. 209-210. DOI: 10.1007/978-3-319-67615-9

Date: 24th-25th September 2017

Team location: Brazil

Cites: None

Cited by: None

Number of citations: 0

Corichi, E.Z., Carranza, J.M., García, C.,Alberto Reyes & Pineda, L.V. 2019,"A Framework Based on Eye-Movement Detection from EEG Signals for Flight Control of a Drone", *Advances in Computational Intelligence*, Cham: Springer International Publishing, Cham, pp.338-353. DOI: 10.1007/978-3-030-02840-4_28

Date: 23rd-28th October 2017

Team location: Mexico

Cites: (LaFleur et al 2013)

Cited by: None

Number of citations: 0

Mamani, M.A. & Yanyachi, P.R. 2017, "Design of Computer Brain Interface for Flight Control of Unmanned Air Vehicle using Cerebral Signals through Headset Electroencephalograph", *2017 IEEE International Conference on Aerospace and Signals (INCAS)*, pp. 1-4. DOI: 10.1109/INCAS.2017.8123499

Conference date: 8th – 10th November 2017

Team location: Peru

Cites: None

Cited by: None

Number of citations: 0

An, Y., Shi, T., Ren, L., Liu, W. & Jiang, X. 2017, "UAV Control in 2D Space Based on Brain Computer Interface", *2017 4th International Conference on Systems and Informatics (ICSAI)*, pp.594-598. DOI: 10.1109/ICSAI.2017.8248359

Conference date:11th-13th November 2017

Team location: China

Cites: (Shi et al 2015)

Cited by: None

Number of citations: 0

Khan, M.J., Zafar, A. & Hong, K-S. 2017b, “Hybrid EEG-Fnirs based quadcopter control using active prefrontal commands”, *2017 International Automatic Control Conference (CACS)*, IEEE, pp. 1-6. DOI: 10.1109/CACS.2017.8284260

Conference date: 12th -15th November 2017

Team location: South Korea

Cites: (LaFleur et al 2013; Kim et al 2014; Khan, Hong, Naseer and Bhutta 2015; Khan and Hong 2017; Khan, Zafar and Hong 2017a)

Cited by: None

Number of citations: 0

2018

Nourmohammadi, A., Jafari, M. & Zander, T.O. 2018, "A Survey on Unmanned Aerial Vehicle Remote Control Using Brain-Computer Interface", *IEEE Transactions on Human-Machine Systems*, vol. 48, no. 4, pp. 337-348. DOI: 10.1109/THMS.2018.2830647

Date: Received July 17, 2017; Revised December 6, 2017 and February 26, 2018; Accepted April 14, 2018; Published May 22, 2018; Current version July 13, 2018

Team member locations: Netherlands x1, USA x2

Cites: Akce et al 2010; Royer et al 2010, Doud et al 2011, LaFleur et al 2013, Kim et al 2014; Kosmyna 2014a, 2014b, 2015b; Khan, Hong, Naseer and Bhutta 2015; Shi et al 2015; **Zhang and Jackson 2015**; Lin and Jiang 2015)

Cited by: (Tezza, Garcia et al 2019; Tezza and Andujar 2019; López et al 2020a; Yan et al 2020; Al-Nuaimi et al 2020; Zhang and Wang 2021; Kapgate 2021; Hekmatmanesh et al 2021)

Number of citations: 8

Rosca, S., Leba, M., Ionica, A. & Gamulescu, O. (2018). Quadcopter control using a BCI. *Conference Series: Materials and Science Engineering*. 294(1), pp.1-15. DOI: 10.1088/1757-899X/294/1/012048

Date: Accepted papers received 22nd December 2017, Published online 12th January 2018

Team location: Romania

Cites: None

Cited by: (Kavichai et al 2019; Dumitrescu et al 2021)

Number of citations: 2

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Conference date:15th-17th January 2018

Team location: South Korea

Cites: (Shi et al 2015)

Cited by: None

Number of citations: 0

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Conference date: 31st January to February 2nd 2018

Team location: India

Cites: (LaFleur et al 2013; Kim et al 2014)

Cited by: (Vishwanath et al 2018; Zhang and Wang 2021)

Number of citations: 2

Wang, M., Li, R., Zhang, R., Li, G. & Zhang, D. 2018, "A Wearable SSVEP-Based BCI System for Quadcopter Control Using Head-Mounted Device", *IEEE Access*, vol. 6, pp. 26789-26798. DOI: 10.1109/ACCESS.2018.2825378

Dates: Received February 5, 2018, Accepted March 12, 2018, Published April 10, 2018, date of current version June 5, 2018

Team location: China

Cites: (LaFleur et al 2013)

Cited by: Duan et al 2019; Gao et al 2019; Yang and Hong 2019; López et al 2020a; Yan et al 2020; Ishizuka et al 2020; Choi and Jo 2020; Mei et al 2020; Wang, Ke, Liu et al 2020; Parikh and George 2020; Kapgate 2021; Hekmatmanesh et al 2021; Kim et al 2021)

Number of citations: 13

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Conference date: 29th – 31st March 2018

Team location: USA

Cites: None

Cited by: (Kavichai et al 2019)

Number of citations: 1

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Conference date: 21st -23rd May 2018

Team location: China

Cites: None

Cited by: None

Number of citations: 0

Ribe, A., Krohn, K.H. 2018, EEG-based Brain Computer Interface for Controlling a Drone - using machine learning, optimized for a battery powered dev. *Master's Thesis*. [Online]. Available at: https://ntnuopen.ntnu.no/ntnu-xmlui/handle/11250/2560785 [Accessed 17 December 2022].

Date: 6th June 2018

Team location: Norway

Cites: None

Cited by: (Kavichai et al 2019)

Number of citations: 1

Zafar, A., Khan, M.J., Park, J. & Hong, K. 2018, "Initial-dip Based Quadcopter Control: Application to fNIRS-BCI", *IFAC-PapersOnLine*, vol. 51, no. 15, pp. 945-950. DOI: 10.1016/j.ifacol.2018.09.072

Conference date: 9th – 11th July 2018

Team location: South Korea

Cites: (LaFleur et al 2013; Khan and Hong 2017)

Cited by: (Yang and Hong 2019; Hekmatmanesh et al 2021)

Number of citations: 2

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Conference date: 18th – 21st July 2018

Team location: South Korea

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Cited by: (Hekmatmanesh et al 2021)

Number of citations: 1

Vishwanath, R.M., Kumaar, S., Omkar, S.N. 2018. A Real-time Control Approach for Unmanned Aerial Vehicles using Brain-computer Interface. *Arxiv*. DOI: 10.48550/arxiv.1809.00346

Date: Uploaded 2nd September

Team location: India

Cites: (LaFleur et al 2013; **Vijayendra et al 2018**)

Cited by: (Hekmatmanesh et al 2021; Ramos et al 2021)

Number of citations: 2

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No date

Team location: USA

Cites: (LaFleur et al 2013)

Cited by: None

Number of citations: 0

2019

Duan, X., Xie, S., Xie, X., Meng, Y. & Xu, Z. 2019, "Quadcopter Flight Control Using a Non-invasive Multi-Modal Brain Computer Interface", *Frontiers in Neurorobotics*, vol. 13, no.23, pp. 1-11. DOI: 10.3389/fnbot.2019.00023

Date: Received 30th November 2018, Accepted 25th April 2019, Published 31st May 2019

Team location: China

Cites: (Royer et al 2010; Doud et al 2011; LaFleur et al 2013; Kim et al 2014; Shi et al 2015; Das et al 2016; Wang, Li, Zhang, Li and Zhang 2018)

Cited by: (Yan et al 2020; Mei et al 2020; Kapgate 2021; Hekmatmanesh et al 2021; Brynestad, K. & Vatsvåg 2021; Dumitrescu et al 2021)

Number of citations: 6

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Conference date: 16th -18th January 2019

Team location: South Korea

Cites: (Khan and Hong 2017)

Cited by: None

Number of citations: 0

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Conference date: 18th- 20th February 2019

Team location: Denmark

Cites: (Yu et all 2012; LaFleur et al 2013;Kim et al 2014; Lin and Jiang 2015; Kosmyna et al 2015b)

Cited by: (Chhabra et al 2020; Kapgate et al 2021; Hekmatmanesh et al 2021; Dumitrescu et al 2021)

Number of citations: 4

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Conference on Brain-Computer Interface (BCI), IEEE, pp. 1-6. DOI: 10.1109/IWW-BCI.2019.8737263

Conference date: 18-20th February 2019

Team location: Denmark

Cites: (LaFleur et al 2013)

Cited by: (Kapgate 2021)

Number of citations: 1

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Conference date: 10th-13th July 2019

Location of team: South Korea

Cites: LaFleur et al 2013; Kim et al 2014; Khan and Hong 2017; Rosca et al 2018; North et al 2018; Ribe and Krohn 2018)

Cited by: (Hekmatmanesh et al 2021)

Number of citations: 1

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Dates: Received 11 July 2019; Revised 21 November 2019; Accepted 27 November 2019; Published 16 December 2019

Team location: China

Cites: (Wang, Li, Zhang, Li and Zhang 2018)

Cited by: None

Number of citations: 0

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Conference date: 26th -31st July 2019

Team location: USA)

Cites: (Akce et al 2010; **Nourmohammadi et al 2018**)

Cited by: (Tezza and Andujar 2019; Tezza, Caprio et al 2020)

Number of citations: 2

Yu, Y., Garrison, H., Battison, A., Gabel, L., 2019, “Control of a Quadcopter with Hybrid Brain-Computer Interface”. *2019 IEEE International Conference on Systems, Man and Cybernetics (SMC)*, pp. 2779-2784. DOI: 10.1109/SMC.2019.8914579

Conference date: 6th-9th October 2019

Team location: USA

Cites: (LaFleur et al 2013)

Cited by: None

Number of citations: 0

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Conference date: 15th-18th October 2019

Team location: South Korea

Cites: (Doud et al 2011; LaFleur et al 2013; Kim et al 2014; Khan, Hong, Naseer and Bhutta 2015; Lin and Jiang 2015; Khan and Hong 2017;; Wang, Li, Zhang, Li, Zhang 2018; Zafar, Khan, Park and Hong 2018)

Cited by: None

Number of citations: 0

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Conference date: 17th -19th October 2019

Team location: China

Cites: None

Cited by: None

Number of citations: 0

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Conference date: 17th-19th October 2019

Team location: China

Cites: None

Cited by: None

Number of citations: 0

Tezza, D., Andujar, M., 2019, "The State-of-the-Art of Human–Drone Interaction: A Survey", *IEEE Access*, vol. 7, pp. 167438-167454. DOI: 10.1109/ACCESS.2019.2953900.

Date: 18th November 2019

Team location: USA

Cites: (LaFleur et al 2013; Kim et al 2014; Kosmyna et al 2014a, 2014b; Shi et al 2015; Lin and Jiang 2015; Khan, Hong, Naseer and Bhutta 2015; Kosmyna et al 2015b; **Zhang and Jackson 2015**; **Nourmohammadi et al 2018**; Tezza, Garcia, Hossain and Andujar 2019)

Cited by: (Tezza, Caprio et al 2020; Kapgate 2021)

Number of citations: 2

Shi, T., Wang, H., Cui, W. & Ren, L. 2019, "Indoor space target searching based on EEG and EOG for UAV", *Soft computing (Berlin, Germany)*, vol. 23, no. 21, pp. 11199-11215. DOI: 10.1007/s00500-018-3670-3

Date: 28th November

Team location: China

Cites: (Kim et al 2014; Shi et al 2015)

Cited by: None

Number of citations: 0

2020

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Date: February 2019

Team location: Poland

Cites: (LaFleur et al 2013)

Cited by: None

Number of citations: 0

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Conference date: 12th-14th April 2019

Team location: India

Cites: None

Cited by: None

Number of citations: 0

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Dates: Received 7 May 2019; Revised 22 August 2019; Accepted 14 September 2019, Available online 18 September 2019

Team location: Mexico

Cites: (Royer et al 2010; Doud et al 2011; Yu et al 2012; LaFleur et al 2013; Kim et al 2014; Kosmyna 2014a; Shi et al 2015; Lin and Jiang 2015; Khan, Hong, Naseer and Bhutta 2015; Kosmyna 2015b; Khan and Hong 2017; **Nourmohammadi et al 2018**; Wang, Li, Zhang, Li and Zhang 2018)

Cited by: None

Number of citations: 0

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Dates: Received July 12, 2019; Accepted November 5, 2019, Published in March 2020 edition

Team location: China

Cites: Royer et al 2010; LaFleur et al 2013; Khan, Hong, Naseer and Bhutta 2015)

Cited by: (Al-Nuaimi et al 2020; Hekmatmanesh et al 2021; Belkacem and Lakas 2021)

Number of citations: 3

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Conference date: 15th – 18th August 2019

Team location: Mexico

Cites: (Yu et al 2012; Kim et al 2014; Shi et al 2015; Lin and Jiang 2015; Khan, Hong, Naseer and Bhutta 2015;Kosmyna et al 2015b; Khan and Hong 2017)

Cited by: None

Number of citations: 0

Yan, N., Wang, C., Tao, Y., Li, J., Zhang, K., Chen, T., Yuan, Z., Yan, X. & Wang, G. 2020, "Quadcopter Control System Using a Hybrid BCI Based on Off-Line Optimization and Enhanced Human-Machine Interaction", *IEEE access*, vol. 8, pp. 1160-1172. DOI: 10.1109/ACCESS.2019.2961246

Dates: Received December 10, 2019, Accepted December 17, 2019, Published December 20, 2019, date of current version January 3, 2020

Team location: China

Cites: (LaFleur et al 2013; Kim et al 2014; Shi et al 2015; **Meriño et al 2017**; Khan and Hong 2017; **Nourmohammadi et al 2018**; Wang, Li, Zhang, Li and Zhang 2018; **Duan et al 2019**)

Cited by: (Zhang and Wang 2021)

Number of citations: 1

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Date: Submission 2nd February 2020; Acceptance 20th February 2020; Published 30th March 2020

Team location: Malaysia

Cites: None

Cited by: None

Number of citations: 0

Ishizuka, K., Kobayashi, N. & Saito, K. 2020, "High Accuracy and Short Delay 1ch-SSVEP Quadcopter-BMI Using Deep Learning", *Journal of robotics and mechatronics*, vol. 32, no. 4, pp. 738-744. DOI: 10.20965/jrm.2020.p0738

Date: Received February 20th , 2020; Accepted June 8, 2020

Team location: Japan

Cites: (Kim et al 2014; Wang, Li, Zhang, Li and Zhang 2018)

Cited by: None

Number of citations: 0

Choi, J. & Jo, S., 2020, "Application of Hybrid Brain-Computer Interface with Augmented Reality on Quadcopter Control". *2020 8th International Winter Conference on Brain-Computer Interface (BCI), IEEE*, pp.1-5 DOI: 10.1109/BCI48061.2020.9061659

Conference date: 26th -28th February 2020

Team location: South Korea

Cites: (LaFleur et al 2013; Khan, Hong, Naseer and Bhutta 2015; **Meriño et al 2017**; Wang, Li, Zhang, Li and Zhang 2018)

Cited by: (Zhang and Wang 2021)

Number of citations: 1

Martinez-Ledezma, J., Barron-Zambrano, J., Diaz-Manriquez, A., Elizondo-Leal, J., Saldivar-Alonso, V. & Rostro-Gonzalez, H. 2020, "Versatile implementation of a hardware–software architecture for development and testing of brain–computer interfaces", *International journal of advanced robotic systems*, vol. 17, no. 6, pp. 1-18. DOI: 10.1177/1729881420980256

Date: Received 2nd June 2020; Accepted 18th November 2020

Team location: Mexico

Cites: None

Cited by: None

Number of citations: 0

Marin, I., Al-Battbootti, M. J. H., Goga,N., 2020, "Drone Control based on Mental Commands and Facial Expressions". *2020 12th International Conference on Electronics, Computers and Artificial Intelligence (ECAI)*, pp.1-4. DOI:10.1109/ECAI50035.2020.9223246.

Conference date: 25th-27th June

Team location: Romania

Cites: (Peining et al 2017)

Cited by: None

Number of citations: 0

Tezza, D., Caprio, D., Garcia, S., Pinto, B., Laesker, D., Andujar, M., 2020, Brain-Controlled Drone Racing Game: A Qualitative Analysis. In: Fang, X. (eds) *HCI in Games*. *HCII 2020*. *Lecture Notes in Computer Science*, vol 12211. Springer, Cham, pp.350-360. DOI: 10.1007/978-3-030-50164-8_25

Conference date: 19th – 24th July 2020

Team location: USA

Cites: Akce et al 2010; Tezza and Andujar 2019; Tezza, Garcia, Hossain and Andujar 2019)

Cited by: None

Number of citations: 0

Al-Nuaimi, F.A., Al-Nuaimi, R.J., Al-Dhaheri, S.S., Ouhbi, S., Belkacem, A.N., 2020, "Mind Drone Chasing Using EEG-based Brain Computer Interface", *2020 16th International Conference on Intelligent Environments (IEEE)*, pp.74-79. DOI: 10.1109/IE49459.2020.9154926.

Conference date: 20th – 23rd July 2020

Team location: UAE

Cites: (**Nourmohammadi et al 2018**; Chen et al 2020)

Cited by: (Belkacem and Lakas 2021)

Number of citations: 1

Mei, J., *et al*., 2020, "Using SSVEP-BCI to Continuous Control a Quadcopter with 4-DOF Motions*," *2020 42nd Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC)*, 2020, pp. 4745-4748, DOI: 10.1109/EMBC44109.2020.9176131

Conference date: 20th-24th July 2020

Team location: China

Cites: (Royer et al 2010; Doud et al 2011; LaFleur et al 2013; Shi et al 2015; Wang, Li, Zhang, Li and Zhang 2018; **Duan et al 2019**)

Cited by: (Brynestad, K. & Vatsvåg 2021)

Number of citations: 1

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Conference date: 25th – 26th July 2020

Team location: China

Cites: (Wang, Li, Zhang, Li and Zhang 2018)

Cited by: None

Number of citations: 0

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Conference date: 11th-14th October 2020

Team location: India

Cites: (LaFleur et al 2013; Lin and Jiang 2015; Chiuzbaian et al 2019

Cited by: None

Number of citations: 0

Parikh, D., George, K., 2020, "Quadcopter Control in Three-Dimensional Space Using SSVEP and Motor Imagery-Based Brain-Computer Interface", *2020 11th IEEE Annual Information Technology, Electronics and Mobile Communication Conference (IEMCON)*, pp.0782-0785. DOI: 10.1109/IEMCON51383.2020.9284924

Conference date: 4th-7th November 2020

Team location: USA

Cites: (LaFleur et al 2013; Khan, Hong, Naseer and Bhutta 2015; **Meriño et al 2017**; Wang, Li, Zhang, Li and Zhang 2018)

Cited by: None

Number of citations: 0

2021

Reddy, M.H.H.N., 2021, Brain Computer Interface Drone, In, Asadpour, V., Engelbrecht (Eds). *Brain-Computer Interface*. IntechOpen. DOI: 10.5772/intechopen.97558

Dates: Received January 18th 2021, Reviewed April 2nd 2021, Published May 20th 2021

Author location: India

Cites: None

Cited by: None

Number of citations: 0

Choi, J.W., Kim, B.H. & Jo, S. 2021, “Asynchronous Motor Imagery Brain-Computer Interface for Simulated Drone Control”. *2021 9th International Winter Conference on Brain-Computer Interface (BCI), IEEE*, pp.1-5. DOI: 10.1109/BCI51272.2021.9385309

Conference date: 22nd – 24th February 2021

Team location: South Korea

Cites: None

Cited by: (Zhang and Wang 2021)

Number of citations: 1

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Date: 10th March 2021

Team location: China

Cites: (Akce et al 2010; Royer et al 2010; LaFleur et al 2013; Kosmyna et al 2014b; Shi et al 2015; Khan, Hong, Naseer and Bhutta 2015; **Zhang and Jackson 2015**; **Nourmohammadi et al 2018**; **Vijayendra et al 2018**; Choi and Jo 2020; Yan et al 2020)

Cited by: (Hekmatmanesh et al 2021)

Number of citations: 1

Kapgate, D. 2021, "Efficient Quadcopter Flight Control Using Hybrid SSVEP + P300 Visual Brain Computer Interface", *International Journal of Human-Computer Interaction* , pp. 1-11. DOI: 10.1080/10447318.2021.1921482

Date: Published 7th May 2021

Author location: India

Cites: (Royer et al 2010; LaFleur et al 2013; Kim et al 2014; Shi et al 2015; Kosmyna et al 2015b; Khan and Hong 2017; **Nourmohammadi et al 2018**; Wang, Li, Zhang, Li and Zhang 2018; **Duan et al 2019**; Christensen et al 2019; Chiuzbaian et al 2019; Tezza and Andujar 2019)

Cited by: (Hekmatmanesh et al 2021)

Number of citations: 1

Wu, X., Li, H. & Chen, J. 2021,”Intelligent command and control of UAV Based on brain computer and eye tracking combined technology” *IMCEC 2021 - IEEE 4th Advanced*

Information Management, Communicates, Electronic and Automation Control Conference (IMCEC), 4, pp. 212–221. DOI: 10.1109/IMCEC51613.2021.9482111

Date: 18th- 20th June 2021

Team location: China

Cites: (LaFleur et al 2013)

Cited by: None

Number of citations: 0

Hekmatmanesh, A., Nardelli, P.H.J. & Handroos, H. 2021, "Review of the State-of-the-Art of Brain-Controlled Vehicles", *IEEE access*, vol. 9, pp. 110173-110193. DOI: 10.1109/ACCESS.2021.3100700

Dates: Received June 18, 2021, Accepted July 13, 2021, Published July 27, 2021, date of current version August 12, 2021.)

Team location: Finland

Cites: Akce et al 2010; Royer et al 2010; Doud et al 2011; LaFleur et al 2013; Kim et al 2014; Shi et al 2015; Lin and Jiang 2015; Khan, Hong, Naseer and Bhutta 2015; **Zhang and Jackson 2015**; Kosmyna et al 2015b; Khan and Hong 2017; Khan, Zafar and Hong 2017a; **Nourmohammadi et al 2018**; Zafar, Khan, Park and Hong 2018; Zafar, Ghafoor, Khan and Hong 2018; Wang, Li, Zhang, Li and Zhang 2018; **Vishwanath et al 2018**; **Duan et al 2019**; Chiuzbaian et al 2019; Kavichai et al 2019; Chen et al 2020; Zhang and Wang 2021; Kapgate 2021)

Cited by: None

Number of citations: 0

Brynestad, K. & Vatsvåg, E. 2021. An Asynchronous Motor Imagery-based Brain-Computer Interface for Two-dimensional Drone Control. *Master's Thesis*. [Online]. Available at: https://ntnuopen.ntnu.no/ntnu-xmlui/handle/11250/2823501 [Accessed 18 December 2022].

Date: June 2021

Team location: Norway

Cites: (LaFleur et al 2013; **Duan et al 2019**; Mei et al 2020)

Cited by: None

Number of citations: 0

Belkacem, A.N. and Lakas, A. 2021, "A Cooperative EEG-based BCI Control System for Robot–Drone Interaction," *2021 International Wireless Communications and Mobile Computing (IWCMC)*, 2021, pp. 297-302. DOI: 10.1109/IWCMC51323.2021.9498781.

Conference date: 28th June- 2nd July 2021

Team location: UAE

Cites: (Akce et al 2010; Kosmyna et al 2014b; Chen et al 2020; **Al-Nuaimi et al 2020)**

Cited by: None

Number of citations: 0

Kim, S., Lee, S., Kang, H., Kim, S. & Ahn, M. 2021, "P300 Brain-Computer Interface-Based Drone Control in Virtual and Augmented Reality", *Sensors (Basel, Switzerland)*, vol. 21, no. 17, pp. 5765. DOI: 10.3390/s21175765

Dates: Received: 27 July 2021, Accepted: 24 August 2021, Published: 27 August 2021

Team location: South Korea

Cites: (Wang, Li, Zhang, Li and Zhang 2018)

Cited by: None

Number of citations: 0

Villegas, I.D., Camargo, J.R. & Perdomo Ch, C.,A. (2021). "Recognition and Characteristics EEG Signals for Flight Control of a Drone". *IFAC PapersOnLine*. 54(4), pp.50-55. DOI: 10.1016/j.ifacol.2021.10.009

Date: 29 October 2021

Team location: Colombia

Cites: None

Cited by: None

Number of citations: 0

Dumitrescu, C., Costea, I. & Semenescu, A. 2021, "Using brain-computer interface to control a virtual drone using non-invasive motor imagery and machine learning", *Applied sciences*, vol. 11, no. 24, pp. 11876. DOI: 10.3390/app112411876

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Team location: Romania

Cites: (LaFleur et al 2013; Rosca et al 2018; **Duan et al 2019**; Chiuzbaian et al 2019)

Cited by: None

Number of citations: 0

Ramos, D., Goncalves, G., Faria, R. & Sanches, M.P. 2021. "Building a Drone Operator Digital Twin using a Brain-Computer Interface", *2021 20th International Conference on Advanced Robotics (ICAR), IEEE*, pp.824-829. DOI: 10.1109/ICAR53236.2021.9659360

Conference date: 6th-10th December 2021

Team location: Portugal

Cites: (Shi et al 2015; **Vishwanath et al 2018**)

Cited by: None

Number of citations: 0

Appendix 2: Full List of Proposed Future Uses/Derivative Purposes for BCIUAV

Akce et al (2010) – None given for BCIUAV

Royer et al (2010) – No actual derivative purposes given: only indications via science fiction

Doud, Lucas and He 2011- None given for BCIUAV

Doud et al (2011) – None given for BCIUAV

Yu et al (2012) – 'augment mobility and perceptibility of the handicapped.'[sic] (2012:669)

Akce et al (2013) – None given for BCIUAV

LaFleur et al (2013)

> The ability to interact with the environment through exploration of the 3D world is an important component of the autonomy that is lost when one suffers a paralyzing neurodegenerative disorder and is one that can have a dramatic impact on quality of life. Whether it is with a flying quadcopter or via some other implementation of telepresence robotics, the framework of this study allows for expansion and assessment of control from remote distances with fast and accurate actuation, all qualities that will be valuable in restoring the autonomy of world exploration to paralyzed individuals and expand that capacity in healthy users. (2013:14)

Kosmyna et al (2014a) – None given for BCIUAV

Kim et al (2014)

> The proposed interface enables both disabled and fully capable people to complete their tasks with various commands in 3D physical space. Through this low-cost and easily wearable device, people can control their flight naturally and easily in everyday life. (2014:91).

Kosmyna et al (2014b) – None given for BCIUAV

Shi et al (2015) – ‘indoor target searching’ (2015:4196)

Lin and Jiang (2015) – None given for BCIUAV

Kahn, Hong, Naseer and Bhutta (2015) – None given for BCIUAV

Kosmyna et al (2015a) – None given for BCIUAV

Song et al (2015) – None given for BCIUAV

Kosmyna et al (2015b) – ‘recreational applications’ (2015b:520)

Zhang and Jackson (2015)

> This research can be applied to many circumstances such as enabling locked-in patients to explore surroundings at will, developing mind-controlled UAV that can be used in military tasks, and becoming affordable toys that can promote entertainment and socialization. (2015:1).

Das et al (2016) – None given for BCIUAV

Chen et al (2016)

> the proposed application is to relax subjects with ALS by operating the air swimmer drone vehicle (2016:10)

Song et al (2016) – None given for BCIUAV

Meriño et al (2017) – None given for BCIUAV

Khan and Hong (2017) – None given for BCIUAV

Khan, Zafar and Hong (2017a) – None given

Peining et al (2017)

> BCI has great potential in providing a hands-free method for controlling a drone. Not only does it benefit the disabled as an option to reach remote objects, it is also a novel approach for recreational drone piloting. (2017:6)

Yin and Gong (2017) – no specification of uses of BCIUAV itself

> The brain computer interface rebuilds a signaling [sic] pathway to restore the missing function for the disabled patients. In daily life, people will be able to achieve the control of environment or to control the game object just by thinking without specific labor (such as brain-actuated robot [5][6], brain-actuate vehicle [7][8] and brain-actuated cursor [9]). In the military field, people in reality can fight in a battlefield only through certain technical equipment thus avoiding being wounded (brain-actuated UAV [10][11]). Therefore, the BCI system has important research value. (2017:2210)

Santos et al (2017) – None given

Corichi et al (2017)

> we developed an application to illustrate how such commands could be used to control a drone that could be used to deliver messages or carry out any other activity that involves the drone having to fly from a start point to a final destination. (2017:338)
>
> This article intends to use EEG equipment acquisition to acquire and process EOG signals in order to reduce the amount of monitoring equipment in people disable to send command to UAVs to communicate whit [sic] other person or bring an object… (2017:339)
>
> Scientists at the University of Texas at San Antonio (UTSA) are trying to turn science fiction into reality by developing technology that will allow soldiers to control a drone only with their minds remotely. (ibid)

Mamani and Yanyachi (2017) – None given for BCIUAV

An et al (2017) – None given for BCIUAV

Khan, Zafar and Hong (2017b) – None given for BCIUAV

Nourmohammadi et al (2018)

> In future, these integrated systems could serve more practical purposes—some conceivable applications are as follows: in hospitals where patients with severe disabilities could use them for transporting objects; in battle fields where wounded soldiers could use them to proceed with the combat; and in space where they could assist astronauts to accomplish multitask missions outside the spacecraft. (Nourmohammadi, Jafari and Zander 2018:338)

Rosca et al (2018) – None given for BCIUAV

Rho and Jo (2018) – None given for BCIUAV

Vijayendra et al (2018) – None given for BCIUAV

Wang, Li, Zhang, Li and Zhang (2018)

> a flight control BCI system would allow tetraplegic people to freely explore the physical 3D world directly using their own brains' neural signals. (2018:26789)

> The proposed interface enables both disabled and capable people to navigate a flight under [sic] physical 3D space in an efficient manner… Interacting with remote places via quadcopter or other telepresence robotics holds much value in helping disabled people and in extending the capacity of healthy people. (2018:26797)

North et al (2018) – None given for BCIUAV

Wang, Wang, Qin and Zhang (2018) – None given for BCIUAV

Ribe and Krohn 2018 – None given for BCIUAV

Zafar, Park, Khan and Hong (2018) – None given for BCIUAV

Zafar, Ghafoor, Khan and Hong (2018) – None given for BCIUAV

Vishwanath et al (2018) – None given for BCIUAV

Mazumder et al (2018)

'deliver and retrieve objects to assist clients who are unable to carry heavy objects' (2018:2)

Duan et al (2019)

> It was observed that through this practical BCI, the user could successfully and efficiently navigate a quadcopter to approach a target while avoiding the obstacles in an outdoor actual environment according to a fixed view. The multi-modal BCI system could restore the capacity to explore the real world for disabled people as well as extend the ability of fully capable people in more practical ways. In the future, this multi-modal BCI system could provide more practical purposes. (1) Injured soldiers could rely on it remain [sic] in combat in battle fields. (2) It could assist astronauts to accomplish multitask missions in space. (3) Patients with severe disabilities could use them for transporting objects. (2018:8)

Zafar, Ghafoor, Yaqub and Hong (2019) – None given for BCIUAV

Chiuzbain et al (2019)

> The goal of this work was to develop a user-friendly, fully independent BCI system that will allow impaired people to control a drone in 3D space by using only their brain. The application intends to enhance the quality of life allowing users to interact with the environment around them. (2019:5)

Christensen et al (2019)

> This work aims at the design and implementation of an electroencephalography (EEG) based motor imagery (MI) brain computer interface (BCI) system that would allow disabled, and able-bodied, individuals alike to control a drone in a 3D physical environment by only using their thoughts. (2019:1)

Kavichai et al (2019) – None given for BCIUAV

Gao et al (2019) – None given for BCIUAV

Tezza, Garcia et al (2019)

> In this study we presented a brain-controlled drone racing game… (2019:161)

Yu et al (2019) – None given for BCIUAV

Yang and Hong (2019) - None given for BCIUAV

Sun and Ma (2019)

> The US. military has set up a similar research and development team, which aims to control UAV with human mind. It is expected that the human mind can be read by computers, and then carry out activities on UAVs and even groups of UAVs…(2019:300)

Wang, Chen et al (2019) - 'fire-fighting' (2019:611)

Tezza and Andujar (2019) – Only mentions the use (e-racing) that the authors have pursued previously.

> Brain-computer interface devices have broad potential as assistive technologies and novelty control methods. Since 2010 researchers have been exploring the use of BCI's to control unmanned aircraft (fixed-wing), and in 2013 the first brain-controlled multi-rotor project was published [35]. Additionally, the first brain-controlled drone race was held in 2016 at the University of Florida [36], followed by a race at the University of South Florida [37] and the University of Alabama [38]. (2019:167444)

> Once BCI reliability and accuracy achieve similar levels to other control modalities, this type of control will allow handsfree interaction and accessibility for disabled users. (ibid)

Shi et al (2019) – 'indoor target searching'(2019:11199)

Paszkiel and Sikora (2020) – None given for BCIUAV

Maiti et al (2020) – None given for BCIUAV

Lopez et al (2020a)

> This paper shows the plausibility of using Unmanned Aerial Vehicles (UAVs) as a serious game for therapeutic purposes through a systematic review of the current state of UAVs and how they have been coupled to BCIs in order to control them through mental commands. Also, challenges and research opportunities from a usability approach related to the game design, interaction design, and cognitive rehabilitation are identified and described. We hope that the research opportunities identified in this paper can be useful to guide future research and gain insight into how to solve challenges related to the use of Unmanned Aerial Vehicles in cognitive therapies. (2020a:160)

Chen et al (2020) – None given for BCIUAV

Lopez et al (2020b)

> This paper presents a plausibility study of the use of UAVs as computational tools for therapeutic purposes through an analysis of the current state of UAVs and how they have been coupled to brain-computer interfaces (BCIs) in order to control them through

mental commands. (2020b:316)

Yan et al (2020)

> Quadcopter is an important way for the human to explore the physical world. The brain-computer interface (BCI) technology is used to control the quadcopter flight in order to help disabled persons communicate with the external world freely.(2020:1160)

Alwasiti and Yusoff (2020) – object retrieval – specifically for disabled people.

> BCI systems are known for low reliability and accuracy. We are presenting a method to enhance this inherent weakness of BCI systems, by providing an assistive autonomous controller whenever the BCI system reaches to the point where fine control is necessary. The course control is performed by the motor imagery BCI which decodes the thinking process of the user and use it for navigating a quadcopter drone. Once the quadcopter reaches an area where the object selected to be picked up enters in the field of view of the bottom camera of the quadcopter, the autonomous controller is taking over the fine movement navigation to handle the rest of the task. This method is an exciting opportunity for several other BCI applications to enhance the reliability and accuracy of BCI systems to be adopted in everyday life of severely disabled patients. (2020:3606)

Ishizuka et al (2020)

> Controlling drones in this manner can assist those with limb disabilities as well as the elderly with disabilities (including vision-related disabilities) to manually manipulate the device. In other words, individuals with disabilities can execute tasks by themselves without the help of a caregiver, thereby improving the quality of life of both the elderly and the caregiver. The proposed system is envisaged to also help nondisabled individuals by incorporating drones in a wide range of applications. (2020:738)

Choi and Jo (2020)

> Brain-computer interfaces (BCI) allows direct communication between the brain and a computer without explicit motor actions. Using electroencephalograms (EEG) allows non-invasive measurement of brain activity with high temporal resolution, making it ideal to be used in asynchronous, real-time control. This allows BCIs to be used by *motor-impaired patients* for many different tasks, such as spelling tasks and controlling real objects like robot arms, cursors, wheelchairs and *quadcopters*. (2020:1 emphasis added)

Martinez-Ledezma et al (2020) – None given for BCIUAV

Marin et al (2020)

> The current research aims to support the brain usage to analyze digital information and get the outcomes, letting the user visualize and hear without using the eyes and ears, such that deaf and blind people can regain their lost sensations. BCI can assist the persons who are immovable to switch gadgets over and to interconnect with people. There are persons who agonized numerous sicknesses and they caused them to become immovable, partaking in the progress of innovative BCI systems. [sic] (2020:1)

Tezza, Caprio et al (2020)

> This paper presents a brain-controlled drone racing video game where users can control a racing drone using a non-invasive BCI headset by performing a motor imagery task. (2020:350)

Al-Numaimi et al (2020)

> In this paper, we present a new way of controlling drone by using a P300-based brain-computer interface that supports the military field as assistive technology. The main idea is that the drone can be controlled by the soldier's brain activity using electroencephalogram (EEG) to chase other drones and discover hidden enemy areas. (2020:74)

Mei et al (2020) – None given for BCIUAV

Wang, Ke et al (2020) – None given for BCIUAV

Chhabra et al (2020)

> This paper presents a novel approach to develop a non-invasive Brain-Computer Interface (BCI) for control of the quadcopters as an assistive device (AD) for those people suffering from neurodegenerative diseases or impaired mobility and have lost the ability to explore the world around them freely.(2020:4250)

Parikh and George (2020) – None given for BCIUAV

Reddy (2021) – None given for BCIUAV

Choi et al (2021) – None given for BCIUAV

Zhang and Wang (2021) – None given for BCIUAV

Kapgate (2021)

> the proposed quad-copter flight control system proved its suitability for patients with severe motor disabilities. (2021:1)

Wu et al (2021) – None given for BCIUAV

Hekmatmanesh et al (2021)

> The combination of unmanned aerial vehicles and BCI is a new idea. The advantages of using drones are significant; e.g., low-cost production, transport and maintenance, readiness to fly quickly, exploitability in perilous situation, use of clean energy, and suitability for demanding applications, such as spacecraft [64]. There are many categories of aerial vehicles for different applications, such as health care and military use. In the present survey, the focus is on the review of bio-signal processing techniques for the control of BCAV applications in the nonmilitary use. (2021:110183)
>
> By solving constraints and reaching the highest accuracy and reliability, potentially new jobs and technologies may be launched, some skilled disabled people may be able to return to their previous duties, many maintenance operations will be safer to carry out and their costs can be reduced, safety at work in hazardous conditions (e.g., provision of first aid in remote or dangerous locations) can be enhanced, and checking and guaranteeing the security of large areas and factories will be easier. Further, new solutions will facilitate, for instance, weather monitoring in inaccessible areas (mountains, pole areas) or the delivery of post. (2021:110187-110189)

Brynestad and Vatsvag (2021) – None given for BCIUAV

Belkacem and Lakas (2021)

> This system is aimed at supporting and assisting complex and cooperative multitask military applications.(2021:297)

Kim et al (2021) – None given for BCIUAV

Villegas et al (2021)

> According to the World Health Organization (WHO), more than 15% of the population suffers from some type of disability OMS (2011) and in Colombia, according to the latest DANE National Administrative Department of Statistics) registry, more than two million people have some characteristic that hinders the development of daily activities. DANE (2010). An increasingly common activity is the use of unmanned aerial vehicles known as drones, which in some countries even require certificates to be used. With the aim of facilitating access and use of this technology to people with motor difficulties, it is proposed to use electroencephalographic signals to give orders to a drone and thus facilitate its handling (2021:50)

Dumitrescu et al (2021)

> The application in its current form can be used in the medical field for the recovery of patients with various neurological disorders, for increasing low cognitive performance and increasing the drone driving skills of military personnel. (2021:22)

Ramos et al 2021:

> In the future, the goal is to adapt the current system to a swarm of drones, improving the training of the mental commands, the digital twin's accuracy and the efficiency of the digital twin's training. (2021:829)