Preliminary Investigation: A background to an ethnographic investigation of Body Worn Cameras (BWCs)

The Socioethical Implications Of Body Worn Computers: An Ethnographic Study

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Abstract

Detailed accounts of the historical, social and political dimensions of body worn camera (BWC) technologies are achieved through an extensive 'netnography' conducted by the researcher, liminal findings derivative of a reflexive practice in the form of a research journal, and critical discourse analysis of interviews and conversations with select key figures. Composed over a two (2) year period, this chapter contains the main structural framework and background for the main thesis, principally a comprehensive review of the historical precursors to BWCs. Due to the burgeoning scale of the thesis in early 2019, in consultation with Supervisor, Professor Katina Michael this intensive write-up was removed to bring the thesis into the acceptable word count for a PhD thesis published through Engineering and Information Sciences faculty at the University of Wollongong. This full and unabridged background chapter was originally titled 'Chapter 4.0 - Background' chapter, following the main '2.0 Literature Review' chapter, '3.0 Research Design' chapter and prefacing '4.0 Observational Study' in the PhD thesis 'The Socioethical Implications of Body Worn Cameras: An Ethnographic Study'.

Keywords

BWC, BWCs, GIS, information systems, netnography, ethnography, history, framework, background, critical discourse analysis, synthesis, journal

4.0 BACKGROUND

This chapter introduces a background study using an online research process called ‘Netnography’ with origins in ethnography according to Bowler (2010) and Kozinets (1998) which is a “... method specifically designed to study cultures and communities online” (Bowler 2010).

Whilst there was a temptation to collect data over the entire research journey and then use a titrate of that to describe every significant BWCs form factor, application, sector use, historical figure, significant movements and likely trajectory in an encyclopaedic manner, the researcher has instead related key readings in a structured narrative, building upon peer reviewed literature presented in the previous chapter. These readings are drawing upon diverse sources derivative of commercial search engines, industry specific online communities as well as popular social media platforms. Given the size and complexity of this chapter and the many and varied sources from which it is derived it is considered as a 'conceptual framework’ - in effect, the historical narrative and contemporary assessment of topics and studies gathered as one resource from an iterative netnography process. The researcher acknowledges that this chapters scale and sheer magnitude serves in many ways as the ‘dictionary' from which empirical studies in latter chapters are referential.

The following *Figure 19. Background Chapter Structure* provides an overview of overall structure of the chapter which is made up of three (3) core components and activities happening simultaneously through this section of this part of the research investigation.

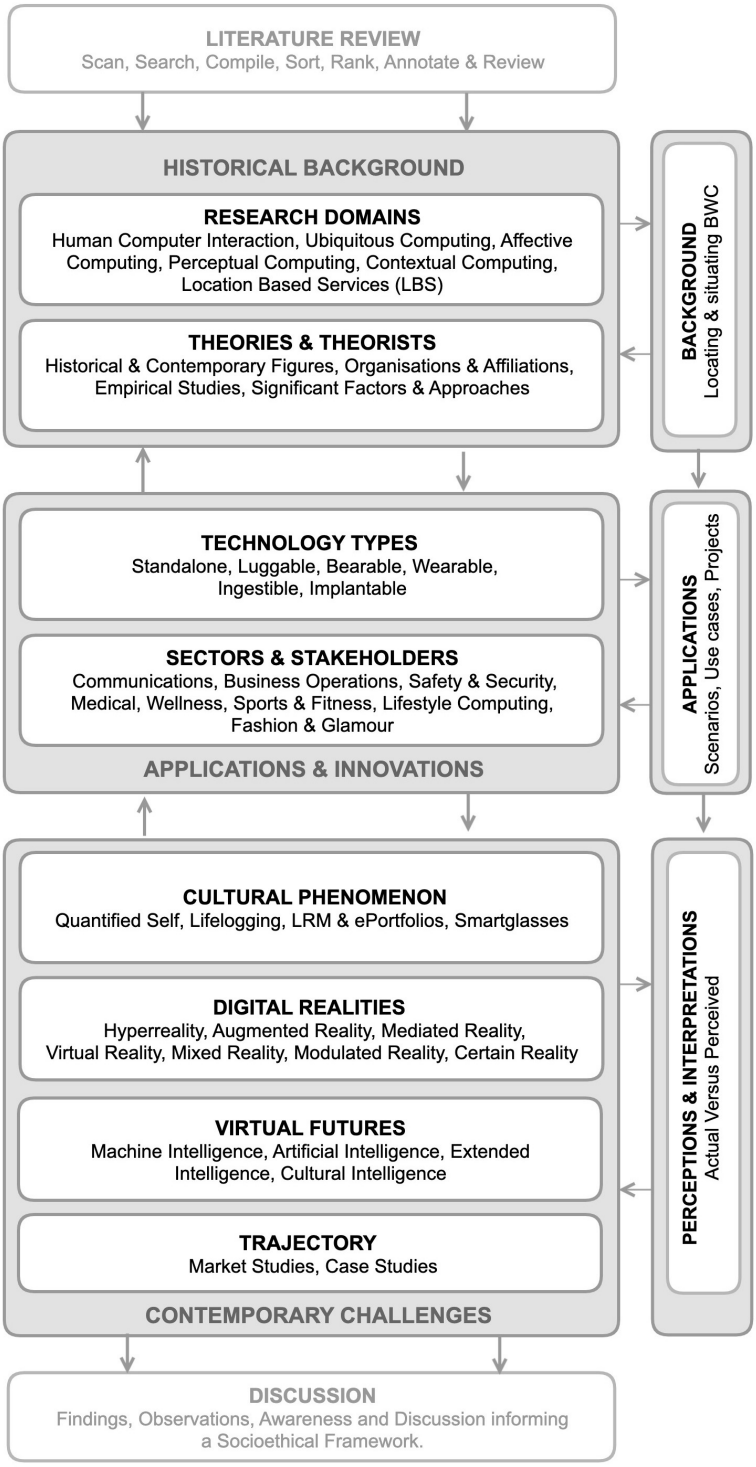

Figure 19. Background Chapter Structure - a compilation of all Netnography activities and related topics for discussion.

4.1 Overview

It is not customary in scientific writing to use the first person register in an engineering and information sciences PhD thesis, therefore, the term ‘researcher’ was used to describe behaviours as a participant observer in events and stakeholder communities from which empirical findings of the research are derived, essentially the epistemological heart of the research inquiry.

> “...Think about the habits and traditions in your field, think about the nature of your field and do not hesitate to take responsibility for your own (possibly not that great) ideas" (Jannson 2014)

As Deegan and Hill (1991) elucidate in their seminal paper titled ‘Doctoral Dissertations as Liminal Journeys of the Self’ the research journey is the backbone for the dissertation, whilst the thesis is an autobiographical account of the researchers learning journey complete with empirical findings. To ensure thesis accuracy and impartiality as a steward of information (Ohio Dominican University Library 2016), the personal liminal transformation of the researcher will be published as short articles in a research journal (RJ), synthesised and re-published as a Research Journal Summary (RJS) for brevity (Hayes 2019b).

> “…The methodological framework adopted here is experiential (Reinharz 1983,1984) and thus combines autobiography with theoretical analysis to (un)cover and (dis)cover reality” (Deegan & Hill 1991).

Through assessment and retention of online human activity, the researcher gained empirical insight into BWCs by tracking interactions and experiences as a participant observer and then interpreting these in an iterative, reflexive process is an investigative Netnography, a portmanteau melding ‘Internet’ or ‘network’ with ‘ethnography’ according to (Bowler 2010; Kozinets 2015; Kulavuz-Onal & Vásquez 2013).

This retention of activity that the researcher conducted is evidenced in the retention of secondary sources tracked, saved and categorised in the bibliographical tools such as the Research Management System (Paperpile) or the publications and bookmarks sharing system (Bibsonomy). Guided through twelve (12) interacting levels, Kozinets (Kozinets 2015) describes how Netnography as a temporal and nonexclusive process can also as (Deegan & Hill 1991) consider, broaden an experiential transfer of knowledge, assisting the researcher through an iterative process of identifying, categorising and ranking resources by historical, social, political and conceptual BWCs innovations and applications.

#	Levels	Description	Tool
1	Introspection	The researcher reflects on the role of the research in their current lifeworld relating an actual life story as it unfolds.	Research Journal
2	Investigation	The researcher devises and/or sharpens the research question to refine the study of sites, topics or people, posing it appropriately, such that it can be reasonably answered by a netnographic approach.	Thesis
3	Informational	The researcher seeks ethical approval to include data retention using a range of verifiable sources.	Research Ethics
4	Interview	Research participants are invited to participate in the research investigation, matched with their various online forms of sociality and open access data.	Conversations & Bookmaking
5	Inspection	A shortlist of online sources to investigate is drawn up reflective of diversity, interdisciplinary and combinations of schemes, possible and useful.	Environment Scan
6	Interaction	Locating a central ‘hub’ for communications which can provide public and private sectors, synchronous and asynchronous modality	Online Communities
7	Immersion	Organic depth of understanding with unfolding interaction building rapport and conviviality	Online Communities
8	Indexing	Iterative, meaningful and targeted high quality data collection, classifying, indexing and journaling results	RMS & Bookmarking & Journal
9	Interpretation	Interpretation striving for understanding and meaning using humanistic, phenomenological, existential and hermeneutic methods.	ATLAS.TI & Leximancer & Scrivener
10	Iteration	Return to sources interpreting continuously, seeking new insights, identifying patterns in data, interactions, representations and reflections	Research Journal & Thesis
11	Instantiation	Symbolic, digital, auto or interpretive humanistic instantiation of netnography; representation as artefact or bodies of data	Research Journal Summary
12	Integration	Integration of findings and discussions with recommended action in the wider world	Thesis Corpus

Table 10. Adaptation of Kozinets 'Twelve Interacting Levels’ in Kozinets, R. V. (2015). Netnography: Redefined (Second). SAGE Publications.

As a participant observer the researcher also sought to engage with participants through online social media, virtual communities and interactive digital worlds. This 'go-to' for benchmarking resources was regarded as the most cogent means through which to escape the ‘disembodied algorithm programmed by statistics and marketing’ of automated ‘rank’ of data highlighted by (Kozinets et al. 2018)

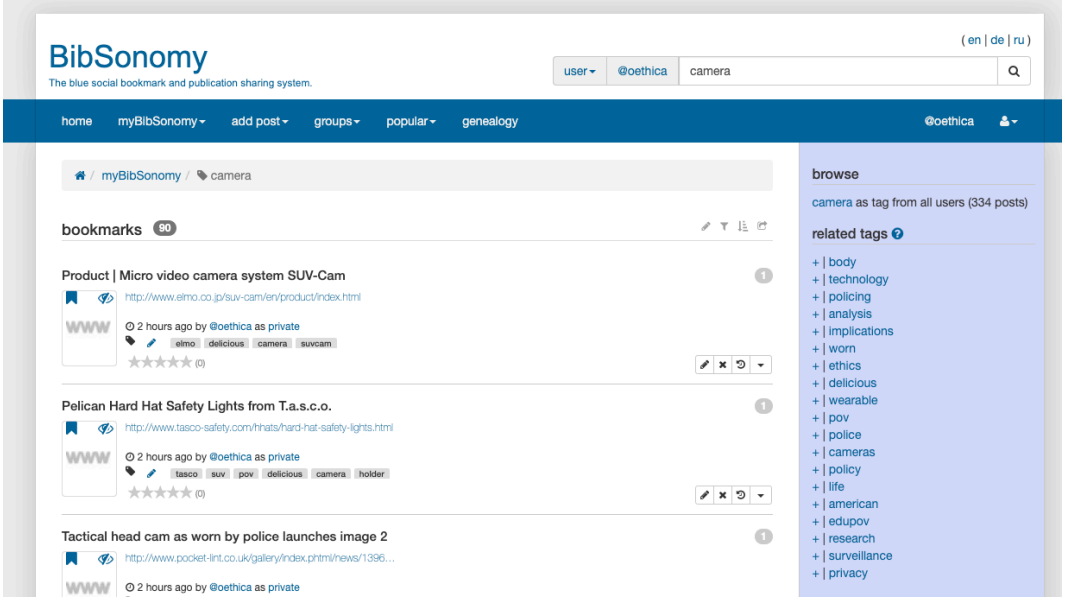

Figure 11. Netnography: BWC Research Bookmarks
- screenshot of researchers own Bibsonomy bookmark library

As a result, the resultant Netnography is by no means as exhaustive as available commercial services, yet incontestably a far deeper personable and relational engagement, than parrot fashioning popular press and uncritically seeking to “... leverage unstructured word-of-mouth consumer-generated data from online communities, to gain empirical insights at speed” (Rabjohns 2019).

By embracing the ethos of reflexive ethnography as described by (Burawoy 2003) all points of ‘immersion’ were tracked and retained using a web browser based bookmaking application, enabling resources to be saved, screencast, annotated, classified and outlined using the very same application. A summary of these resources located are published as *Figure 11: Netnography - BWCs Research Bookmarks*

tracking BWCs specific, related and associated disciplines as online resources in the form of hyperlinked data accessible through most web browsers.
As Participant Observer (PO) over a six year period, the researcher engaged with many individuals and groups within interdisciplinary online communities, culminating in the development of ten (10) differing bookmark outlines containing one thousand, one hundred and sixty (1,160) bookmarks of publicly accessible online resources.

This real-world knowledge and relational experience as novice researcher engaging with experts was exponentially accelerated in roles as Co-Publicity Chair and Symposium General Committee member of the 2013 IEEE ISTAS'13 Symposium (Hayes & Michael 2014). The opportunity to engage with globally dispersed IEEE SSIT stakeholders by consent in traditional, in-person anthropocentric research methods ie. semi-structured interviews almost immediately extended to 'mapping' this human activity by electronic engagement using a range of online tools and services. The researcher was also invited to administer and co-author with Professor Katina Michael and Dr. M.G. Michael in early 2010 on the concept of 'Uberveillance' M.G. Michael and K. Michael (2009).

> "... This website provides the general public, the community and those afforded free and unconditional access to the world wide web, access to information regarding the concept and understanding of Uberveillance " (Hayes et al. 2011).

The database of knowledge amassed over a ten (10) year period decade, broadened the researchers thinking and knowledge of key themes such as 'identity', 'privacy', 'regulation' and 'society' culminating in a publication titled 'In The Night Garden' (Hayes 2015f) as well as exploring research specific topics such as the effects of life-logging on society (Michael 2012).

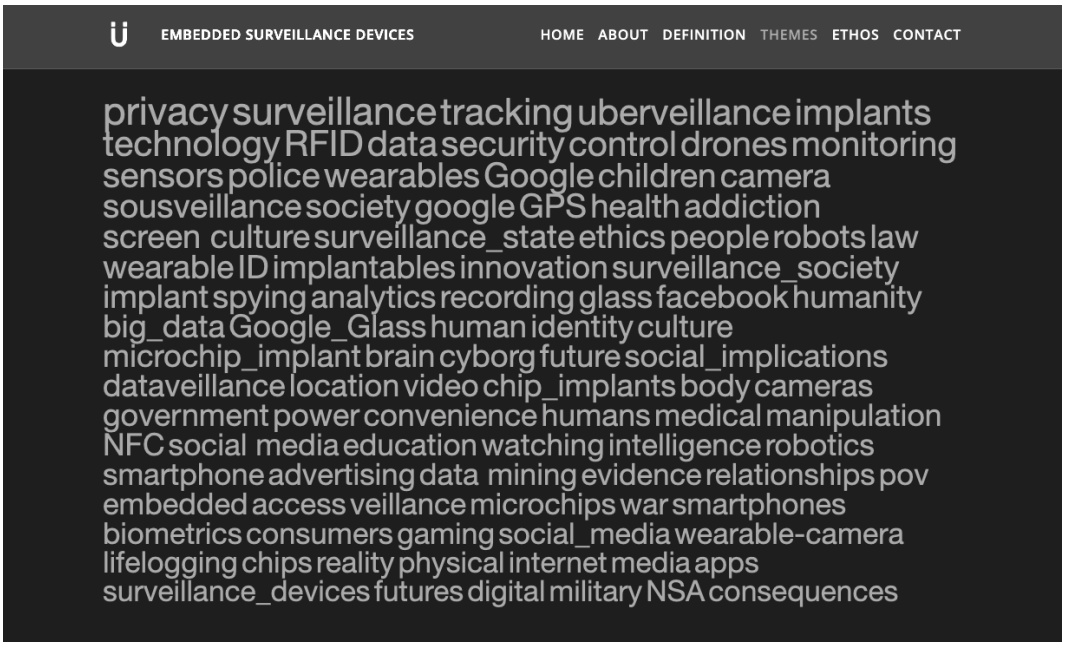

Figure 12. Concepts & Themes: Uberveillance Website - screenshot from Hayes, A., Michael, K., & Brown, J. (2020, February 24). Uberveillance.

Another enduring record is also evidence of the researchers iterative process of Netnography, a persistent resource and digital archive containing important historical artefacts such as the IEEE ISTAS'13 Final Program (Michael & Hayes 2013), the IEEE ISTAS13 Publicity poster (Mann, Michael, et al. 2013), press releases and sponsor endorsements. The site also contains many different virtual community links which intersect with the event held at the University of Toronto, Canada.

This researcher activity and online resource represents many hundreds of hours engaging in virtual and physical settings with key figures, many of whom provide detailed accounts of the historical, social and political dimensions of BWCs in conversations with the researcher. The following *Table 14. Framework for Critical Discourse Analysis* was used as the guide and steps for conducting the critical discourse analysis.

Step	Action	Details
1	Examine the **Discursive Object** as it evolves through the interview transcript	As framed by the research question; what are the social impacts and ethical implications of body worn computer for humanity? The wearable technologies industry as the *discursive object* - **Example: Are educators (stakeholder) who adopt, adapt and use BWCs then through the various dependencies that digital media creates (systems) then 'enframed' by BWCs? (power relations)**
2	Identify differing **Discourses** throughout the interview transcript	Through an examination of difference in ***constructions*** (BWCs also known as POV) what appears as the same discursive object is identifiable through a range of differing constructions, ontologies. **Example: foundations of HCI wearable computing conjoin corporations in the inventions, test-bedding, user acceptance trials, supported by scientific research communities challenges**
3	Establish how the **Action Orientation** and shifts alter perception and meanings	A close examination of discursive contexts within which BWCs function in construction relates to other constructions produced in surrounding text? Example: **How do wearable technologies ie. BWCs play out in the wake of the Ferguson killings in the United States of America?** "*... What is gained from constructing the object in this particular way at this particular point within the text?" (Willig 2003, p. 174).*
4	Locate the **Positioning** (or Subjects) of the actors in relation to interview questions	This step involves examining the *subject positions* that the discourse offers. **Example: Engineers create and test wearable technologies then tested using human subjects by large corporations only seeking to profit from the consumer surveillance they create.** *"...[D]iscourses construct subjects in addition to objects, and, as a result, make positions available within networks of meaning that speakers can take up (as well as place others within)" (Willig 2003, p. 174).*
5	Ascertain the participants experiential **Practice** and related power position	The relationship between the discourse and practice whereby examination of the subjective position then limits what the subject within them can say or do. **Example: The wearable technology industry contributes to or influences discourse which precludes social impact or ethical implications from rich descriptions on the detrimental or beneficial effects of BWCs.** *"... systematic exploration of the ways in which discursive constructions and the subject positions contained within them open and/or close down opportunities for action". (Willig, 2003 p. 175)*
6	Highlight the levels of **Subjectivity** that the participant exhibits in interview	In this last step the relationship between discourse and subjectivity influence is examined for how this shapes the ways of 'seeing or being the world.' Example: **The role of BWC's in our organization provides employees with the peace of mind that unlawful activities and unsubstantiated claims cannot gain legal traction against us.** *Note: Subject 'statements' forming the backbone for the narrative account, scaffolded minimally by the researchers own interpretation of the significance of objective through to subjective account.*

Table 14. Framework for Critical Discourse Analysis - An adaptation of Carla Willig's (2003) Framework for Critical Discourse Analysis in (Buchanan 2008)

As with any source which can be freely accessed through the Internet, sources of literature and internet accessible content in this chapter engender the need for deep

circumspection, yet, with sources verified, this information provides a counteract to the potential bias of relying only on a limited peer reviewed literature and the limited perspectives of related grey literature drawn from the same sources.

To achieve that quality assurance, in an evolving self-reflection ethical principles and guidelines were adhered to and data appropriately sourced, the researcher mindfully abided by the ethical principles and associated set of guidelines set out by 'The National Statement on Ethical Conduct in Research Involving Humans' (National Health and Medical Research Council, 1999; Health & Australia 2007).This was achieved by; (1) checking for research integrity with respect for persons, beneficence, justice, consent, research merit and safety; (2) examination of the peer review process if any; (3) interrogating the depth of inquiry by verification of sources and affiliations divulged within that information or knowledge resource.

Mindful of the contemporary context of this research inquiry, the researcher then sought in the following chapter, Observational Study to diversify existing sources by interacting as a participant observer with experts across differing stakeholder groups. These observations of human activity cross-checked with empirical data derivative of interdisciplinary and intercultural perspectives through interviews, conversations as well as seeking secondary data resources from peers and mentors, situate the researcher "... as an embodied, temporally, historically and situated human being…" (Kozinets et al. 2018).

The next step then involves conducting a grounded and situated review of 'on-the-ground data collected from the field' as described by (Jammula 2014) which is perhaps the single most salient example of the transmogrification of the researcher. Comparisons can be made between this methodological approach of collecting data using a continuous Netnography process as comparatively similar in project time-span duration to the ten year life-logging journey of Morris Villarroel, professor of animal behaviour at the Polytechnic University of Madrid who states:

> "... part of our day to day goes through trying to identify, control and analyze this data, not only to protect us, but also with the aim of knowing ourselves better and improve our lives in some aspects" (Villarroel 2019).

In subsequent chapters, concepts and emergent themes derived from interviews and experiential accounts inform what social impacts and ethical implications research participants consider pertinent to discuss with the researcher as participant observer. Furthermore, this chapter also draws upon knowledge gained by the researcher in role as a Web Administrator and co-Author of the Uberveillance website (Hayes et al. 2011), during which the collection and collation of relevant data informing the contemporary position of 'Uberveillance' over a nine (9) year period substantially assisted in the identification and provision of intelligence for where BWCs are located in the international research context.

4.2 Historical Background

The foundation for what would become the crux of Dziga Vertov's revolutionary, anti-bourgeois aesthetic in the form of the camera as an extension of the human eye was coined in 1923, stating "... I am an eye. I am a mechanical eye. I, a machine, am showing you a world, the likes of which only I can see" (Gartenberg Media Enterprises 2020).

> "… capturing "the chaos of visual phenomena filling the universe (...) over the next decade-and-a-half, Vertov would devote his life to the construction and organisation of these raw images, his apotheosis being the landmark 1929 film The Man With The Movie Camera. In it, he comes closest to realising his theory of 'Kino-Eye,' creating a new, more ambitious and more significant picture than what the eye initially perceives" (Gartenberg Media Enterprises 2020).

Humanity at odds with industrial (and later digital technologies) are depicted also in what is regarded as the last great American silent film titled 'Modern Times', produced in 1936 starring Charlie Chaplin. Inspired by the social philosophy of Karl Marx, through the absence of dialogue Chaplin sets about cleverly using self composed music, contrasting music and sound effects coupled with humour to "...

better denounce the exploitation of man by man, machine-proxy" (The Philosophy.com 2012).

> "... Charlie is struggling with a machine frightening, to gigantic gears. The worker becomes an appendage of the machine. It dictates its furious pace, dehumanises individuals whose behaviour resembles that of a robot" (The Philosophy.com 2012).

In a similar dialogic form, a documentary entitled 'La Télévision, œil de demain: Television, the eye of tomorrow' (Les Documents Cinematographiques 2017) released in 1947 startled viewers with depictions of the impacts of technology on society with people carrying, navigating by or fixated to portable and wearable technologies embedded with screens, television and imbued with telepresence.

The film, based on the essay by futurist and science fiction writer Rene Barjavel titled '*Cinema Total: Essays on Future Forms of Cinema'* (Barjavel 1944) depicts a future not unlike present day society, almost seventy years since it was released. Barjavel predicted a persistent, pervasive and ubiquitous presence of digital screens, mobile technologies and networked connection not unlike the Internet.

Computational devices and platforms which humans connect through as a result of technological innovation and development are significant in their own right as also described by Marshall McLuhan (McLuhan 1964, p.7) in '*Understanding Media: The Extensions of Man'* who is famously quoted as saying, ".. the medium is the message". Body worn computational devices with real time recording and transmission, location services, network connection are perhaps as Vertov despised, Chaplin decried, Barjavel predicted and McLuhan attested, are now positioned as a medium of epic significance in the history and likely trajectory of technologies impacting upon humanity.

The historical background, innovations and contemporary challenges of wearable computing as foundation for BWCs could be described chronologically and yet through narrative, the influence of key figures and their affiliations is more cogently illustrated by bringing forward examples of their human activity in centres of

scientific excellence. The social interactions between key figures, theorists, corporate and other significant investors are then aligned through their contributions to wearable computing and related domains. In reiteration, the acronym ‘BWC’ used in this research investigation refers to the principal reference and ‘proper’ definition, Body Worn Computer (BWC) which could be used interchangeably with Body Worn Cameras (BWCs) with little differentiation as they are now ‘smart’ smart connected devices, with only a range of sector specific differences in nomenclature including Body Worn Video (BWV) or Police Body Cameras (PBC).

By considering BWCs as an extension of human communications in a historical context, in essence wearable computing is the synthesis of these interactions as an emergent condition. Historically, it will be revealed that the symbiosis of humans and machines is now a synthesis inclusive of content and location services, cogently co-locating BWCs and the human counterpart. This innovation clearly intersects with many other domains of wearable computing, each constituting a thesis in their own veritable right due to the complexities, depth and historical breadth of development of BWCs over the last fifty years.

4.2.1 Research Domains

At a fundamental level, the earliest forms of wearable computing may have been a portable abacus, a numerical tallying device as far back as early dynasties of the Asian Empire according to (Steve Mann 2013c; Han 2017). The invention of the mechanical clock led to the creation of the personal wrist watch and thereafter, electronic devices began appearing with inbuilt countdown or clock-like features, likewise the invention of stereophonic sound and the electronic hearing aid relates (Bauters 2013).

The inclusion or exclusion of technologies and their practices in this research domain is summarised in 'A Brief History of Wearable Computing' by Bradley Rhodes, MIT Wearable Computing Project (Rhodes 1998), condensed for readability by the researcher below in *Table 16. Adaptation & extension of Rhodes (1998): 'A Brief History of Wearable Computing'*.

> "...their exclusion, when advocated, is justified on grounds that these devices do not adequately meet the 'always on, always ready, always accessible' (Mann 1998) criterion for wearable computing" (Viseu & Suchman 2010)

The proliferation of wearable 'computational capability' via ubiquitously network connected devices was the next most important paradigm shift which, in turn, made possible economically oriented innovations 'irrespective of time and place' indicates (Gribel et al. 2016, p.1). The following table '*Adaptation & extension of Rhodes (1998) - 'A Brief History of Wearable Computing'* provides a historical snapshot of significant historical events which inform how BWCs have come into existence, on a trajectory of analogue to digital ubiquity.

YEAR	INNOVATORS	FOUNDATIONS & COMPLETE SYSTEMS
1268	Roger Bacon	Earliest recorded mention of eyeglasses
1665	Robert Hooke	The concept of augmented senses mention in literature
1762	Thomas Harrison	First practical marine chronometer, pocket-watch
1907	Alberto Santos-Dumont	Creation of the first wristwatch by Louis Cartier
1945	Vannevar Bush	Proposes the idea of a "Memex" in "As We May Think" [MIT]
1960	Heilig	Patents head-mounted stereophonic television display
1962	Heilig	Patents virtual reality simulator "Sensorama Simulator"
1960	Manfred Clynes	Coins the word "Cyborg" in "Cyborgs and Space"
1966	Ed Thorp	Claude Shannon: Analog first wearable computer [MIT]
1966	Ivan Sutherland	Bob Sproull: first computer based head-mounted display [MIT]
1967	Bell Helicopter	HMD experiments with input from servo-controlled cameras [Bell]
1967	Hubert Upton	Invents analogue wearable computer, eyeglass-mounted display to aid lipreading [Bell]
1968	Douglas Engelbart	Demonstrates one-handed chording keyboard [SRI]
1972	lan Lewis	Invents a digital camera-case computer to predict roulette [Cal Tech]
1972	Keith Taft	First wearable belt computer
1977	CC Collins	Develops wearable camera-to-tactile vest for the blind [Smith-Kettlewell]
1977	Hewlett-Packard	Releases the HP 01 algebraic calculator watch [Hewlett Packard]
1978	Eudaemonic Enterprises	Invents a digital wearable computer in a shoe
1978	Steve Mann	Eyetap' wearable vision camera aid released
1981	Steve Mann	Backpack computer to control photographic equipment
1983	Taft	Commercializes toe-operated computers based for counting cards
1984	William Gibson	Writes 'Neuromancer'
1986	Steve Roberts	Builds a recumbent bicycle with on-board computer
1987	Terminator'	Film is released: point-of-view cyborg text/graphic overlay
1989	Reflection Technology	Private' Eye head-mounted display
1990	Gerald Maguire	John Ioannidis: 'Student Electronic Notebook' with Private Eye and mobile IP
1990	Olivetti	Active Badge': infrared signals to communicate person's location
1991	Doug Platt	Debuts his 286-based "Hip-PC"
1991	CMU team	Develops 'VuMan 1' for viewing and browsing blueprint data
1991	Mark Weiser	Proposes idea of *Ubiquitous Computing* in Scientific American
1992	Thomas Preston Caudell	Coined the term 'Augmented Reality'
YEAR	**INNOVATORS**	**FOUNDATIONS & COMPLETE SYSTEMS (cont.)**
1993	Thad Starner	Lizzy' computer, Doug Platt's design

1993	BBN	Pathfinder', wearable computer with GPS / radiation detection system
1993	Thad Starner	Remembrance Agent' augmented memory software
1993	Feiner, MacIntyre, Seligmann	KARMA augmented reality system
1994	Mik Lamming, Mike Flynn	"Forget-Me-Not," continuous personal recording
1994	Edgar Matias	"Wrist computer" with half-QWERTY keyboard [UofT]
1994	DARPA	DARPA; 'Smart Modules Program' wearable computers
1994	Steve Mann	Transmitting images from head-mounted camera to the Web
1996	Xybernaut	Belt worn computer with head mounted display
1996	ViA	Belt worn computer with audio interface
1996	DARPA	DARPA sponsors "Wearables in 2005" workshop
1996	Boeing	Hosts wearables conference in Seattle
1997	'*Beauty and the Bits*'	Creapôle Ecole de Création, Bunka Fashion College in Tokyo, DOMUS in Milan, Parsons School of Design in New York, Alex Pentland; 'Smart Clothes Fashion' Show
1997	CMU, MIT, Georgia Tech	First IEEE International Symposium on Wearables Computers
1997	Bradley Rhodes	The Wearable Remembrance Agent' augmented memory
1997	Steven Feiner	The Touring Machine': 3D augmented reality system
1997	Richard DeVaul	Richard DeVaul, Steve Schwartz, Josh Weaver, Daniel Barkalow, Steve Dunn, Chris Elledge, Jonathan Gips: Wearable computer MIThril vest
1998	Symbol	Wrist worn computer with finger scanner
1998	ISWC	2nd International Symposium on Wearable Computers
1998	Thad Starner	Lizzy' PC/104 based wearable computer
1998	Bruce Thomas et al	Backpack terrestrial navigation computer
1998	Alex Pentland	Body Electric' Networked Entertainment World conference featuring dance and performance involving wearable computers
1998	Thad Starner	Real time sign language recognition using wearable video
2003	ISWC	2nd International Semantic Web Conference (ISWC); Florida
2005	Sigtronica	August 19; 'seamless computational couture.'
2005	MIT	MIT Wearable Computing Group 'Hackfest'
2006	Sigtronica	August 19; 'seamless.computational couture.' by Sigtronica

Table 17: Based of Rhodes (1998):'A Brief History of Wearable Computing' - extension from 1998 onwards

Wearable computing which is ubiquitously connected to the Internet argues (Fitzgibbon & Reiter 2003, page 2) needs now to be considered holistically, where information is derived from ‘conjoint’ data types (images, audio recordings, text files, web pages) with BWCs yet another example of a technology with which to rapidly gain ‘different perspectives on people, events and the world’. Rigorous scientific investigations of psychographic factors which influence social acceptance or ethical resistance for wearable technologies must therefore also encompass critical appraisal of whether BWCs ‘improve human computer interfaces supporting everyday life activities’, a focus of empirical studies conducted by (Gribel et al. 2016; Matsuyama 2006).

In the collation of resources, it was identified by the researcher that seven (7) main areas of computing are pertinent to understanding BWCs with research domain specificity as; (1) *human-computer interaction* diversifies; (2) *ubiquitous devices*, as ‘things’ which; (3) en masse exhibit their own resonant presence in an *affective context*, where; (4) *perception of their role* is balanced with; (5) impartial, rational assessment of new and emergent contextual applications with further and future; (6) *feature enhancements* enabled by; (5) *location based services* (LBS) as the main networked conduit.

Human-Computer Interaction

According to Iyad Rahwan, director of the Center for Humans and Machines (CHM) at the Max Planck Institute for Human Development in a contemporary Human-Computer Interaction (HCI) context, the exponential impact on humanity of wearable computing which includes BWCs is that now:

> “... machines impact our lives, and with artificial intelligence (AI), increasingly those machines have agency" (Pavlus 2019).

An examination of how conceptual frameworks informing how humans can augment human intellect (Englebart 1962) prepared in 1962 by the Stanford Research Institute for the Director of Information Sciences, Air Force Office of Scientific Research,

Washington DC interestingly pre-dates Rahwan's assertions by 51 years. This is just one indicator of the considerable challenge of providing a historical account of wearable computing which is a subfield of the domain Human-Computer Interaction (HCI).

> "... An underlying principle of HCI is the requirement the design and development of technology be for the benefit of individuals (users) and society at large, through the employment of distinct user-oriented approaches and methodologies" (Abbas 2020).

The myriad of related forms of computing, theories and theorists, applications and innovations discussed in this chapter must therefore be considered contextually, informing the understanding of BWCs as a recent computing phenomenon, aligned with or conversely dividing sectors and stakeholders. In essence, wearable computing is a subfield of the multi-disciplinary field, Human-Computer Interaction (HCI).

> "... HCI strives to engineer the relationship between humans and machines (...) an obvious HCI application is using a mouse and keyboard to operate a PC" (Han 2017).

According to Steve Mann however, the reciprocity of humans and computers has been thwarted by proponents of HCI who have resisted engagement in interdisciplinary projects unless it perfectly suited them, emphasising that despite this 'intellectual precariousness' human computer symbiosis "...over the past 20 years, wearable computing has emerged as the perfect tool for embodying humanistic intelligence (HI) (S. Mann 2001).

> "... When a wearable computer functions in a successful embodiment of HI, the computer uses the human's mind and body as one of its peripherals, just as the human uses the computer as a peripheral. This reciprocal relationship is at the heart of HI" (S. Mann 2001).

Protagonists in the field of human-computer interaction (HCI) Mann emphasises, separate the human and the computer, regarding them as separate entities, whereas "...

in HI theory, we prefer not to think of the wearer and the computer with its associated I/O apparatus as separate entities" (S. Mann 2001).

This assertion by Mann mirrors the congruence of research participants historical accounts of HCI and their concurrence of opinions that HCI is the core domain and foundation through which BWCs are interlaced and mutually inclusive with the research paradigm of wearable computing. Literature located through the Netnography backs up this assertion, including historical accounts such as a chance meeting in 1956 of Manfred Clyne's scientist, inventor, and musician who took up a research role as 'Chief Research Scientist' on the offer from Dr. Nathan S. Kline, an American scientist, researcher in the field of psychology and psychiatrist. Kline was at the time Director of the Research Center of Rockland State Hospital and had by 1960 invented the CAT computer (Computer of Average Transients).

Together, although Clyne's is credited with coining the term 'cyborg' meaning 'cybernetic organism', a being with body parts both organic and biomechatronic, the essential premise of body-borne computers or wearable computing Clyne's and Kline considered as 'extensions of the more than human Self' as described by (Leigh et al. 2017).

> "... The purpose of the Cyborg, as well as his own homeostatic systems, is to provide an organisational system in which such robot-like problems are taken care of automatically and unconsciously, leaving man free to explore, to create, to think, and to feel" (Madrigal 2010).

In effect Clyne's considered the 'techno-self' and the related multidisciplinary field of human-computer interaction (HCI) founded by John M. Carroll (The Interaction Design Foundation 2019b) which first focussed on graphical user interfaces, multi-modal interaction techniques, model-based user interface specification, as necessitating inclusion of human identity study. Clyne's postulated that in a technological society a host of emerging ubiquitous, handheld and context-aware interactions would likely shift the relationships between humans and technology. The implications of this shift according to (Viseu 2003) is the concept that wearable computing would no longer simply extend the capabilities of the human body, rather

the human body would become an ‘intimate host’ in what J.C.R. Licklider had coined 45 years earlier as the ‘Man Computer Symbiosis’ (Licklider 1960).

Mathematician Edward O. Thorp, who some consider ‘Father of wearable computing’, similarly expressed in 1961 commensurate with Clynes that within this hybrid state, the coupling of the ‘human and non-human actors’ blur the boundaries for those who consider humans as rational and fully operational without post-human augmentation (Viseu 2003). The shift in self referencing through a ‘natural born cyborg’ nomenclature (Clark 2001) describes as also synonymous with interdisciplinary research in the cognitive sciences, engineering and human intelligence paradigm encompassing the MIT group ‘SafetyNet - Borgs Outside Medilab’ (Mann 1996a), with Manns own PhD thesis pertinently titled ‘Personal Imaging’ (Mann 1997).

In an ‘unmistakably doubled articulation’ Scott Bukatman in (Gray 1995, p.322) expresses that ‘humans with electronic pacemakers, artificial joints, drug implant systems, implanted corneal lenses, and artificial skin’ are inextricably located in a cybernetic loop, a human computer interaction signalling an end to traditional concepts of identity, arguably central to the premise argued by Donna Haraway in ‘A Cyborg Manifesto’ (Haraway 1991; Lupton 2013).

> “... a creature in a post-gender world (...) it has no truck with bisexuality, pre-oedipal symbiosis, unalienated labour, or other seductions to organic wholeness through a final appropriation of all the powers of the parts into a higher unity" (Haraway 1991).

Visualising that HCI alliance, in a contemporaneous context, Amber Case also situates this ‘cyborg’ as, “...anything that is an external prosthetic device creates one into a cyborg”. (Case 2010a). Case argues that a cell phone which can be considered as a technosocial object, enables an actor (the user) then to communicate with other actors (secondary users) on a network which as David Hess considers as ‘low-tech’ cyborgs’ trading information in an exchange of connectivity. (Case 2010a) A figure developed by (Case 2010b) titled ‘What is a Cyborg?’ which is useful in considering Cyborgism

from a humanistic perspective situates a series of interlocking circles with a central diamond-like shape, not unlike an Axon (AXON 2017a) body camera.

In close relationship with the central motif ‘CYBORG’ are four (4) key facets; (1) Artificial Systems; (2) Adaption; (3) Drugs; and (4) Hypothermia. In the nearest junctions to those facets are four (4) further areas; (A) Models; (B) Environmental Simulation; (C) Mineral Metabolism and (D) Hypo-metabolism. These all occur with four main domains being; (1) Cybernetics; (2) Sensory Deprivation; (3) Nutrition and (4) Life Systems.

Kevin Warwick, Reading University’s Visiting Professor of Cybernetics (Ip et al. 2009) however considers the leap from the handheld and voice activated device including the BWCs to embodied technological cognition as already manifest, given as Amal Grafstra, ‘Technologist, Author & Double RFID Implantee’ asserts “... DIY cyborgs (...) are upgrading their bodies with hardware without waiting for corporate development cycles or authorities to say it’s OK” (House 2014).

> “... Transhumanism aims to alter the human condition for the better by using technology (as well as genetic engineering, life extension science and synthetic biology) to make us more intelligent, healthier and live longer than has ever been possible – eventually transforming humanity so much it becomes “post-human” (House 2014).

According to Lazar Puhalo, Fellow of the Chester Ronning Centre of the University of Alberta, Canada though, with reference to his formal studies including physics and neurobiology, Lazar contends that much of what is now being developed, including body worn computing technologies such as BWCs veers away from Cyborgism as a real concern with valid prosthetics, now simply emulating an imitation of “... we are Borgs; resistance is futile" (Lazar Puhalo in Michael 2014b).

> “... Transhumanism presumes that the soul and the body are totally separate entities so that the soul can function outside the body and be downloaded into an avatar and also that it can be evolved to be totally independent of the human body" (Lazar Puhalo in Michael 2014b).

This perspective of Lazar closely aligns with the views of N. Katherine Hayles, Duke University (Pötzsch & Hayles 2014) who considers what she observed in the 1980s and 1990s as a contradiction of the ‘trans’ deconstruction of the liberal humanist subject and the attributes normally associated with it such as autonomy, free will, self determination. Instead, for Hayles the genesis of ‘posthumanism’ came to the fore, such as capturing the informational patterns of the human brain and uploading these to a computer to “... achieve effective immortality” (N. Katherine Hayles in Pötzsch & Hayles 2014 p.2).

> “... To me this seemed absolutely wrong, even pernicious, because it plays on mere fantasies of cognition and of what constitutes human life” (N. Katherine Hayles in Pötzsch & Hayles 2014 p.2).

Ubiquitous Computing

In the late 1980s, Mark Weiser, chief scientist at Xerox PARC, was credited with coining the phrase ‘ubiquitous computing’ in the journal Scientific American according to (Lamkin 2014), predicting a third wave of computing, a movement where personal technology would no longer be confined to the desktop, in effect become a ubiquitous part of our everyday lives.

> “... One of the indisputable facts of the digital era is that we are living in a time when more information is gathered, collected, sorted and stored about the everyday activities of more people in the world than at any other time in human history" (Andrejevic 2012).

As Andrejevic (2012) posits, this ‘ubiquity’ of computing includes ‘lateral surveillance’ as network infrastructures, digital media forms and increasingly sophisticated devices are honed for consumer marketing and monitoring. The Internet, the world's most powerful digital information transfer agency, therefore has only enabled humanity to transcend an industrial society to that of a mediated information

society, creating dichotomies of power through access according to (Andrejevic 2002).

> "… A recurrent theme across (research) domains is that the Internet tends to complement rather than displace existing media and patterns of behaviour" (DiMaggio et al. 2003).

Arguably though, Ubiquitous Computing (Wissinger 2017; Abowd et al. 1998) by virtue of humans having continuous connection to the Internet, is now facilitated through points of connection via wearable computing, including wearable vision systems as described in research conducted with the support of the Ministry of Education, Culture, Sports, Science and Technology, Japan (Matsuyama 2006, p.14). The engineering of wearable vision systems in 'parallel', 'divergent' and 'convergent' configuration which surround 'human eyes and share the same field' the notion of 'ubiquitous vision system' is no longer a foreign parlance in the domain of Human-Computer Interaction.

> "... We believe ubiquitous and wearable vision systems enable us to improve human-computer interfaces and support our everyday life activities" (Matsuyama 2006).

The consumer awareness of third party surveillance has led to initiatives such as 'ScreenAvoider' tactics (Korayem et al. 2014), especially relevant in the BWCs lifelogging context as mitigation strategies for 'inadvertent' data capture collide with privacy threat model (Ferdous et al. 2016; Ferdous et al. 2017; Ostkamp et al. 2015) assertions that "... the right to privacy is one of the fundamental human rights in any modern society" (Ferdous et al. 2016).

Traditional notions of informed consent, anonymity, confidentiality, privacy, benefit and maleficence reinforce the need for ethics governance in an age of ubiquitous computing according to (Mok et al. 2015), especially considering the rapid adoption of wearable technologies. This is especially pertinent reinforces (Elazhary 2019) who calls for a disambiguation of paradigms such as Mobile Cloud Computing (MCC) which 'hoovers up' personal data from the Internet of Things (IOT) world, (Abbas et

al. 2015) positioned at the intersection of ‘opportunistic sensing, participatory sensing, mobile crowd-sensing, and mobile crowdsourcing’.

Conversely, with claims that the term ‘ubiquitous learning’ is being problematically aligned with technological determinism according to Blackall (2013) due to an “... absence of critique, and proposes that the phrase become less about device, platform, applications, or ideas of technologically 'enhanced' pedagogy" (L. Blackall 2013). These traditional notions as described by (Mok et al. 2015) are under assault claims (L. Blackall 2013) and instead of a mechanistic and technologically deterministic approach, switching to a focus on values and principles that guide perspectives and practices in learning such as the use of BWCs could lead to the development of an *ethical framework for ubiquitous learning*.

> “... Here, ubiquitous learning becomes a term more associated with situated learning, conviviality, and open access. (L. Blackall 2013)

Affective Computing

From a contrasting position and shift from the human-centric approach, affective computing also known as Artificial Emotional Intelligence (AEI) coined by Rosalind Picard in 1995 of the Affective Computing Research Group at the MIT Media Lab rose quickly as a key interdisciplinary field spanning computer science, psychology, and cognitive science.

> "... Computers are beginning to acquire the ability to express and recognise affect, and may soon be given the ability to "have emotions" (Picard 1995).

Picard's work, unlike Blackall's ethical framework for ubiquitous learning in which Blackall proposes the human is the focus of activity, provides a contextual framework within which to consider how digital technologies contribute to the manner in which we interact in society and contextually, how BWCs 'may eventually think for themselves'. This notion from Picard who is often attributed with building the first artificial intelligence computer with a focus on the emotional capacity of computer engineering, continues to be highly contentious as a benchmark for considering computers as sentient beings, capable of thought and having emotions.

> "... Within the HCI stream of Information Systems (IS) related research, there is a limited amount of studies that address theory inspired design of actual IT artefacts, or address the ubiquitous context of technology use" (Dibia 2015).

The level to which the interface design influences human behaviour and motivations through emotions such as mood are directly associated with social norms and utility accrual most especially reflex, perception and cognition (Forgas and George 2001; Forgas and Moylan 1991 in Dibia 2015, page 2). According to Dibia, wearable devices such as BWCs with sensing capabilities that track, monitor or pervasively 'nudge' human behaviour are impacting upon society, with both positive and negative normative implications (Pelegrín-Borondo et al. 2017; Tiidenberg & Gómez Cruz 2015) as wearable devices (Dibia 2015, page 2).

Parallels with the Cognitive-Affective Normative (CAN) model, especially the assessment of new ‘insideables’ as embodied computing which visualise through surveillance of the human form as ingestible or implantable technology (Pelegrín-Borondo et al. 2017) are discussed further in the subsection of this chapter, 4.3 Applications & Innovations: Technology Types.

Perceptual Computing

Within the realm of Perceptual Computing according to (Mendel & Wu 2010), subjective judgments based on observation and interpretations developed which extrapolate upon standard definitions of wearable computing, are integral in the analysis of data and ensuing discussions in this BWCs research investigation.The manner in which ‘computing with words’ recorded as clusters of concepts and eventually as cogent themes could be grouped, ranked and from which visualisations could be formed, arose as (M. Billinghurst 2014) attributes from ‘relevant human perceptual principles’, aligned by modus with the seven (7) ‘Gestalt Principles Of Perceptual Observation’ humans then “... form pattern recognition and how we subconsciously group entities together" (MacNamara 2016).

Lotfi Zadeh, the father of ‘fuzzy logic’, who coined the phrase ‘computing with words’ (CWW) emphasises that this ‘perceptual computation’ may explain “... perception based rational decisions in an environment of imprecision, uncertainty and partial truth" (Mendel & Wu 2010). Using the same principles, human logic and rationality can therefore be attributed to expressions by the researcher in this thesis as; (1) unique code sets; (2) visualisations by enumerated table; (3) interpretations as rich descriptions and; (4) subjective accounts with enhanced perceptual extensions harnessing QDAS computational machine encoding of qualitative data using tools such as Atlas.TI. These very same attestations of computing enhanced perception were extolled by MIT’s Rehmi Post, Thad Starner, Steve Mann and Alex Pentland, all part of the ‘Perceptual Computing Group’ in the 1990’s, often referred to as the ‘borgs’.

> "... If you frequented Kendall Square in the 1990s, you may have encountered one of the pioneers of wearable computing, students who ambled around Cambridge wearing special goggles with built-in cameras and display screens, toted computers in backpacks and messenger bags, and palmed special one-handed keypads so they could enter data. Sprouting wires everywhere, they looked like cyborgs late for a Halloween party" (Kirsner 2012).

Similarly, the Future Computing Environments Group (Abowd et al. 1998) at the Georgia Institute of Technology who were engaged by the year 2000 in mobile computing solutions and distributed infrastructure started referring to networked and ubiquitously connected devices as 'context aware computing' or Contextual Computing.

Contextual Computing

A personalised, persistent, consistent and dependable interface observed (Starner et al. 1997) then engenders trust, which in turn, the user becomes reliant on. The wearable computing system then becomes the 'the mediator for other computers and interfaces', in effect what could be referred to as the 'consumer dependency model'.

> "… Ideally, wearable computing can be described as the pursuit of a style of interface as opposed to a manifestation in hardware" (Starner 2001).

Prior to being recruited by Google Inc. a key wearable computing project at MIT Media Lab Wearable Computing Group including Starner was the 'MIThril' project (MIT Media Lab 2003a). Described as a 'next-generation wearables research platform' researchers at the MIT Media Lab' worked on the development and prototyping of new techniques of human-computer interaction (HCI) for body-worn applications.'

> "… The MIThril hardware platform combines body-worn computation, sensing, and networking in a clothing-integrated design. The MIThril software platform is a combination of user interface elements and machine

> learning tools built on the Linux operating system" (MIT Media Lab 2003a, p.3).

A photograph taken by Sam Ogden of the MIThril crew titled aptly ‘MIThril Crew (Ogden 2003) is useful in a historical reference, interestingly with an equal representation of male and female members, each with a headworn wearable computer other than Thad Starner who is pictured wearing a Twiddler device (Lyons et al. 2004). The ‘2nd International Semantic Web Conference’ (ISWC)(Semantic Web Science Association 2003) provided the MIThril project with an audience who were already coining ‘contextual computing’ which inevitably led to the title ‘Contextual Computing Group’ (Georgia Tech 2017b).

The MIThril project, MIT ‘Borg Lab’ with Alex Pentland (Starner et al. 1998), Richard W. DeVaul (R. W. DeVaul 2003), Jonathan Gips and Michael Sung (Ebner et al. 2016) are also attributed with terms ‘context awareness’, ‘visual contextual awareness’ or ‘context aware applications’, with the ‘Memory Glasses’ (MIT Media Lab 2003b) application perhaps the foundation for Google’s ‘Google Glass’ project with Thad Starner as Project Lead.

In a presentation by DeVaul, member of the MIThril team in 2003 at the Second Annual ‘I Wanna Be a Cyborg’ event, an MIT BorgLab production, re-defined wearable applications as:

> “... A true wearable application is a mobile, persistent, proactive, and context aware system which is designed to extend the capabilities of the wearer. Like clothing, a wearable application is always present and always doing its job, even when the wearer isn't focusing on it" (R. W. DeVaul 2003).

Three (3) critical criteria were then determined by the team as pertinent and indeed stipulated as the guides or hallmarks for whether a technological innovation met context aware wearable application descriptions:

1. *Mobile and persistent* - “... always with you, always doing its job”;
2. *Proactive* - “... semi-autonomous, capable of getting the wearer's attention”;

3. *Context aware* - "... senses and understands the wearer's relevant context".

Building upon the concept of the 'wearable remembrance agent' (Rhodes 1997) and of significance in this research context is the inclusion of HCI for 'Memory Glasses' as:

> "... A small head-mounted display showing pictures and text associated with the wearer's present location and conversation partner are superimposed over a portion of the visual field of one eye" (R. DeVaul 2003).

With the rapid ascension of wearable computing as a contextually aware, ubiquitously connected and as developments indicated, autonomous 'agent' the advent of 'smart' network connection (Lee et al. 2016) to the Internet suddenly opened up new market opportunities to leverage user data, monetise subscription services and 'mesh' related peripherals such as bluetooth streaming cameras or audio earbuds, with the human 'user' now a carrier for a number of 'on-body' connected devices.

Empathic Computing

As described in the University of South Australia 'Empathetic Computing Lab' website, the core principles of Empathic Computing are purportedly grounded in a research field which enables the development of computer systems that 'recognise and share emotions and help people better understand one another'.

> "... Empathy is about seeing with the eyes of another, listening with the ears of another and feeling with the heart of another" (Empathic Computing Lab 2020).

Borrowing heavily on the semantics of human association, 'research projects at the Empathic Computing Lab explore(ing) systems create understanding' with research involving BWCs and many other HUD and HMD wearable computing technologies which interface with augmented and virtual reality such as 'Empathy Glasses', which is "... a head worn prototype designed to create an empathic connection between

remote collaborators" (Masai et al. 2016). Research themes congruent with this domain as cited as; (1) Empathic Computing; (2) Collaborative Interfaces; (3) Augmented Reality and (4) Virtual Reality. According to the University of Auckland 'Empathic Computing Laboratory' the work conducted to date "… is at the junction of three computer interface trends" (The University of Auckland 2020).

> "...These trends are; (a). the way we capture content, which has advanced from still photography in the 1850s to today's streaming 360-degree video on a portable machine; (b). Increasing bandwidth, which allows you to download a movie in seconds and do higher-quality video conferencing; (c). '*implicit understanding*' where computers are able to watch and listen to us in order to understand what we are doing" (The University of Auckland 2020).

A comprehensive assessment of works in Empathic Computing, the Empathic Computing Laboratory (ECL) as an academic research laboratory at the University of South Australia in Adelaide, Australia, and at the University of Auckland in Auckland, New Zealand is explored further in the 'Virtual Reality' and 'Augmented Reality' section of this chapter.

Location Based Services (LBS)

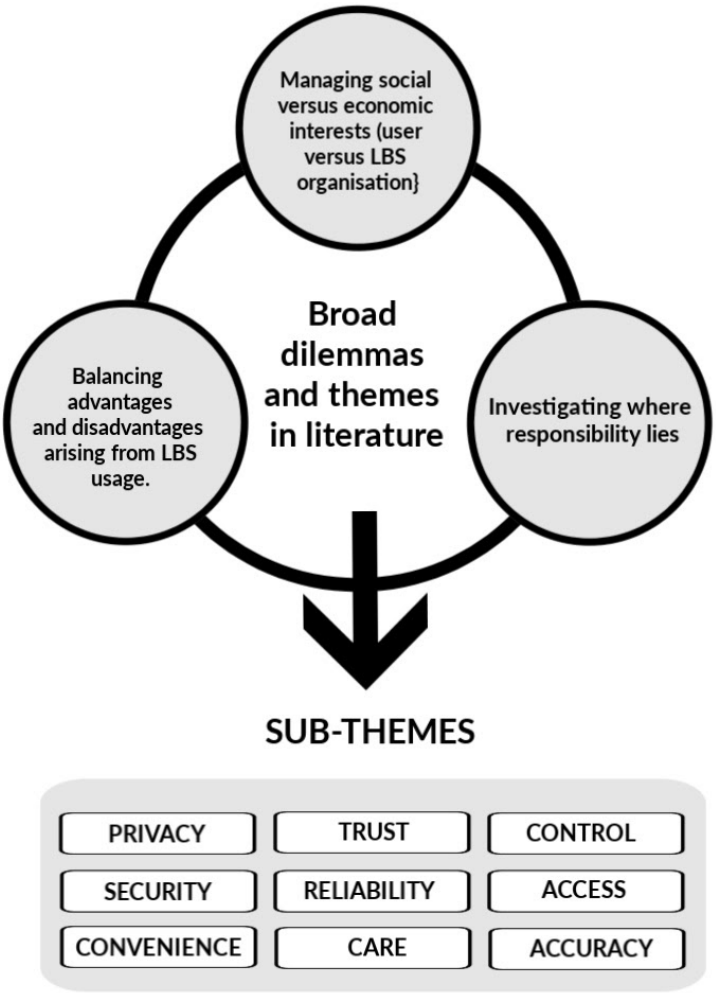

Figure 20.'Summary of ethical dilemmas and themes relevant to LBS', reproduced with permission from 'The regulatory considerations and ethical dilemmas of location-based services (LBS): A literature review' (Abbas et al. 2014).

The ethical implications of LBS as it pertains to BWCs are comprehensively outlined in a paper by Abbas, Michael & Michael (Abbas et al. 2014), in which "... what is moral and what is legal are not identical" (Quinn (2006) in Abbas et al. 2014 p.91).

The social implications of LBS (Abbas et al. 2014) reinforce, can therefore be examined by focusing on themes and dilemmas providing a rich analysis of the implications or alternatively based on two factors:

> "... actions or activities may be morally flawed and legally acceptable in the same instance (...) two prominent ethical dilemmas emerge with respect to LBS, which are the risk of privacy breaches, and the possibility of increased monitoring leading to unwarranted surveillance by institutions and individuals" (Abbas et al. 2014).

A summary of broader ethical dilemmas and themes, investigative responsibility, the balance of advantages and disadvantages, as well the management of social versus economic interests are illustrated in conjunction with sub-themes relevant to LBS being; (1) privacy ; (2) trust; (3) control; (4) security; (5) reliability; (6) access; (7) convenience, (7) care and (8) accuracy as Figure 20:'Summary of ethical dilemmas and themes relevant to LBS',in *Figure 20: Summary of ethical dilemmas and themes relevant to LBS (Abbas et al. 2014).*

The inclusion of Location Based Services (LBS) as a research domain is considered by the researcher as critical in the understanding of BWCs, in fact the core means through which the 'intelligence' of knowing where a device exists as an event, located in time and space. This persistent and pervasive connection arguably disconnecting sentient beings from 'place' is central to the research argument, not simply expressed as to whether BWCs are of benefit or conversely a detriment to humanity.

> "… What I am conscious of is saying what I discovered, what I learned and nothing more powerful than anecdotes that matches empirical evidence which demonstrates that LBS 'burns' culture as it gives away patterns to the anthropos and makes those patterns exploitable" (Hayes 2019).

Applications that utilise the position of an end-user, an animal or ‘thing’ based on a given device whether they be handheld, wearable, or implanted for a particular purpose are LBS by definition according to (Perusco & Michael 2007). Subjectively, of particular interest to the researcher, is whether LBS which intersects with contemporary forms of BWCs is the penultimate affordance or conversely the root of all human-centric issues pertaining to device user loss of privacy.

> “... This area has potentially wide-ranging implications for society. In fact, LBS has been described as being ‘...without a doubt one of the most exciting developments to emerge from the mobile telecommunications sector’” (Michael 2005).

Ideologically, these challenges are illustrated in *Figure 3: Premise of Location Based Services* encompassing the premise that; (a) control *decreases* trust; (b) trust *augments* privacy; (c) privacy *requires* security; and (d) security *increases* control as; return to (a).

> “... Privacy requires security as well as trust. A person’s privacy can be seriously violated by a security breach of an LBS system, with their location information being accessed by unauthorized parties (...) Of course, control and privacy are mutually exclusive. Constant monitoring destroys privacy, and privacy being paramount rules out the possibility of LBS tracking" (Abbas et al. 2014).

The regulatory considerations and ethical dilemmas of LBS attests (Abbas et al. 2014) emanate from the study of the social and behavioural implications (Michael & Michael 2011) in particular privacy implications of ‘normality mining’ using predictive behavioural profiling (Gasson et al. 2011), all informants of the continuing development of a socio-ethical framework (Abbas et al. 2015).

> “... Laws, similar to global technical standards, usually take a long time to enact. A more holistic approach is required to analyse technology and social implications" (Michael 2007).

The convergence and trajectory of automatic identification and location-based services toward chip implants and real-time positioning capabilities emphasise (Michael & Michael 2009), as inherent with ‘social, cultural, and ethical implications of the technological possibilities with respect to national security initiatives’. It has only been through regulatory oversight that injunctions brought about by the representation of peak privacy organisations such as the Electronic Privacy Information Centre (EPIC) (Electronic Privacy Information Center 2019) and the Electronic Frontier Foundation (EFF) (2015; 2017) that monitor the proliferation of BWCs with LBS enhanced real-time automatic facial identification as campaigned by Privacy International (PI) (Privacy International 2019).

4.2.2 Theories & Theorists

To avoid apocalyptic visions of a post-humanist epoch of humanity collapsing amongst the orchestrations of a technological Singularity, broad, yet limited considerations of humanistic intelligence (HI) (Han & Ishii 2017), considered by Mann (S. Mann 2001; Mann 2017) as at the apex of BWCs role in society, are considered by the researcher amongst many other contributions from significant figures affiliated with the field of wearable computing.

The extraordinary renditions and calculations by historical figures such as John Von Neumann of the point at which machines-building-machines reach a state of ‘self reproducing automata’ (Von Neumann 1966; Scharf 2016) despite their seemingly apocalyptic associations are important also, considering the already rapid deployment of wearable computing across the global law enforcement sector and the resultant proliferation of BWCs, each device as a node, one small part of a greater digital panopticon (Galič et al. 2016; Caluya 2009).

The researcher considers that to better understand empirical studies as significant contributions to human society from domains of research integrity, the act of revealing key figures and their industry and corporate affiliations is as compelling and as ‘exciting’ as the innovations they report. According to Thad Starner, director of the

Contextual Computing Group (CCG), College of Computing at Georgia Institute of Technology, also the longest-serving Technical Lead/Manager on Google's Glass (Google Inc. 2020) personal computers were soon after their inception as stand alone units considered to have a limited capacity as machines used generally “...only a small fraction of the day" (Starner et al. 1995).

> “... Wearable computing hopes to shatter this myth of how a computer should be used. A person's computer should be worn, much as eyeglasses or clothing are worn, and interact with the user based on the context of the situation" (Starner et al. 1995).

As a wearable computing invention, as a collaborative innovation and later as a global networked mass surveillance vehicle, historically wearable computing was for a long time relegated to ‘those crazy inventors’ yet inextricably linked, interwoven and as some might argue, inseparable by constitution with many interdisciplinary computing studies which all form the historical backbone for BWCs. The discernible influence of Steve Mann (Mann 2005) and Thad Starner (Starner et al. 1995) as prior members of the MIT Media Lab or ‘BorgLab’ is most clearly illustrated as part of the greater developments since 2010 of wearable computing in the figure, ‘A Short History of Wearable Computing’ in (Han & Ishii 2017).

Contemporary & Historical Figures

It is evident from reviewing multiple sources of literature that a solid theoretical framework informs how BWCS continue to develop and historically, the many figures in some way aligned with theories as illustrated in *Figure 5. Theoretical Framework* that have contributed to understanding BWCs theoretical underpinnings.

Given the many differing theoretical positions and fundamental differences of approach to wearable computing, the focus on influential human actors and by association, those institutions who have contributed to critical discourse, defines in duality, not the sole mono 'deterministic' character of how BWCs shape society. This discourse has undoubtedly been informed by Heidegger who interrogates the realm of craft as it pertains to poises, in the context of BWCs is at a level of surveillance where the *human becomes the camera;* something that did not exist before.

> "... According to Heidegger, technik - by contrast to techne - refuses "to let earth be an earth" (Vinegar & Boetzkes 2014).

Philosopher Karl Marx also speaks of "... the "forces of production" (technology plus workers' capabilities) as well as the structure of relations of production and the superstructure of politics and culture" (Adler 2006).

Likewise, Immanuel Kant (Schönfeld & Thompson 2019; Kant 1914) could be credited as the core to critique of practical and evolutionary philosophy, a defender of 'pantheism, naturalism, evolution, cosmic expansion theory and holism'. Of most interest in the context of BWCs is Kant's renditions in *Foundations of the Metaphysics of Morals (1785)* distinguishing between 'things' and 'persons' describing the former as natural means and the latter as rational ends.

> "... Persons (humans) are free; what distinguishes them is their will, a faculty of determining oneself to action (...) self-determination is the basis of freedom; necessitation is the mark of nature" (Schönfeld & Thompson 2019).

In a human political context, using Kant's persuasions, BWCs as 'things' may also then be considered as technologically deterministic, that is, following a developmental path which would concur with the reductionist and evolutionary economics theories of Thorstein Veblen (Hodgson 1998), or by contrast, the positivist social dimension of science as an evolution would position BWCs as a mere artefact, mutually shaping society as extolled by Auguste Comte (Bourdeau 2018).

These criticisms of a linear model of innovation that are aligned with technological determinism are most notably reinforced by Robin Williams, Professor of Social Research on Technology at the University of Edinburgh, Scotland, director of the Institute for the Study of Science, Technology and Innovation (ISSTI 2020a), founded by the late David Edge (ISSTI 2020b) and aligned with the theory Social Shaping of Technology (SST).

> "... Much of this research is united by a shared concern with 'social shaping'. This perspective rejects determinist notions that see science and technology or their impact on society as 'given', in favour of the view that complex political, economic and other social forces together shape science and technology, and so govern our choices over them" (ISSTI 2020a).

Likewise as the 'originator of the thesis -antithesis-synthesis triad' Georg Wilhelm Friedrich Hegel could also be considered as a protagonist of the dualisms of form which BWCs occupies as it joins its human counterpart, psychologically melding 'subject' and 'object' which (Stephens 2014) equates with Postman's 'dualistic thinking to a metaphorical conception' by analogy. Of greater importance the researcher will relate are the works of Heidegger, especially the conceptual associations through which (Heidegger 1977) encapsulates how technology will 'play out' for humanity.

> "... Today all things are being swept together into a vast network in which their only meaning lies in there being available to serve some end that will itself also be directed toward getting everything under control. Heidegger calls this fundamentally undifferentiated supply of the available - the "standing-reserve" (Heidegger 1977).

It is important to note that these conceptual associations of Heidegger, of humanity in some way subservient through an assumption of technological disempowerment, also surface in the analysis of research participants contributions using a Foucauldian Critical Discourse Analysis. Foucault was selected as a critical literary 'lens' whose works inform the best serving examination of power relations and anthropology of ethics as described by (Faubion 2001). Through dialogue, research participants relate their own interpretations of 'power' and 'control' as major themes and 'Veillance' as emergent themes are described and as associated with the positions of (Foucault 1982). This study of power relations, society and the role of restraining the government from oppressing members of its 'society' could also be examined through the political theory lens of John C. Calhoun, a firm believer that "... Society is necessary to man; government is necessary to society" (Merriam 1902).

> "... But the government itself contains the germs of evil, and must in its turn be controlled or balanced. To this end is erected a constitution intended to hold in check the destructive tendencies found in government" (Merriam 1902).

Fiercely critical of traditional religious centres of 'moral servitude', the works of Friedrich Nietzsche, a german philosopher (Nietzsche 1891) resonate clearly considering the 'hermeneutics of suspicion', which the researcher considers useful in critical inquiry of BWCs as artefacts of corporate structures and their social network presence. Notwithstanding, when examining whether the propagation of fear through 'false consciousness' in order to sell products that 'divide and conquer' exists, Nietzsche clearly delineates between the virtues of suspicion as overriding the alienation of abject pessimism.

> "...even supposing we must aim at power, maybe that is exactly what makes the world a terrible place, rather than providing any reason to think that power, or its pursuit, is valuable" (Anderson 2017).

Likewise, Engels postulates on the myriad of separations and inevitable position of alienation of those who as described by Jean-Jacques Rousseau, in *The Second*

Discourse, (1712–1778) fall foul of BWCs as a result of clever marketing enrolling and inflaming consumers with '*amour propre*' or self-loving through technological infatuations (Leopold 2018).

These infatuations might well be translated in this research investigation context as behaviours which emerge in the battle for patriarchal recognition of 'Father of Wearable Computing' despite the fact that many in their own unique way have contributed to what it means to now have 'always-on' and 'anywhere' connectivity as humanistic computing reality. The contradictions of 'self-reference' within the realm of wearable computing are according to Jurgen Habermas (Wagner & Zipprian 1989; Bohman & Rehg 2017) a forfeiture of power and rationality, with BWCs occupying a liminal position as Ray Kurzweil, inventor and futurist (Kurzweil 2011; Kurzweil 22 Sep, 2005) would argue in a post-anthropocene quagmire.

Habermas would counteract with an assertion that freedom, subjectivity, or creativity is the modern reason for human completion, rather than self-transformation through subsuming power to machines, nor oligarchs controlling "… a system of procedural rules for achieving consensus and agreement among communicating subjects" (Zalta 2015).

Similar phenomenological considerations regarding subjective authority of moral ascendency are the foundations for understanding contemporary philosopher Jean Paul Sartre's (Sartre 1946) humanist arguments, in this case in examining the leadership of wearable computing we become conscious of the 'authentic', where idealism and ego thwart the ethical and conscious fight for freedom (Flynn 2013).

The paradox in light of Sartre's assertions occurs when examining the self centrism of Steve Mann, engineer, professor and inventor well known as a proponent of augmented reality, computational photography and wearable computing wearable computing.

> "... In some sense, I chose to learn about computing by 'being' a computer, and to learn about photography by 'being' a camera for more than 30 years. I call this 'learn-by-being." (Mann 2012).

It is through the critical thinking of Habermas that leaders of technological shift could then be considered as ‘humanists’ including John McCarthy, computer and cognitive scientist, who is often attributed as ‘the father of AI’ in the early developments of the LISP computer language which became the standard for Artificial Intelligence (AI), computer networking preceding the Internet and cloud computing believed that “... every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it" (Childs 2011).

Alan Mathieson Turing, considered as the ‘father of abstract computing’ with the invention of fundamental logical principles of digital computing, computer programming and first marketable electronic digital computer in 1951 (Copeland 2012) is another figure whose legacy as a mathematician, computer scientist, logician, cryptanalyst, philosopher and theoretical biologist led to being known as an exponent of complex systems and “... the hypothesis that the human brain is in large part a digital computing machine" (Copeland 2020).

> “... as Glasses have highly promoted our seeing, there may be found many mechanical inventions to improve our other senses of hearing, smelling, tasting and touching" Robert Hook, 1665 in (Pentland 1998, p.1)

Organisations & Affiliations

In a contemporary context, Sandy Pentland, academic head at the Massachusetts Institute of Technology (MIT) Media Laboratory is of the opinion that “... if we can endow these tools with sufficient situation awareness to make them a help rather than a hindrance, they offer the promise of enhancing human intelligence in a seamless and enjoyable way" (Pentland 1998, p.6).

> “... Our wearable data collection system lets users collect their experiences into a continually growing and adapting multimedia diary” (Blum et al. 2006).

Over a twenty year period wearable computing has become inextricably intertwined, where the human as only one part of the computational process embodying Humanistic Intelligence (HI) according to (Steve Mann 2001c). It is also important to note that Gary T. Marx (Marx 2015) who is renowned for work in the field of surveillance and privacy coined the term ‘sousveillance’ popularised by Mann et al. (Mann 2005; Michael et al. 2013; Mann 2012) when Mann was a former student of Marx and AI scientist Minsky (2007; et al. 2013).

Joining Pentland and Mann, fellow colleague at MIT Thad Starner, as the Lead of ‘Project Glass’ quotes Google CEO Larry Page who stated in the context of humanistic intelligence and augmented reality that the goal a head-worn camera and HUD vision system “... is to reduce the time between intention and action" (T. Starner 2013). Not surprisingly, Starners corporate employment critically positions innovation with avid product endorsement and consumer hype by alignment:

> “... Soon, Google Glass will be worn by many more users as part of the Glass Explorers Program. (…) I encourage you to participate in exploring this new lifestyle, enabled by Glass" (T. Starner 2013, p.16).

Mark Billinghurst, Professor of Human Computer Interaction at the University of South Australia (M. Billinghurst 2014; Billinghurst & Busse 2015) who has championed augmented reality and provided technical expertise and pedagogical application to the Google Glass program (M. Billinghurst 2014) is also noteworthy for his contributions to the IEEE International Symposium on Mixed and Augmented Reality (ISMAR) (Arth et al. 2015) alongside Rob Manson, CEO and Founder of Awe Media (Manson 2013). With the onset of web 2.0, big data, reality mining and the semantic web many new projects, groups, laboratories were created including the MIT Human Dynamics Laboratory (Anon 2009) and research groups such as ‘Camera Culture’:

> “...The group conducts multidisciplinary research in modern optics, sensors, illumination, actuators, probes and software processing. This work ranges from creating novel feature-revealing computational cameras and new

> lightweight medical imaging mechanisms, to facilitating positive social impact via the next billion personalised cameras" (MIT Media Lab 2017).

The Massachusetts Institute of Technology (MIT) has undoubtedly cast an indelible footprint across the field of wearable computing although according to Steve Mann "... in the early days, a lot of it was gimmickry" (Han 2017)

A photograph taken by (Mann 1996a) titled 'Borgs outside MediaLab' triggered by wireless device is useful (as a self portrait) in describing the bulky and seemingly absurd wearable computing systems of that era, which to the viewer might seem to illustrate Mann's statement in (Han 2017)**.**

Bradley Rhodes, (Rhodes & Mase 2006) MIT graduate and Kenji Mase, professor at Nagoya University, Japan recount how in 1996 the American military research group Defence Advanced Research Projects Agency (DARPA) sponsored an event titled 'Wear2005' in which delegates were encouraged to predict and identify gaps to what may thwart such prediction for wearables, prefacing the 9th Annual International Symposium on Wearable Computing, Osake, Japan. Masakazu Miyamae was soon identified as a leader in how sensor enhanced wearables would harness LBS and RFID for indoor and outdoor applications. Kenji Mase brought MIT graduate Bradley Rhodes into contact with Hirotake Yamazoe, Akira Utsumi and Kenichi Hosaka authors of seminal paper, "... A Body-Mounted Camera System for Capturing User-View Images without Head-Mounted Camera" (Yamazoe et al. 2005).

Large investments in hardware development by corporations since have seen wearable technology explode across a global stage and corporations have continued to invest in the wearable computing domain including Google, Boeing, IBM, Microsoft, Toshiba and Motorola.

Empirical Studies

An examination of empirical research in the literature review produced a few outstanding examples of positive interdisciplinary approaches to addressing the social

impact and the ethical implications of BWCs for humanity, with notable exceptions primarily focussed on why the over-representation of policing involving BWCs is a negative for communities, especially those subject to the very worst of law enforcement brutality.

Since 2015 there has been an explosion of quantitative based empirical studies, yet as (Laming 2019b; J. Murphy 2018a) attest, there is a dearth of qualitative, ethnographic accounts of BWC's that bring the broader opinions and public voice into the vestige of empirical research. Conceptual and normative complexities surface throughout available literature, which, as this investigation reveals, highlights a lack of subjective accounts from those most impacted by BWCs, hence the motivation by the researcher to engage through an authentic ethnographic approach to "... communicate, present oneself, and interpret others' presentation of self in a technologically mediated interactional environment".

Difficulties arise for the legibility of empirical research when association between research units and supporting organisations are proven or are perceived to be compromised, where ethical and peer review processes are breached and where alienation due to philosophical accounts and personal conflicts are not resolved. To a degree this dilemma is partially resolved when empirically intact research results are transparently available for interrogation in a socio-legal context "... significant main effects of both eyewitness race and BWC status" (Saulnier et al. 2019).

> "… the results of one of the first experimental examinations of the effects of three BWC status conditions (absent, transcribed, viewed) and eyewitness race (Black, White) on mock jurors' case judgments, in a case in which a community member (defendant) was charged with resisting arrest but where the officer's use of force in conducting the arrest was controversial" (Saulnier et al. 2019).

Qualitative studies of BWCs used in an Australian educational context (Hayes et al. 2010; Ridgway 2010) and within the domain of mobile learning (Hayes et al. 2012; Downes 2007; Ragus et al. 2005) pre-date much of the emphasis in peer reviewed literature which is heavily influenced by BWCs in policing and law enforcement. The vast array of resources which focus on the judicial inquiry into BWCs needs therefore

to be considered as indicative of the vast capital spend on BWCs, perhaps as the literature indicates, an emergent meta-paradigm of human-borne CCTV.

Existing and ongoing body worn camera research according to (Lum et al. 2015; J. Murphy 2018a; Brucato 2014) will require extensive and diverse interdisciplinary and intercultural investigations, building upon an already over-represented body of reports and industry affiliated research with questionable rigour. Notably also, with the onset of industry trials spearheading whole-of-nation implementation (United States of America Justice Department 2015) of BWCs in law enforcement projects in the United States of America and the United Kingdom prior, trepidation from leading human rights and social justice groups as well as privacy advocates such as the Electronic Frontiers Foundation (Lawrence 2017) is focussed on mass surveillance in the immediate form of facial recognition coupled with AI they believe is leading to a state of locative enhanced (Ashbrook & Starner 2002) pervasive, predictive policing.

In the United States many BWCs empirical studies such as randomised controlled trials have been conducted which focus on the response-to-resistance and clear reduction of serious external complaints against police (Ariel et al. 2015; Rowe et al. 2018; Jennings et al. 2015) as have field experiments (Ariel et al. 2015; Turner et al. 2019) which examine self awareness from being watched, in effect, it normalises 'socially-desirable' behaviour in response to policing presence. Conversely on-officer perceptions (Jennings et al. 2014; Katz et al. 2015) of the use of body-worn cameras in law enforcement contrast with the outcomes of reviewing police-citizen contacts (Ready & Young 2015), yet as (Lum & Koper 2019; Lum et al. 2019b) there is a yawning gap in the 'need-to-know' dichotomy of police and citizen relations, the role of networks in endorsing BWCs (Young & Ready 2015) as well as perceptions (Crow et al. 2017) of law enforcement leadership involving BWCs.

International studies broaden the scope of BWCs investigations by introducing reports, white papers, trial papers, legal notes and case studies including the results of pilot trials (Edmonton Police Service 2015) complete with results of public opinion surveys, again, quantifiably focussed with scant 'voice' from the unmediated publics perception other than when in their imminent state of incarceration (Taylor & Lee 2019). Earlier smaller cluster randomised trials of BWCs in the United Kingdom

involved academic institutions such as the College of Policing and the Mayor's Office for Policing and Crime (MOPAC) (Grossmith et al. 2015) including 'BWV' as data influencing criminal justice outcomes of domestic abuse incidents (Henstock & Ariel 2017) notably concurrent with full operational testing (Ellis et al. 2015) in the Isle of Wight in conjunction with the Institute of Criminal Justice Studies at the University of Portsmouth.

Papers such as the seminal 'Existing and Ongoing Body Worn Camera Research: Knowledge Gaps and Opportunities' by (Lum et al. 2015) indicate that as a result of the proliferation of BWCs in policing, have since have broadened investigations into corruption, police legitimacy, self legitimacy, and victim satisfaction (Morrow et al. 2016; Ariel 2017).

Despite the avalanche of public monies already tied up investigating BWCs, quantitative research evidently fails to bring about the awareness of key issues of BWCs as they translate into the criminal justice system, reinforcing "... the need for appropriate guidelines and legislation (...) to maximise the effectiveness of the technology as well as balance ethical and cultural demands" (Christodoulou et al. 2019).

> "... four key issues that we believe require further empirical attention: (1) *bias* involved in viewing BWC recordings; (2) *the effect of BWCs* on officer memory and credibility; (3) the effect of BWCs on *officer well-being*; and (4) specific *considerations* involved when officers review their own recordings" (Christodoulou et al. 2019).

Empirical research conducted by Lawrence and Peterson (2019) by comparison is currently focussed on the push to automate rather than continue to allow officers the autonomy of self-activating BWCs, joining current concerns that BWC-wearing officers who are already involved or have a personable relationship with community members, as a result of the requirement to wear BWCs may be less likely to engage in proactive activities that are highly discretionary, which in turn many lead to further confrontations (Lawrence et al. 2019).

> "... As departments continue to develop BWC programs or fine-tune their existing BWC policies, more research is needed to understand the degree to which BWCs affect officers behaviours and interactions with the public" (Lawrence & Peterson 2019).

Significant Factors & Approaches

Throughout the literature and in conversation with research participants or as researcher in role as participant observer, at events across many differing locations, in differing cultures and groups, a range of significant approaches and significant factors emerge which influence the route that the researcher chose to engage with the subject matter. One of the most significant approaches to this research investigation was determined to be the importance of engaging with data and human participants and allowing Grounded Theory by emic approach to manifest which "...differs from other research approaches in that it does not impose preconceived ideas on the research setting" (Jammula 2014).

When trying to explain social realities involving BWCs the researcher acknowledges that it is tempting due to the depravities of factual recount of violence through the lens of the on-officer camera to switch at times to the etic perspective of the observer, hence the reason why Activity Theory provides a highly reasoned principle to understand and remain focussed on the perspective of the studied social group. It is also important to note that significant approaches and factors experienced by others in the field of BWCs were limited at the time of literature review which accounts for why narrow cast pilot trials and industry specific applications under proprietary protection, join inaccessible government or military projects due to secrecy restrictions or commercial interests.

In turn this makes this research all the more salient given the focus is in participant observer role engaging with experts and their communities compiling an ethnography through action research. As was revealed through the RJS (Hayes 2019b) the researcher was then forced to admit 'responsibility' of prior knowledge in the field through commercial and research engagement, clearly separated from the analysis of

empirical evidence collected, serving as a most cogent account of the researchers activities, a revealing process steeped in transparency because, as (Schreiber, 2001) states, “... He or she cannot “unlearn” what is already known" (Thornberg 2012 p.2).

To avoid accusations of conducting research which was counterintuitive to the researchers original professional domain of educational technologies, by conducting a self evaluation of the literature review, existing BWCs empirical studies were then verifiably evaluated, in turn informing what approaches were appropriate to conduct a social impact and ethical implications research investigation. Comparably, using a socio-technical approach based on “...Vygotskian theory and a Grounded Theory methodology’ as described by (Haas 1999) to critically appraise BWCs, whilst similar in form to this research inquiry would have resulted in limited knowledge of the social impacts and ethical implications of BWCs, hence conducting activities through the GT constant comparative method as it “...makes sure that the emergent concepts are grounded patterns which remain no matter what and without forcing" (Glaser 2016).

Explaining and extending prior practices utilising the Internet and other digital data retention platforms and service such as bookmarking, annotation and content retention via a Netnography approach (Kozinets 2015) complemented the logical GT approach. Likewise, an examination of HCI approaches from over one-hundred and two (102) publications by (Kjeldskov & Graham 2003) informed the researcher of “... what to avoid being current trends in HCI significant trends with a clear bias towards building systems and evaluating them only in laboratory settings, if at all" (Kjeldskov & Graham 2003 p.327).

One of the most important or significant factors which then influenced the manner in which literature sources or contemporaries were referenced and drawn upon in this study has been the awareness that first-person digital technologies challenge every aspect of traditional institutional approaches to research ethics, which in turn “... makes ethics governance more important" (Mok et al. 2015).

4.3 Applications & Innovations

Arguably, a further fifth period based on a recent wave of BWCs innovations, ‘Smartworld’ in which implantable or ingestible ‘wearable technology’ could be added to a comprehensive visual presentation titled ‘Introduction to Wearables’ by (Mark Billinghurst 2014) who suggests only four (4) periods of wearable computing and related technologies as:

1. *1960 - 1990* - Early Exploration: Custom build devices and interfaces;
2. *1999 - 2000* - Academic & military research: MIT, CMU, Georgia Tech, EPFL;
3. *1995 - 2005* - Commercial Uses (First Wave): Niche industry and military;
4. *2010 onwards*: Consumer, industry, head worn applications.

Rapid prototyping claim (Billinghurst & Busse 2015) then led to major changes in personal and human computing platforms:

I) Desktop PC then;
II) Laptop/tablet then;
III) PDA/phone then;
IV) Head/body worn devices such as Google Glass.

Mindful that this research investigation has bridged almost a decade of innovation and a plethora of applications since commencement, in effect, this thesis then draws upon two (2) main historical time-frames:

1. *The foundation for human computing* provides an account of how prototyping, testing and development of wearables in one sector then influences another and;
2. *The significant theories, theorists and place centres* for organisations and corporations that key figures including participants inhabit.

In a time of great uncertainty, the capacity to recognise and respect those inventors whose seemingly outlandish experiments and boundary pushing against regulatory

control or wilful acts of social disobedience is an imperative, particularly considering the global impact leaders in the wearable computing domain have had on humanity.

> "... Why did I go to such extremes? Because I realised that the future of computing was as much about communications between people wearing computers as it was about performing colossal calculations" (Steve Mann 2013a)

4.3.1 Technology Types

Innovation and development has influenced the scale reduction and form factor complexity of technologies from bulky 'luggable' to 'miniaturised' lightweight or 'mobile' subsequently enabling the computer to become 'wearable' according to (Steve Mann 2013c). A brief history of wearable computing compiled by (Rhodes 1998) details the 'foundational thinkers, innovations, and experiments' that helped pave the way for wearable computing, starting in 1268 with the first mention of portable eyeglasses.

A scan of the literature indicates that the domain of wearable computing is rich with forerunners to body worn camera technologies, evolving historically from analogue mechanical standalone devices through to the first personal digital camera by Steve Sasson of Kodak (Mait et al. 2014). With the onset of ubiquitous Internet access and with connection to services through Location Based Services (LBS) these devices have evolved as pervasive 'humancentric' (Michael 2005) multi-function wearable devices incorporating still capture, motion or video action.

> "... Using evidence-based approaches, we can know what consumers are thinking, how they are feeling, and even what they will do next with a high degree of accuracy" (Michael et al. 2015).

In turn, by knowing the whereabouts and behaviours of those now wearing these 'smart' devices including 'smart glasses'(Hofmann et al. 2017; Rauschnabel et al. 2018), the availability of access to personal data in turn generates big data and this

provides obvious reasons why powerful institutions seek to tap this human data stream. In the seemingly unending quest of humanity to engineer an immortal state, these institutions in turn debunk criticism of Artificial Intelligence, instead persuading consumers that their corporate interests in making the most from legitimising a technological Singularity, or at the very least driving neural and other implant projects with lead to "...the creation of cyborgs (human-machine hybrids) with superior capacities" (Reinares-Lara et al. 2018).

As networked and ambient connections to the available domestic Internet and other networks have emerged so too did the 'Electrophorus', the human 'bearer' of the technology, cyber logging (Mann 2003) as one part or node in many forms of digital 'a life-long extension' according to (Michael 2014a). The mannerisms in which the handheld or 'bearable' computer have engendered 'mediated mass self-communication' (of which BWCs data can also be categorised) is evident in the example of the "... citizen camera-witness (...) camera-wielding political activists and dissidents who put their lives at risk to produce incontrovertible public testimony to unjust and disastrous developments around the world, in a critical bid to mobilise global solidarity through the affective power of the visual" (Andén-Papadopoulos 2013).

Luggable

To extrapolate on how this Internet network connection relates in specificity of influence for this research investigation of BWCs, as a subset to wearable computing we must firstly examine the historical dimensions of BWCs dating as far back as subminiature cameras with mechanised timers strapped to pigeons (birds) invented in 1907 by German Apothecary, Julius Neubronner.

This case according to (Wilkinson 2013) is one of the first documented cases of cameras being strapped to the 'body', transitioning standalone cameras from an analogue acetate fixed state to that of multi-stakeholder luggable 'hand held', 'body worn' or 'wearable' form concurs (Williams 2018). Covert military operations during the First and Second World War using concealed subminiature cameras were soon

replaced by the advent of ‘Ultra Miniature’ body-worn cameras enabling the photographer to become hands and free of the need to be vision-tied to the operations of the device, still being used in SEBE research (Lahlou 2011) at the London School of Economics.

> “...One of the first examples of body-worn cameras in popular culture was perhaps presented in the 1986 film Aliens, when the Colonial Marines search the exomoon colony with cameras on their helmets. The idea of strapping a camera on one’s person to record a first-person view of events used to be an idea reserved for science fiction" (Berdjis 2016, p.9).

By virtue of their historical transition from acetate film to replicable digital audio and video capture, BWCs are therefore considered to be wearable computational logging device reinforces (Mann 1996b). In the film industry by comparison, wearable filmic devices predate this definition film by a decade, the most well known being the ‘helmet camera’ (Bruce 2008; Cecala et al. 2013), a precursor to the wearable closed circuit television camera (CCTV) (Ben Brucato 2015), which principally was at that time to record action from the first person perspective known as ‘point-of-view’ (POV).

Wearable

The evolution of the wearable camera as described by Nicole Boyd, writer at *Video & Filmmaker* quickly engaged the public consumer, from standalone luggable device to wearable computational devices such as the ubiquitous GoPro camera created by founder and CEO, Nicholas D. Woodman.

According to Boyd, the action-adventure era of photographers and cinematographers began with the marketing discovery as an appetite by the paying public for ‘*first person view*’ (Boyd 2014), with an example cited in the late 1950’s when Bob Sinclair and Tom Ryan of the ‘Ripcord’ crime fighting parachutists film crew began shooting film using the ‘helmet-cam’, a hands-free body worn camera.

> "... The duo created hidden chutes, breakaway clothing, helmet cams and wing suits (so cameramen could adjust their speed of fall), innovating the genre in the process" (Boyd 2014).

In 1965, footage from a Denver Broncos football practice (Jhabvala 2015) shows quarterback Jacky Lee wearing a General Dynamics Astronautics helmet camera, with historical footage soon showing Formula 1 racing car driver Jackie Stewart wearing a Nikon helmet-cam in 1966 (Boyd 2014). The ability to bring to mainstream television a field-of-view motion picture from the perspective of the driver for the sports enthusiast fundamentally changed the entertainment and racing car industries.

Other examples of corporations investing in wearable camera innovation was in the racing car industry, specifically Steve McQueen in the 1971 'Le Mans' film (Boyd 2014), also footage from 'On Any Sunday' featuring McQueen wearable a helmet camera riding a speedway motorcycle, as well as Jack Brabham (Franokiso 2019), wearing a bulky helmet-mounted stereoscopic racing helmet camera. Developments by Sony of lightweight, battery powered black & white portable video cameras enabled Gary Patmor, stuntman and skydiver in 1972 to achieve many aerial body double shots (Boyd 2014). Boyd then reinforces that helmet cameras which were rarely cited in the wearable computing domain until the early 1980's, became popularised when Dick Garcia wore an Aerial Video System (AVS) Canon CI-10 camera, during the 1986 Nissan USGP 500 World Championship at Carlsbad Raceway in California, a 'first for live televised POV film'.

> "... During the race, AVS transmitted the camera footage via portable microwave to the ABC broadcast truck, which was then edited into the live broadcast, the results were a first for televised live racing" (Boyd 2014).

While Mark Schulze became the first filmmaker to be credited in 1987 with 'wearing' the camera and capturing the 'first person perspective' using CMOS chip cameras made by RCA, Boyd emphasises these recordings went to a digital video recorder (DVR) in Schulze's backpack. In 1991, the VSR-3 Ridell helmet developed by Aerial Video Systems (AVS) for the World League of American Football containing a miniature camera, antenna and two pound battery pack also transmitted live game

data states (MacGille 1992). A veritable explosion of helmet camera types, configurations and ubiquitous connections since the mid-1990s has seen point-of-view footage mainstream in filmmaking such as ‘Line of Sight’ (Brunelle 2012) by Producer and Cast, Lucas Brunelle showcasing bike messengers travels in candid interactions across metropolitan USA, through to advanced sky-diving with the Blackmagic Micro Cinema Camera (BMCC) (Blackmagic Design 2019).

Bearable

The literature and resources in this domain are quick to distinguish between what constitutes a ‘luggable’ device with its counterpart to the ‘hand-held’ device, yet, confusingly (which was of interest and became the main point in participant questioning) the nomenclature in this domain of wearable computing clearly shifts from ‘portable’ when as (Ip et al. 2009; Gillett 2006; House 2014) attest, the human body becomes the receptacle for ‘seeing’, in effect the human body ‘becomes’ the camera.

> “... the term "Body-Borne Computing" or "Bearable Computing" as a substitute for ‘Wearable Computing’ so as to include all manner of technology that is on or in the body, e.g. implantable devices as well as portable devices like smartphones" (Steve Mann 2013c).

The term ‘Bearable Computing’ according to Mann clearly differentiates ‘Wearable Computing’ from ‘Ubiquitous Computing’ (Steve Mann 2001a), with ‘wearcomp’ (Mann 1996b) and ‘smart-glasses’ (Ackerman 2012b), although used interchangeably, often negating that “...applications of body-borne computing include seeing aids for the blind or visually impaired, as well as memory aids to help persons with special needs" (Steve Mann 2013c).

> “... body-borne computing in the inclusive sense is for everyone, in the form of such applications as way-finding” (Steve Mann 2013c).

Notably, common wearable computing vernacular by early 2000 included ‘wearable operating systems’ (WearComp OS), ‘head-mounted displays unit’ (HMD), ‘wearable keyboard’ (Twiddler), ‘wireless network connection’ (WLAN or UMTS), ‘augmented reality’ as differing from ‘augmediated reality’ and ‘facial recognition’ coinciding with the formation of the MIT ‘Borg Lab’. Body-borne computing therefore, has by association, historical breadth and scope in the field wearable computing, with innovations that ‘encompass’ or as Heidegger relates, ‘enframes’ the human form, including contemporary custom NFL Network helmet integrated POV systems (stillmotion 2011) or advanced helmet mounted displays (HMD) that incorporate monocular and binocular camera systems, wearer waypoints, points of interest and targets by BAE Systems (BAE Systems 2017).

> “... Instead of looking at handheld devices, we will wear see-through displays built into contact lenses. This phenomenon is well under way" (Pedersen & Blakesley 2013).

Corporations such as Google Inc. with the Google Glass product (Healey & Stephens 2017) despite vocal opposition due to privacy concerns have more recently engaged with BWCs as a transitional technological form which normalises ‘near-eye’ (Vorraber et al. 2014) technologies. By ‘occupying’ and prosthetically enhancing that perspective or the field-of-view, the Head Mounted Device (HMD) or as a Heads Up Display (HUD) has proven useful for manufacturing purposes (Caudell & Mizell 1992) or as a workplace instruction device, “... projecting real-time content for a seamless integration of the digital and the real world (...) increase accuracy and efficiency when following step-by-step instructions in the workplace" (VUZIX 2020).

Many examples of similar investment from the private business sector such as Intel’s ‘Vaunt’ smart-glasses incorporated a low-powered retinal focussed laser, then ceased development as swiftly as they had appeared in the wearable marketplace (The Verge 2018). This may concur with the many mobile telephone ventures that disappeared with the advent and epic scale of human attachment to the smartphone, which according to LumusVision and (Microsoft 2018) is in itself shifting to a mixed-reality where the “...future is looking up (...) transparent displays transform the way people interact with reality’ (Lumus Vision 2020).

Embodied

A publication by MIT Press titled ‘Embodied Computing’ is a seminal work edited by Isabel Pederson and Andrew Iliadis in the domain of Computer Science, field of Human-Computer Interaction in which “... practitioners and scholars explore ethical, social, and conceptual issues arising in relation to such devices as fitness monitors, neural implants, and a toe-controlled computer mouse" (Pedersen 2020).

Employing terms such as ‘body-centered computing’ similar in modus to that of "bearable computing" (Steve Mann 2013c), Pederson and Iliadis posit that the trajectory of technologies, “... now goes beyond the “wearable” to encompass implants, bionic technology, and ingestible sensors" (Pedersen 2020).

> “… In this sense, wearable computing can be defined as an embodiment of, or an attempt to embody, Humanistic Intelligence. This definition also allows for the possibility of some or all of the technology to be implanted inside the body, thus broadening from ‘wearable computing’ to ‘bearable computing’ i.e. body-borne computing" (Steve Mann 2013c).

The blurring of boundaries between humans, computers and the onset of Artificial Intelligence (AI) is a juncture for BWCs as those who have contributed to this publication are leaders in the debate of how BWCs also reconfigure the relationship between human bodies and their environment, including Abbas (Abbas et al. 2015; Abbas et al. 2011), Iliadis (Iliadis & Russo 2016), Genosko (Ralón 2012), Jethani (Daly & Jethani 2014), Lupton (Lupton 2013), Michael (Michael 2005), Michael (Michael et al. 2015), O'Gorman (O’Gorman 2018), Orth (Orth 2001), Pedersen (Pederson 2013), Perakslis (Michael et al. 2013), Warwick (Warwick 2003) and Wissinger (Wissinger 2017).

Using terms such as the ‘aura of cool’ and the ‘final frontier of techno-supremacism’, Pederson and Iliadis note that these essays are focussed not simply the latest innovations in the field, rather on “... the importance of considering embodied

technologies in their social and political contexts rather than in isolated subjectivity or in purely quantitative terms" (Pedersen 2020). The term ‘embodied computing’ resonates well with the researcher, deemed inclusive of the core premise of cyborgism where technological acceptance models which authentically engage human actors in assessment that leads to actioning cultural, social impact and ethical implications restraint, broadens the scope of ‘physiological interfacing, embodiment, and productivity’ to embrace “... affective and normative factors (which) have the greatest influence on the acceptance of a new technology” (Pelegrín-Borondo et al. 2017).

> “... Wireless medical devices (“wearables”) applied on-us, in-us and around-us present great opportunities for clinical research, early prediction of disease, care delivery, and healthcare management. In-body medical devices may be injected, implanted, or ingested and, when paired with complementary medical devices, may support remote patient monitoring, therapy delivery, or diagnostic purposes" (IEEE Standards Association 2020b).

The main connection here with BWCs which interface as ‘body object’ with Artificial Intelligence as a social embodiment of technology (Veyrat et al. 2008) the researcher believes will be whether they contribute to the ‘end of anthropomorphic realm’ in the form of Technological Singularity. In the foreseeable future though, with recognition that the brain is not the sole cognitive resource we have available to us to solve problems (Wilson & Golonka 2013) whether computers become conscious and fully autonomous despite all the skepticism which suggests its a long way off, remains the most pressing of human concerns according to (Signorelli 2018).

> “... the embodied nature of human cognition is highly relevant to the question of whether downloading a human personality might ever be possible. In my view the answer to this is ‘no’. Certainly it will not be possible within the next 50 years" (Pötzsch & Hayles 2014).

4.3.2 Sectors & Stakeholders

The Wearable Application Technology Chart as developed by (Beecham Research 2017) serves as a useful overview as to the diversity of wearable computing

technology applications encompassing BWCs. With varied applications, functions and products across multiple industries and sectors, BWCs are one (1) of the many ‘wearables’, ‘wearable devices’ or ‘smart electronic devices’ across eight (8) differing interdisciplinary areas:

1. *Communications* - Personal, interactive group, location services, base station tracking;
2. *Business Operations* - Logistics, knowledge sharing, information access, customer service, access control;
3. *Safety & Security* - Military, emergency services, identity recognition, rescue-tracking, law enforcement, community policing, environment monitoring & control;
4. *Medical* - Vital signs monitoring, vision enhancement, on-body notifications;
5. *Wellness* - Physiological monitoring, motion tracking, social interactions;
6. *Sports & Fitness* - Eye tracking, activity HUD, locational navigation, performance enhancement, data feedback;
7. *Lifestyle Computing* - HUD augmented immersion, realtime streaming, gesture control, object/code recognition;
8. *Fashion & Glamour* - Relational enhancement, audience engagement, event tracking, reaction response.

In the next section of this chapter, examples of BWCs and related device types which are known to be used in that sector or industry are described. Ideally wearable technologies that are body worn, hands free and more recently automated with artificial intelligence (AI) according to (Vandrico Inc 2017) a Wearable Technology Database tracking 427 devices from 266 companies, must in application be:

1. *Wearable* - be worn on the body throughout its use; it should not be carried;
2. *Controllable* - be controllable by the user either actively or passively;
3. *Enhancing* - augment knowledge, facilitate learning or enhance experience;
4. *Mobile* - give users the freedom to act naturally, not be limited to a fixed area.

The inclusion of sensors for mechanical, acoustic, optical and environmental purpose as well as wireless connectivity on BWCs necessitates an entirely new definition:

> "…. Wearable digital devices that incorporate wireless connectivity for the purposes of seamlessly accessing, interacting with and exchanging contextually relevant information" (Bower & Sturman 2015).

This concurs with the BWCs definition used in this research investigation that the term Body Worn Computer (BWC) could be used interchangeably with Body Worn Cameras (BWCs), with little differentiation given the fact they are now 'smart' network connected devices, capable of so much more than previous generations of wearable cameras according to (Visual Labs 2017).

Communications

Body worn cameras such as the VIO POV HD camera have been used as a low profile broadcast-quality camera and more recently the VIO Stream camera (VIO-POV 2017) which can stream and record simultaneously. This device has been instrumental in military combat and a host of other potentially hazardous zones due to its robust design and disposable battery power options, upgraded from the original versions used in educational trade training settings by (Ridgway 2010) and now with the capacity to stream via a 4G LTE pipeline with live video as high as 30 frames and 1.5Mb per second. (VIO-POV 2020).

Another HUD that challenges the perceptions of what a body worn camera constitutes is the AiRScouter by Brother Technology (Brother Technologies 2017) which has a 720P IP54 rated display, adjustable focus but most importantly complies with FAA 107 regulations about line of sight when you are flying a drone, capturing film for commercials, that feeds the video back as a live stream, effectively the drone is an extension of the operator and through the HUD the operator 'becomes the camera'. Body worn camera technologies which have been used in human communication and in an educational context since the early days of human computing at the Massachusetts Institute of Technology (MIT) interestingly, have recently received criticism by (Harfield 2016) in a moral context of appropriating the term 'POV' which is used by the pornography film industry by members of the educational technologies industry, yet Google Glass as a HUD capturing and transmitting data mostly attracted concerns regarding privacy, contributing to their now consolidated industry specific alignment (Knight et al. 2015; Ebner et al. 2016; Ackerman 2012a; Metz 2014).

A collision of both concerns is illustrated considering the manner in which the 'EyeTap' device which is understood to be co-located 'inside' the human eye by (Steve Mann 2001b; Mann April 2-7, 2005) yet, in present-reality is a continuous life-logging and visual communication device.

> "...Wearing my eyeglasses which embody the EyeTap technology of both image capture and image display (the special glasses look just like ordinary

> bifocal eyeglasses) I teach a class of about 20 students, how to become one with the machine (…) I also teach the students how to build their own systems, and many of the new scientific principles in the emerging field of Personal Cybernetics" (Mann 2006, Fig.1.0).

Geoff Lubich (Lubich 2012; Ridgway et al. 2011), Richard Ross (Ross 2010), Stephan Ridgway (Hayes et al. 2013), Leigh Blackall (L. Blackall 2012), Michael Coghlan (Michael 2009) and Simon Brown (Brown 2012) are also educators who have used BWCs in an educational context, predominantly for training and assessment purposes across Australia and New Zealand, richly described in a manuscript containing case studies by the researcher (Hayes et al. 2010). Of great concern to civil libertarians and human rights advocates (and educators alike) is the imposition, and what they consider to be the stultifying and stymying effect of BWCs that are now being deployed inside educational settings as a punitive measure, extolling the virtues of outright compliance where "... before we would have total denial of any behavioural problems, now they can take control of their own behaviour because they check themselves before they act" (Calla Technology Ltd. 2018).

Coupled with school surveillance systems which replicate mass surveillance in society, one of the core functions of an educational paradigm will undoubtedly be the future critical appraisal of why the United States of America and the United Kingdom consider they have justification to mandatorily demand teachers, school resource officers, and principals with body-worn cameras, "... generalised into two broad categories: (1) prevention (to deter poor student behaviour) and (2) evidence (to capture footage should any misbehaviours, illegal or otherwise, occur for the purposes of disciplinary action)" (Taylor 2018).

As with all communication technologies, most especially those whose core function is to liberate the human user from a static position (under surveillance) to one of continuous computing access (under constant surveillance), the truest challenge is then engaging humans in a 'new-normative' communication zone, that is building familiarisation by occupying the visual sense with 'visual layering', perhaps why even prior to Glass being released predictions included, "... Even if Google glasses

themselves fail, it is only a matter of time before some other system succeeds" (Katz 2013).

> "... As the objects themselves are not anchored in an environmental context or a specific type of activity, the designers have to base their thinking on something that is constantly moving and used for multiple activities" (Veyrat et al. 2008).

Business Operations

As 'smart glasses' have proliferated across industry, leaders such as General Electric (multinational conglomerate), The Boeing Company (aviation), Volkswagen (vehicular transport), AGCO (agriculture), DHL International (courier, parcel, and express mail service), Dignity Health (health care), NSF International (product testing, inspection and certification) have all engaged in testing devices such as the Google Glass Enterprise Edition (Ackerman 2012a; Google 2017a). Much of these pilot trials have led to full operational shifts within advanced assembly, customer interaction and design laboratory industry applications.

The Google Glass device originally featured an 8MP camera, recording alert, WiFi connection, a multitude of sensors and voice recognition amongst other features, now exponentially more advanced and has been adopted as an industry specific application device since the release and 'living laboratory' testing of the Google Explorer Edition (Kothari 2017; Google Inc. 2020). Another smart glass developer Vuzix by comparison claims the Vuzix M300 Smart Glasses (VUZIX 2017) delivers enhanced functionality for commercial applications varying from field service to logistics to manufacturing, mainly due to the 'hands free access to real time information' with clear application advantage in industrial, medical, retail, supply chain, remote help desk, and other aspects of business. Atheer Air Glasses (Atheer 2017) by comparison are also a BWC device provider in this space working mainly with 'industrial enterprises across manufacturing, construction, heavy industry, logistics, retail, medical, energy, and field technical services'.

At the other end of the spectrum, situated in both the United Kingdom and the United States of America in the protective care, policing and community services sectors a very different example of BWCs in the form of a wearable, wireless camera (WCCTV Body Worn Cameras 2018) connects with a GSM cellular network over 3G, 4G and WIFI, most notably used in 2016 in the building and construction projects such as the S&C North Alliance, Babcock International / National Rail Network Project.

Safety & Security

Body worn cameras used in law enforcement and policing are formally known as ‘body worn video’ (BWV) although the term ‘body worn camera’ (BWCs) has become synonymous with wearable technologies such as the ‘Axon Body 2’ (AXON 2017b) which has audio, HD video capture and streaming, wireless activation, GPS location and many other advanced enhancements reportedly including live-time facial recognition.

> “… British police departments became the first to show an interest in BWV devices, and they began to conduct field tests on them as early as 2005. The initial pilot studies, small in size, took place in Plymouth, England, in 2005 and 2006" (Harris 2010).

Unashamedly, body worn camera suppliers in the United Kingdom coined and market street level surveillance as ‘body worn CCTV’ with low-lux 720p and 1080p HD recording capabilities, equipped with a 140° wide angle lens and footage with GPS location claiming that “... Rewire Security body-worn cameras can capture footage up to 8 hours on a single charge. Body-worn cameras have become an essential tool in preventing and lowering the number of physical confrontations" (Rewire Security 2020).

According to Ben Brucato (2015) the proliferation of police issue BWCs is not surprising though across these high populated cities, which, as (Palmer 2016) relates, Australian senior police expressed the same serious reservations about body-worn camera use only to be overridden by law and order politics, which in turn “... is no

accident that body-worn cameras and other police recording devices have emerged at a time of increasing sousveillance of police (Palmer 2016 p.142).

The main challenges for the law enforcement, security and related sectors using BWCs of any brand or model with biometric enhancements are the lack of privacy protections in general terms, evident with assertions that "... Australian privacy law and jurisprudence is 'woefully underdeveloped'" (Palmer 2016 p.142).

> "... Public order offences, such as offensive language, are more likely to be recorded by a BWV device than offences such as robbery, sexual assault or fraud. There is a risk that vigorous prosecution of such offences could result in increased criminalisation of people who use public spaces, including Aboriginal people, homeless people and young people" (Legal Aid NSW Australia 2018).

Security guards patrolling public housing estates in the Northern Territory, Australia have also been mandatorily equipped with the same Axon BWCs as law enforcement officers, with Housing minister Gerry McCarthy claiming that "... This technology will allow PHSOs to capture true and independent observations of their work interactions and identify instances of anti-social behaviour or non-compliance with housing policy" (Legal Aid NSW Australia 2018).

> "... The cameras will also act as a safety tool for officers (...) it has been shown that members of the public moderate their behaviour when being filmed, which will reduce the likelihood of these confrontations occurring" (Legal Aid NSW Australia 2018).

Military applications of imaging, cameras and body worn cameras include intelligence gathering, surveillance, reconnaissance, targeting and battle-damage assessment with the Vio POV HD Tactical Video Camera (Mil-Spec Monkey 2008) are just one example of a body worn camera technology developed as part of the United States Army Research Laboratory (ARL) (Mait et al. 2014) for military and law enforcement applications. Featuring a 32GB SD Card flash memory, LCD screen and a multitude of body worn mounts the VIO POV is also known as a flexible,

rugged off-the-shelf tactical helmet camera for law enforcement and television production.

Body worn chest mounted cameras are also being trialled with members of the 11th Security Forces Squadron U.S Air Force with law enforcement officers, K-9 handlers, lead gate guards, emergency service teams, training and quality care officers. The body worn cameras are being trialled ‘to develop Air Force security forces evidence-collecting capabilities’ and to ‘assist with filling in the gaps in altercations when they need to be recounted for evidentiary purposes’ according to (Fetter 2016). Q-Sight (BAE Systems 2017) is another developer with helmet-mounted see-through displays manufactured by BAE Systems, that clip onto existing helmets with a circular display resolution of 768 pixels, DVI-D and analogue signal input. By contrast, covert operations and miniaturised or concealed body cameras provide security personnel, private investigators and crowd controllers with robust body worn cameras for frontline operations, such as the Edesix Videotag (Edesix 2017) complete with VMS streaming capability, long life batteries, Wi-FI and CCTV integration.

Boasting corporate clients such as Pepsico, US Department of Homeland Security, Boeing, United States Steel, the New York Police Department and Chevron, the Brickhouse Security Group market a range of “... styles, capabilities and form factors, from eyeglasses to shirt buttons (...) it will be easy to find the body worn camera that suits your needs" (BrickHouse Security 2017). Another form of covert operations camera is the BU-19 by Lawmate (Robertson 2017) which is an analog CCD camera and high gain microphone worn underclothing and recording through a buttonhole. The researcher tested a number of Lawmate’s range of CMOS cameras that are disguised as earphones, lapel cameras and also distribute head worn front of house security staff cameras (Hayes 2013a).

The ‘OnCall Wi-fi Pro’(m-View 2015) is an example of a body worn camera that connects firefighters by GPS location in real-time for dispatch or command purposes, complete with infra-red recording and wide angle lens, whereas the Zepcam is used interchangeably between firefighting, first person responder, private security and law enforcement, “... allowing officers to de-escalate and capture forensic video and data (...) making the public area a safer and more secure place" (Zepcam Editor 2019).

> "... Several fire and rescue services are experimenting with the use of body-cams to ensure better protection in attacks against firefighters. The analysis of the origin of this violence makes it possible to better apprehend it and thus to better prevent it. Most often they are citizens, rescued victims and their relatives, who have inappropriate behaviour" (Zepcam Editor 2019).

Medical

A case in that illustrates the delicate or blurred edge between augmented reality, mixed reality, virtual reality and a likely trajectory of mobile BWC 'goggles' is the medical da Vinci Surgical System, a robotic assemblage of components for state-of-art minimally invasive surgery.

> "..The da Vinci® Surgical System enables surgeons to perform delicate and complex operations through a few small incisions" (da Vinci Surgery 2017).

Professor Katina Michael attended a two day conference hosted by the 'Australasian Association for the History, Philosophy, and Social Studies of Science' at the Australian National University in November 2017 where she met Michael Arnold, a social studies of technology researcher. During Arnold's presentation Michael made notes including the following interesting observation:

> "...The surgeons have no further periphery vision than what they see in the robot goggles. The surgeons report that they do not require haptic feedback and they feel they have all the vision they need. Quote from one of the surgeons paraphrased was: 'You are down there. You are in there. No doubt about that'" (Michael 2017).

The most important distinction that must be made here is that the surgeon (as Arnold can attest) is at "one" with the machine and a 'present reality' is being electronically fed to the surgeon by cameras. The surgeon sits in an immersive console, head resting in fixed goggles that have a 3D HD vision system of cameras to enable the surgeon to

see the patient and the site of the operation which requires using robotic arms and medical instruments. In this case the ‘goggles’ are augmenting reality and the user, the surgeon’s vision, is enhanced for the task of surgery. The goggles are not body worn yet the cameras provide a live feed to assist the surgeon in their augmented activity. The surgeon must operate in a console booth almost 3 metres away from the patient yet is able to use all senses to engage in an activity which ceases operation immediately if physically retracted.

This restriction is at this point a condition of the da Vinci Surgical System patent although there are many test cases where surgeries are performed robotically using equipment network connected through the Internet. It is also feasible that such technologies will one day be performed with mobile BWCs and across vast differences in physical space. Google Glass Enterprise Edition (Google 2017a) is also being used by doctors and healthcare professionals worldwide.

> “... Now, instead of typing on a computer during consultations, they can connect with patients by looking them in the eye, listening as they talk, and asking questions, all with confidence that all the note taking work is being done in the background" (Kothari 2017).

Another case in point are the eSight (eSight Corporation 2017) electronic glasses for the legally blind that incorporate sensor, forward facing high definition camera providing the wearer with short, mid and long range vision amplification via OLED video feeds in screen. For those seeking point-of-care smart-glasses then the Eyes-On 3 device by Evena Medical provides:

> “... Heads-up, see-through, eyes-on technology allows the user to have full situational awareness, to keep eye contact with the patient plus a clear view of the patient’s area of interest" (eSight Corporation 2017).

Large companies such as Augmedix are also using HUD optical devices such as Google’s Enterprise Edition which incorporates a camera for hands free consultations with patients, with streamed, real-time connection as one of the key uses of this technology.

> "… Augmedix gives providers a team of real-time, quality-controlled, and customised remote scribes, accessed through Glass" (Augmedix 2017).

The RNIB Project in collaboration with the University of Oxford have also developed smart glasses for the visually impaired.

> "… Hicks studied retinal prosthetics in which a chip is implanted in the back of the eye to improve vision for those with eye conditions. He developed the smart glasses when he realised the computer-enhanced images displayed close to the eye had greater benefits" (Hicks, Stephen 2014).

Ideal for general medical and nursing, Daqri Smart Glasses (DAQRI 2017) are augmented reality enriched data visualisation devices that allow for remote access, streamed project data, with claims that they maximise efficiency and accuracy in task completion with low latency.

> "... The most important thing in the relationship between nurses and their patients is 'trust' said Sarah" (DAQRI 2017).

Wellness

Referencing the '2018 Global Wellness Economy Monitor' an annual report brought out by the Global Wellness Institute reinforces that "... from 2015-2017, the wellness economy grew 6.4% annually, nearly twice as fast as global economic growth (3.6%). Wellness expenditures ($4.2 trillion) are now more than half as large as total global health expenditures ($7.3 trillion) and the wellness industry represents 5.3% of global economic output" (Global Wellness Institute 2018).

With a tie to the Quantified Self movement, wearable computing technologies which include monitors for sports use of BWCs such as the Pivothead Recon (Lubich 2013) were designed to capture data extending now to workplace assistance 'point-of-view' telepresence or 'headless smart eyewear' with 4G live-streaming, similar to Google's

own Enterprise Edition ‘on-the-job’ personal care, preventive health and wellness awareness programs (Pivothead 2020).

> “... In effect, these technologies are turning the body into media, so that a health consumer can become their own 24 hour news channel focused entirely on the real-time representation of wellbeing" Dr Ruth De Souza, CEH Stream Leader in Research, Policy and Evaluation in (McInerney & de Souza 2016).

In the United States of America it was announced in the rollout of BWCs in the 2017 - 2018 period, that to meet National Officer Safety and VALOR Initiatives the OJP’s Bureau of Justice Assistance would provide $12.1 million worth of funding with over half of that funding awarded for officer safety and wellness programs. By comparison the BJA awarded more than $12.2 million to seventy-five (75) law enforcement agencies under its ‘BodyWorn Camera Policy and Implementation Program’ according to the US Justice Departments LE Wellness-Safety Fact Sheet (US Department of Justice 2018).

Sports & Fitness

The GoPro wearable body camera is probably the most widely known manufacturer of products that can be used across a whole range of settings, most popular in the area of sports. The GoPro Hero 6 has a GP1 chip, can shoot 4K and 1080P video, has slow motion replay, is waterproof to 10 metres and has hands free voice command control as well as an image stabiliser. The GoPro Fusion (GoPro 2017) is a recent extension to that range that can also be rigged to interact with drone technology and augmented reality display connection.

More advanced Augmented reality glasses such as the The Everysight Raptor made by Everysight, a technology company from Israel are designed for cyclists, boasting ”... a Touchpad: to activate different functionalities (...) built-in audio with internal speaker as well as two microphones (...) front 13.2MP camera to capture HD videos and photos (...) memory and storage with 2 GB of RAM and either 16 or 32 GB of internal memory (...) controller features with large buttons for use even with cycling

gloves" (Calvert 2019). Even Google Glass Explorer Edition was pitched as having sports applications with promises of ‘scores pushed to you in real time’ (Healey 2013).

Lifestyle Computing

Tracking ‘consumer attitudes’ and through ‘affirmation of life’ marketing, technology company Oxford Metrics Group (OMG) created a lanyard worn “...wearable, intelligent, automated camera (...) designed to capture thousands of previously ‘unseen’ moments each day" (Autographer 2016).

> “... The act of self-documenting has, for some, evolved from a record of a fleeting moment, to a continuous digital proof of identity" (Stylus 2014).

According to Simon Randall head of OMG Life, irrespective of the claims that life-logging cameras bypass the rights to privacy of bystanders who have not provided permission to be captured by the BWCs (Chowdhury et al. 2016b; Chowdhury et al. 2016a) the “... Autographer ensures that the best moments which may have otherwise been missed are completely captured. Over time, these moments gain sentimental value and with Autographer you can ensure you have both the memory and image to hold onto" (Smith 2013).

Shonin, a lifelogging company based in Toronto Canada have aggressively taken their Streamcam product (Shonin 2017) for public release calling the ‘lifestyle device’ a ‘personal security camera to capture your side of the story’, which “.. the team behind Shonin says the camera is designed to capture “your side of the story,” citing possible uses like “... documenting road rage, abuses of power, events and protests, threats, and assault" (Deahl 2017).

As with many other conceptual projects, the camera is not yet released but the hype of the Kickstarter website suggests the organisation will be in it for the long haul.

> “… An American becomes the victim of violence every half a second. That’s over a million people every year, just in America. Our team decided to help, and Shonin was born with the mandate to make the world safer, fairer and more just" (Deahl 2017).

The manufacturer's describe the camera as a ‘one click to the cloud device’ that is waterproof, records audio, 720P video and has a 2.5 hour recording range. A similar product but on an even smaller scale is the CubeCamPlus (Kehan 2017) manufactured by Kehan which boasts live streaming to social media, Wi-Fi, Micro-SD card and a camera with a 120 degree field of view. It is 41mm wide, 41mm high and only 13 mm deep in scale.

It appears that the Memoto (PetaPixel 2013; Hayes 2013d) prototype has been the inspiration for other body worn cameras with 1080P video capacity such as the SnapCam LE (ION USA 2017) with features not unlike the CubeCamPus, taking 8MP photos, has in-built WiFi, 32GB storage via microSD card, 3 hours recording time or Bluetooth connection to smartphones and streaming to social media channels. The latest lifelogging camera on the market, marketed as a lifestyle camera is Google’s ‘Clips’ camera (Google 2017c) which is a wearable, artificial intelligence (AI) (Li 2018) driven camera that grabs ‘motion photos’, 16GB of onboard storage with three hours of passive smart capturing per charge. The camera has a 130-degree field of view, Gorilla Glass 3 for durability, and has USB C, Wi-Fi Direct and Bluetooth LE for connectivity and shoots at up to 15 frames per second, and self selects for stable, clear shots of its subjects according to (Etherington 2017).

> “...You would think the thing Google wants you to clip it to is yourself and of course you're certainly free to do that, but Juston Payne, the product lead for Google Clips, says that's not really what it's meant for" (Bohn 2017).

By October 2019 the Verge was reporting that, “... Google confirmed Clips’ removal to The Verge and tells us that Clips will continue to get support until December 2021. (Peters 2019). It joined tiny form factor software driven cameras on the market like the ‘Rylo’ camera (Pierce et al. 2017) that stitches a 360 video view of its surroundings whether mounted or head worn like a GoPro Fusion (GoPro 2017) which resembles a black box body worn camera.

Fashion & Glamour

By direct association with wearable fashion textiles, smart glasses and other forms of BWCs that intersect in feminist science and technology studies (STS) according to Elizabeth Wissinger differ from “... fashion scholars focused primarily on garments and celebrating potential techno-futures" (Wissinger 2017).

> “... contemporary wearable technology resurrects the techno-utopian ideas and expressions of the early twentieth century (...) the functionality of fashion is to unify subject, society and environment under a totalising technological order" (King 2011).

In an era of wearable technology pitched by marketers as the ultimate fashion accessory as questioned by (Edwards 2003), Vue Smart Glasses (Vue 2017) are one of many companies looking to corner the fashion smart glasses market. Their ‘stylish and discreet’ smart glasses allow users to listen to music, track movement activity, make phone calls, gesture control, listen to navigation, report time, have bone conduction audio, wireless charging and come in a range of styles and colours.

The Mira Prism (Mira 2017) by comparison is technically a headset / lens kit that allows for a mobile phone to be used to project holograms to a lens with a wide field of view. The device has a level control and allows for the viewer / wearer to interact with others without visual restriction (of the wearer), technically an Augmented Reality (AR) device.

4.4 Contemporary Challenges

As a participant observer engaged in ethnographic activities with peers, research participants, at private and public events, as well as through an iterative review and ever expanding bibliography captured in the ethnography of online sources, the researcher's awareness broadened on the position for BWCs in contemporary society.

A review of the larger corpus of the Netnography literature and sources suggests that the social embodiment of BWCs as a technological device is predominantly referenced as requiring "... a constant dynamic play between the de-configuration and re-configuration of the distributed socio-technical networks of action (...) it deserves in the analysis of human–device coupling forms" (Veyrat et al. 2008).

> "… the individual–eyeglass coupling as a corporal synthesis cut off from the environing material space, thought of either as a cognitive endogenous system (multifunctional lenses) or as a semiological support for social differentiation (multiple frames)" (Veyrat et al. 2008).

These 'frames' enable transferability to interdisciplinary, cultural and technological contexts, which as described by Kuypers using the concept of 'framing analysis' (Kuypers 2009) further elucidate that BWCs, situated relationally in a power dichotomy are as much a cultural phenomenon as a technological artefact borne of wearable computing innovation, therefore "... body camera policies must address not only concerns about surveillance, but also data control" (Joh 2016a)

> "... Body cameras collect video data - lots of it - and thus many have raised questions about increased government surveillance" (Joh 2016a).

As precursor to an 'embodied' computing platform, visibly shifting the parameters of what constitutes BWCs, the 'wearable' smartphone, with its multitudes of sensors whilst technologically differentiated by sector device type and ontologically by functional requirements, now sweeps across health research as a technologically facilitated and pervasive cultural phenomenon (Gurrin et al. 2013) according to Cathal

Gurrin, Associate Professor at the School of Computing, at Dublin City University. Likewise, a contemporary challenge for society are how BWCs now also contribute en masse as ‘Uberveillance stalks the streets’ (Michael & Clarke 2013/6), exponentially more akin to phenomenological discourse within which humans as ‘things’ and carriers of BWCs are now constantly logged, one step beyond how ‘asset mapping using mobile technology impact the discursive planning environment affecting a cultural landscape’ as described by (Boone 2015).

4.4.1 Cultural Phenomenon

As a cultural phenomenon wearable technologies BWCs included have been likened to that of a revolution across society, which according to Fort et al. (2015) given that ‘wearables as personal information gathering devices that feed into larger data sets’ then questionably, “... what if the wearable evolution became an ethical revolution? (Fort et al. 2015).

> “... Glaucon’s challenges to his interlocutor, Socrates, is that once given the chance to get away with his actions, Gyges did as any person would: he did whatever he wanted because, in the final analysis, humans are ethical only for the fear of being caught" (Fort et al. 2015).

By the same analogy, perhaps this explains the explosive power of dissenting bodies en masse recording their own repression via smartphones and BWCs, transcending fear through mediated global communication networks who provide aggregation of graphic testimony, in turn mustering political solidarity in what Kari Andén-Papadopoulos from Stockholm University, Sweden calls ‘citizen camera-witnessing’ (Andén-Papadopoulos 2013).

> “...They are like so many cages, so many small theatres, in which each actor is alone, perfectly individualised and constantly visible” Visibility is a trap" (Foucault 1995).

Whilst some may claim the rise of China's totalitarian state of social credit as abominable (Botsman 2017; Sapio 2017b; VICE News 2019) other writers use science fiction to reposition the issue more tactfully and under the safety penning their encoded views through MIT Press as "... Technology is making people unhinged and violent. Can an algorithm stop them?" (Qiufan 2018).

Not surprisingly due to censorship of 'China's Social Credit Initiative in a Global Context' project website featuring scholars and experts from PennState, the Foundation for Law and International Affairs, and the Coalition for Peace and Ethics now provides returns a NULL crawl URI (Sapio 2019).

> "... Together, surveillance, self-censorship, censorship, and strategic information dissemination constitute mechanisms and forms of information control. How strongly a country relies on each mechanism, coupled with how many options it has to implement them, defines its information control model" (Weber n.d.; Open Technology Fund 2019).

It would be remiss at this point in the discussion of the cultural phenomenon of BWCs to bypass the inordinate amount of attention that engineers give science fiction writers, scientists and futurists like David Brin (Brin 1999). With the catch-cry 'science fiction writers dream-dreams and engineers try and build these dreams', invariably ethicists challenge their dystopian prose yet, how truly cogent Brinn's words are when we consider what is now manifest with BWCs in modern day society.

> ".. Science fiction writer David Brin calls it "a tsunami of lights" — a future where tiny cameras are everywhere, lighting up everything we do, and even predicting what we'll do next" (Lien & Dave 2015).

Meanwhile, as many participants in this investigation express, corporations develop new ways to infiltrate and ingratiate the unwitting public with technologically facilitated social sorting akin to the contemporary works on this topic by David Lyon (Lyon 2003) or historically as George Orwell, English novelist and essayist, journalist and critic penned in his democratic social fiction work 'Nineteen Eighty-four' (Orwell 1990).

Quantified Self

In considering how influential the techno-social activity of the Quantified Self movement has become with life-logging using BWCs (Selke 2016) as the most available example, it is interesting to note the huge backlash from European Union countries who consider US centric corporation funded development of wearable technologies as lacking privacy controls, privacy enhancement or presenting safety risks for consumers as described by (Leibenger et al. 2016).

> "... The spectrum of Lifelogging ranges from sleep, mood, sex and work logging to 'Thing' and 'Deathlogging'" (Selke 2016).

These questions are not dissimilar to the views of (Michael 2014a) who assert that there is a seemingly naive regard for what is the sacrosanct giving away of bio-rhythms, receiving back only a titrate of that and potential narcissistic loss or profound awareness as humans "listen in" on themselves using wearable computing.

> "...what is normative for memory (...) the use of technology has increased the prominence of truth in that role (...) considerations should be used to help drive our reactions and regulations in areas such as privacy, deletion, data protection and informational self-determination" (O'Hara 2010).

In the quest for informational self-determination, deprecative terms such as 'the white, the worried and the well' are often coined to describe the marketing pitch and affordance differential of self-monitoring, which necessitates questioning "... which culturally and linguistically diverse communities and the health workforce that support them and who should be involved in shaping the research around that?" (McInerney & de Souza 2016).

> ".... The technological promise also brings concerns, including the impact on the patient-provider relationship; and the appropriate use and validation of technologies. Technologies are also developed with particular service-users in

> mind, and rarely designed with the participation of people from structurally and culturally marginalised communities" Dr. Ruth De Souza in (McInerney & de Souza 2016).

As an example of how these wearable computing tools of 'quantified emancipation' becoming the bane and nemesis of others reports Fort al. (2015) speaking of Tesco employees who "... required its distribution centre employees to wear the (then) new technology known as Motorola Arm-Mounted Terminals. These devices allowed Tesco to measure their employees' productivity, providing data points such as loading and unloading speeds and other similar metrics (Fort et al. 2015 p.6).

> "... While Tesco will not discuss the success or merits of such initiatives, the devices reportedly increased productivity and efficiency, resulting in an expanded use of the devices. Any real or perceived impact on employee morale was left unmentioned" (Fort et al. 2015 p.6).

Life-logging & Death-logging

As the literature reveals, the chronology of time and the fallible state of biological memory has served as a consistent driver for technological innovation and development in the 'Life-logging' domain, with specificity in this study of BWCs.

> "... Human memory is all too fallible – most of us frequently forget things that we have to do, and often find it hard to recall the details around what we have previously done. Of course, for those with clinically diagnosed memory disorders, which are by their nature more severe than those found in the average population, these issues are particularly troublesome"(Hodges et al. 2006).

Life-logging as its own phenomenon can be attributed as inspired by Vannevar Bush's 1945 'Memex' vision (Bush 1945) who, in his seminal article in the Atlantic titled 'As We May Think' despondingly remarked that "… the fact that specialisation becomes

increasingly necessary for progress, and the effort to bridge between disciplines is correspondingly superficial" (Bush 1945).

> "... Consider a future device… in which an individual stores all his books, records, and communications, and which is mechanised so that it may be consulted with exceeding speed and flexibility. It is an enlarged intimate supplement to his memory" (Bush 1945).

Inspired by the 'Memex' vision J.C.R Licklider wrote 'Man-Computer Symbiosis' (Licklider 1960) and visions of 'The Teddy' (Norman 1992) amongst many other data retention human computing global initiatives, the development of the United States of America Pentagon's 'LifeLog' project which was run by DARPA, the Defence Department's research arm, which "... aimed to gather in a single place just about everything an individual says, sees or does" (Knight et al. 2004).

> "…Out of this seemingly endless ocean of information, computer scientists would plot distinctive routes in the data, mapping relationships, memories, events and experiences" (Knight et al. 2004).

The announcement by project lead Dr. Douge Gage of the end to the DARPA Lifelog initiative following the DARPAs 'mass detection program' TIA (Madsen 2003) and FutureMap (Naef 2003) projects did not surprise Peter Harsha, director of government affairs (Computing Research Association 2015) nor Lee Tien (Electronic Frontier Foundation 2011) as "...they discovered they weren't ready to deal with the firestorm of criticism" (Electronic Frontier Foundation 2011).

Howard Shrobe, Principal Researcher Scientist (Massachusetts Institute of Technology 2013) Computer Science and Artificial Intelligence Laboratory (CSAIL) had spent weeks preparing a bid for a LifeLog contract with his team as "... we were very interested in the research focus of the program ... how to help a person capture and organize his or her experience. This is a theme with great importance to both AI and cognitive science" (Knight et al. 2004).

Private sector research sponsored by Microsoft Research continued with the MyLifebits (Microsoft Research 2001; Bell 2006) experiment as part of the Continuous Archival and Retrieval of Personal Experiences (CARPE) research agenda, a lifetime storage and a software research project exploring privacy, visibility, transparency and exposure(Cohen 2008; Reynolds 2015; Mann April 2-7, 2005) coinciding with the United Kingdom CRC Grand Challenge ‘Memories for Life’ event as described in (MaseKenji et al. 2007; Murakami et al. 2005).

Gordon Bell, Researcher Emeritus of Microsoft(Gemmell et al. 2006) set about digitising everything in his life which he details in a seminal book titled, ‘Total Recall’, (Cherry 2005) renamed a year later as ‘Your Life, Uploaded’ (Bell & Gemmell 2009).

> “... Wearable cameras emanate from research efforts in the field of life-logging. Life-logging refers to the digital capture of a person's everyday activities, from a first-person point of view in an unobtrusive and passive fashion" (Doherty et al. 2013).

Bell is pictured wearing a life-logging head-worn camera in the paper titled ‘The MyLifeBits Lifetime Store’(Gemmell et al. 2003, p.2) in which he describes the work of Jim Gemmell and Roger Lueder who developed the MyLifeBits software and co-wrote ‘A Digital Life’(Bell & Gemmell 2007), in which they describe leveraging SQL servers to track and record hyperlinks, annotations, reports, saved queries, pivoting, clustering, and fast searches. The team collaborated with the Microsoft ‘Sensecam Project’ and Bell continued to be seen wearing lifelogging cameras in 2013 at the IEEE ISTAS’13 (Michael & Hayes 2013) ‘Smartworld’ symposium in Toronto, Canada.

The Microsoft ‘SenseCam’ project (Microsoft 2004) established on February 25, 2004 was ‘originally conceived as a personal Black Box accident recorder’ however the concept expanded exponentially when it became evident that looking through images previously recorded, elicits vivid remembering of the original event. The SenseCam which is a body worn camera device that takes wide field-of-view photos by automatic timer as well as photos triggered by accelerometers, heat sensing and audio,

has been a catalyst for many medical, healthcare, lifestyle and life metrics research projects.

The CodePlex Archive contains records of the pre 2017 browser used to ‘segment’ data captures into ‘events from the Vicon Autographer, Vicon Revue, or SenseCam images.

> “... Researchers at the University of Oxford, Dublin City University, University of California San Diego, Auckland University of Technology, and University of Melbourne have extended the original SenseCam browser. It is recommended that all Autographer and SenseCam researchers use this browser" (Doherty, Moulin, et al. 2011).

The early works of Steve Mann’s cyborg (Mann & Niedzviecki 2001) neck worn sensor cameras paralleled the innovation of Lyndsay Williams (Fleming 2014) who shortly after joining Microsoft Research Cambridge tested automatic cameras that led to the development of the Oxford Metrics Group, ‘OMG Life’ Vicon Revue (Dishman 2014) life-logging camera released commercially in 2009 under licence from Microsoft.

> “...Technologies often evolve faster than legal and ethical systems can respond and unforeseen ethical issues emerge; healthcare technologies are a heterogeneous group, and ethical issues should be assessed separately and thoroughly" (Kelly et al. 2013).

Research has continued into medical applications to assist in memory recall that eventuated from disease or brain trauma such as Alzheimer's patients as championed by Andy Kropa (Kropa 2015b) firstly using the Vicon Revue then subsequent iterations of the Sensecam. The original device took low resolution photos only, weighs 94 grams, had 2GB of memory, a temperature sensor, light color and intensity sensor, infrared motion detector, multi-axis accelerometer, 3-axis magnetometer (compass), battery and flash memory.

SenseCam along with the images, now reportedly stores a log file, which records sensor data, timestamps and GPS metadata.The device is neck worn like a lanyard and soon became a popular tool for ethnographic studies in social phenomena, including task observations (Byrne et al. 2008). Similar such observations and tools are methodologically aligned with Subjective Evidence Based Ethnography (SEBE) which provides access to subjective experience using the First Person Perspective (FPP) useful in analytical Replay Interviews (RIW) according to (Lahlou et al. 2015).

> "... it gets data in the field and from discussions with "native" participants themselves. As in classic ethnography, the researcher must have some first-hand knowledge of the field to be able to communicate effectively with informants, to understand what constructs they refer to and therefore to share to some degree their own "emic" perspective (in the participant's own terms)" (Headland, Pike, & Harris, 1990; Headland, 1990; Jahoda, 1977; Young, 2005) as cited in (Lahlou et al. 2015).

The onset of more advanced life-logging applications and body worn camera devices such as the Autographer from the Oxford Metric Group (OMG) Life clippable, lanyard life-logging camera the Autographer (Smith 2013) launched in the UK in late 2014 boasted five sensors and taking over 2000 photos automatically a day. A historical photo published in 2013 in Australia of an individual with a body harness (Coghlan 2013a) that suspends his smartphone at chest height with an adjustable GoPro body harness (Coghlan 2013b) is the earliest known example of this concept for the researcher.

Unfortunately many enthusiasts of life-logging devices and personal image and data search engine driven timelines have fallen foul of the collapse of parent companies that their data was synced and backed up within. The Narrative Clip life-logging product has reverted its operations back to the former company Memoto (PetaPixel 2013), headed up by Martin Kallstrom and the Narrative company claim to be still in control of the impending switch back for many customers.

> "... no data will be deleted on October 31st, but there will be 1-2 days of downtime while it's being transferred to the new company. There's a risk of

> further disruptions in the coming weeks while necessary adjustments are made" (Narrative 2016).

Likewise, as of October 16, 2016 the OMG Life project announced they were ceasing operations and the fate of the Autographer (Autographer 2016) and its customer data is also now unknown. In a research context the smartphone as a platform for wearable cameras in health research is being examined now as a contemporaneous means to record subjects with far greater accuracy and intensity, a more accessible alternative to the Sensecam elucidates (Gurrin et al. 2013).

Research into life long collections, subject motivations, social interactions by Niamh Caprani, Noel E. Connor and Cathal Gurrin (Caprani et al. 2014) continue at the Clarity Centre for Sensor Web Technologies (Clarity Centre for Sensor Web Technologies 2017) at Dublin University.

LMS & ePortfolios

From the onset of networked communications through Internet accessible connections, the development of Learning Management Systems (LMS) and ePortfolios could be construed as following a technologically deterministic realm as debunked in an article titled ‘Our Technology Is Our Ideology: George Siemens on the Future of Digital Learning’ written by (Siemens 2014).

> “... Colleges are increasingly using adaptive technology in large online or blended courses to help students learn at their own pace. But while these solutions make learning more efficient, they’re perpetuating an outdated form of learning, Siemens says" (Siemens 2014).

As a protagonist of data driven systems which collect information of learners as they navigate these online spaces, Siemens is savvy as protagonist, unlike his colleague and fierce critic of the LMS, educational designer Leigh Blackall (Blackall 2005a) who preferences the term ‘open networked learning’ (Blackall 2011).

> "… If we do things right, we could fix many of the things that are really very wrong with the university system, in that it treats people like objects, not human beings. It pushes us through like an assembly-line model rather than encouraging us to be self-motivated, self-regulated, self-monitoring human beings" (Siemens 2014).

With many examples of how Open Learning Relationship Management (OLRM) systems as coined by Leo Gaggl, data scientist and open systems developer, (Hayes & Gaggl 2013) contiguously retains BWCs data as part of a students greater ePortfolio (Hayes 2013b), the 'edu-sophical' theory of Connectivism as coined by (Siemens 2014; Downes 2007) best describes that interplay between ubiquitous systems and devices, definitively manifest and not limited to the applications of BWCs in an educational context by (Gaggl et al. 2012; Ridgway et al. 2013; Fitzgerald et al. 2013; Ross 2010).

Smart Glasses

An overview of body worn cameras available as *Appendix 9.2.1: Body Worn Computers: Smart Glasses, eGlass and In-sight Mediated Vision* provides a comprehensive range of body worn computers, body worn cameras, 'smart glasses' through to augmented reality, in-sight ,visor and prototypes wearable computing devices such as Empathy Glasses (Masai et al. 2016) as identified through the Netnography process.

> "... This data paper provides a limited overview by example only of body worn cameras, body worn video (BWV), smart glasses, heads up display (HUD), in-sight head mounted display (HMD) augmented and mixed reality technologies that are currently available as restricted, commercially available or public access" *Appendix 9.2.1.*

In the Smart Glasses category, body worn computer devices include:

1. '*Hololens*' by developed by Microsoft with Holograms, sensor fusion, advanced graphics, sensors, spatial sound and an apps SDK;
2. '*SmartEyeGlass*' manufactured by Sony, with gyroscope, accelerometer, ambient light sensor and HD camera;
3. '*Sensory Ware*' manufactured by MagicLeap, which overlays digital 3D graphics onto your view of the real world via smart glasses / headset with transparent lenses;
4. '*Spectacles*' manufactured by Snap, POV 10 second video, twin cameras and mobile sync.;
5. '*Vue*' manufactured by Vue, with which to listen to music, track movement activity, make phone calls, gesture control, listen to navigation, report time, have bone conduction audio, wireless charging and in a range of styles and colours;
6. '*Ares & X5*' which is a SLAM technology with adjustable optics, Bluetooth 4.0, keyboard, wireless tether and SDK.

A further twenty-two (22) smart glasses examples are provided and for brevity the reader is encouraged to visit *Appendix 9.2.1: Body Worn Computers: Smart Glasses, eGlass and In-sight Mediated Vision.*

A first hand historical account of the evolution of wearable technology is by contrast displayed in an extensive exhibition titled 'On You: A Story of Wearable Computing' at the Computer History Museum (Computer History Museum 2015) in Mountain View, California, created and curated by Thad Starner and Clint Zeagler of Georgia Institute of Technology. In a tabular format the researcher took the main events depicted in this online interactive exhibition and provided further evidence of the innovators in this domain in a data paper titled 'The Road To Wearable Computing' which is also available for the readers review at *Appendix 9.2.1*.

> "... Pioneers have experimented with wearable computing for half a century. Yet our bodies remain largely free of the smart tech that fills our pockets and purses. Why? Besides questions around how wearable computing might fit into our lives, the technology wasn't ready" (Starner & Zeagler 2015, sec.Introduction).

Of particular interest in this historical exhibition of wearable computing artefacts is the '*School of Glass*' exhibit, a collection of headworn cameras developed at Georgia Tech. in conjunction with commercial entities such as Google and Nexus One, with reference to predecessor 'Memory Glasses' developed by the MIT Borglab (DeVaul et al. 2003).

> "… Google Glass marked a significant turn for wearables by leveraging technology advances to develop an experimental device for daily life. The team behind Glass, including Georgia Tech's Thad Starner, addressed many technical and practical challenges to developing a vision of everyday wearables" (Starner & Zeagler 2015).

According to the Computer History Museum, the Google Glass project started in early 2010 and by December 2010 several team members were wearing the 'Pack', a backpack with a laptop, GPS and mobile keyboard, attached to the headset (HMD)

with a TacEye display, webcam, IMU, multi-touch touchpad and earbuds. (Computer History Museum 2015).

> "... It was the first operational version of Glass" (Computer History Museum 2015).

This is hotly contested by Professor Steve Mann at Toronto University, Canada who maintains the first operational 'smart glass' was coined by himself in 1978 as 'Digital Eye Glass', or 'Eye Glass' including 'Glass Eye' and eventually as has been popularised 'Glass' ostensibly a wearable computer that enables the human eye to become 'both an electronic camera and a television display' (Djurkic 2015; Steve Mann 2013d; Mann 1996b; Mann 2012).

Prototypes listed in the School of Glass' exhibit at the Computer History Museum of Mountain View, California, and the Georgia Institute of Technology exhibition titled 'On You: A Story of Wearable Computing'(Computer History Museum 2015). include:

1. '*The Pack*' - *2010* - in combination with backpack;
2. '*The Ant*'; '*The Bat*'; *The 'Cat*'- 2011- including a Nexus One mobile phone;
3. '*The Dog*' - 2011 - incorporating high-end computer board;
4. '*The Emu*'- 2011 -enclosed system and bone conduction speaker;
5. '*The Fly*'- 2011 - stainless band, sleek design;
6. '*The GNU*' - 2011 - first consumer model;
7. '*The Lennon*' - 2011 - first 'all-day-wear' prototype;
8. '*The Hog*' - 2012;
9. '*The Ibex*' - 2012 - the first 'living lab' consumer release;
10. '*The Koala*' - 2012;
11. '*The Glass Explorer*' - 2013 - a public experiment.

In an educational context, creating compelling user experiences for wearable computers focusing on design guidelines, prototyping tools, research directions and a hands-on design experience were subsequently championed by Mark Billinghurst,

professor of Human Computer Interaction at the University of South Australia (M. Billinghurst 2014).

> "... These topics will be presented using a number of platforms such as Google Glass, the Recon Jet and Vuzix M-100, although the material will be relevant to other wearable devices" (M. Billinghurst 2014).

The researcher sought out and was granted permissions as a Professional Associate through the University of Canberra, under the supervision of Professor Robert Fitzgerald, to communicate with and interview online through Google Hangouts forty-seven (47) Google Glass Explorers (Hayes 2015a). In the latter half of 2014 it was evident that problematic aspects of Google Glass, especially in the education sector were causing friction with their cohort, encapsulated in questions by previously enamoured educators such as, "... What does it mean when everyone and everywhere is visually documented and uploaded?" (Goodman 2015).

> "... In addition to the much-discussed topics of privacy and surveillance in current news, how might wearable devices like Glass affect our behaviour and how we interact with people if, or when, such technology becomes the norm?" (Goodman 2015).

With an acknowledgement that early adopters were becoming critical of the social impacts of Glass and with raising privacy concerns Google suspended the program (O'Brien 2015) in early 2015 although many technology pundits predicted that "...even though Google's head-worn computer is going nowhere, the technology is sure to march on" (Metz 2014).

The concept continues to be developed via the Enterprise Google Glass X team (Google 2020b) with Jay Kothari (Kothari 2017) and through projects like 'Captioning On Glass' (Georgia Tech 2017a) at Georgia Tech, Contextual Computing Group under faculty leadership of Thad Starner, Scott Gilliland and Clint Zeagler.

In personal correspondence with the researcher in early 2015, Chris Blackall, researcher at the Centre for Applied Philosophy and Public Ethics (CAPPE),

Australian National University (ANU) in Canberra, Australia (Australian National University 2020) stated when discussing why Google Glass as a ‘social experiment’ was suspended, “... it would be interesting to think about how Glass may/may not fit into an 'ethics of care' framework, particularly how it relates to education” (C. Blackall 2013).

> “... My own view is that as schools, as social institutions, become increasingly dominated by instrumental attitudes to learning and knowledge, some parents and small groups will establish their own small-scale education initiatives underpinned by mobile/ubiquitous ICT, such as Glass" (C. Blackall 2013).

Law Enforcement

In the context of law enforcement, BWCs are often referred to as a Police Body Camera (PBC) and also Body Worn Video (BWV), used interchangeably and within the realm of BWCs concisely available at *Appendix 9.2.1: Body Worn Cameras: A Bibliography and Sources.*

> “... Commercially available BWCs have flooded the market so that there are now over 60 different body worn cameras produced specifically for law enforcement use" (Hung et al. 2016b p.6).

A comprehensive review of BWCs titled ‘A Primer on Body Worn Camera Technologies’ prepared for the United States Department of Justice by the National Institute of Justice (NIJ) contains a wealth of data including cross industry comparisons of device types and their vendors. Body worn camera systems background, market studies, technology overview with market surveys, data management principles, legal considerations and implications are described in detail.

> “... Perceived potential problems include citizen privacy concerns, police officer privacy, health and safety of the officer wearing the BWC, training and

> policy development, and substantial cost for implementation" (Hung et al. 2016b p.8)

In response to multiple primers, copious market studies, empirical findings from trials of BWCs across multiple US jurisdictions and referencing parallel studies across the world, human rights groups, social justice networks and civil liberty groups conducted their own investigations in light of the expenditure on BWCs in the wake of the 2014 Ferguson killing of Michael Brown and ensuing civil unrest.

> "... Even the American Civil Liberties Union has supported the use of BWCS. (…) However, support of BWCS by civil liberties associations has been mixed. In Canada, civil liberties associations have been somewhat more wary of these technologies, having historically expressed skepticism over accountability claims used to justify BWCS"(Banks 2014).

Intermediated support and conditional acceptance of the role of BWCs was also enshrined as described in the '*Civil Rights, Privacy, and Media Rights Groups Release Principles for Law Enforcement Body Worn Cameras*' who continue to emphasise that "... body worn cameras are not a substitute for broader policing reforms and, when deployed without appropriate safeguards, can even compound problems of over-surveillance and biased policing" (The Leadership Conference on Civil and Human Rights 2015). In a contemporary context, the push for policy and laws that enforce automated recording according to the policing district, coupled with AI enhanced BWCs capable of acute facial recognition, has drawn heavy criticism from a coalition of organisations opposed to corporate investment in this space, stating "... Amazon Rekognition is primed for abuse in the hands of governments. This product poses a grave threat to communities (...) including people of color and immigrants" (Higgins 2018).

> "... If combined with facial recognition or other technologies, thousands of police officers wearing body-worn cameras could record the words, deeds, and locations of much of the population at a given time, raising serious First and Fourth Amendment concerns" (Electronic Frontier Foundation 2017).

Serious concerns about Axon, a major U.S. police technology vendor proposed integration of real-time face recognition with body-worn camera systems have also been raised by a coalition of groups including the Leadership Conference on Civil and Human Rights, Upturn and the Center on Privacy & Technology at Georgetown Law, who collectively penned a letter asserting that AI and BWCs is “...categorically unethical to deploy (...) Axon must not offer or enable this feature" (The Leadership Conference on Civil and Human Rights 2018).

> “... the letter also calls on the ethics board to center the voices and perspectives of those most impacted by Axon’s technologies in its review process (...) those who live in the most heavily policed communities will have no legitimacy" (The Leadership Conference on Civil and Human Rights 2018).

Recent aggressive marketing developments are noted from suppliers such as Utility, Inc. who are a “... vertically integrated US manufacturer and supplier of an intelligent ecosystem of software and hardware solutions" (Utility Inc. 2020).

> “... BodyWorn is the most advanced police body camera on the market. Using artificial intelligence to create situational awareness, the assistive features operate seamlessly within our complete evidence ecosystem. Finally, a smart solution for law enforcement" (Utility Inc. 2020).

4.4.2 Digital Realities

Since the dawn of discussions of where humanity engages through a framework of digital realities in a man-computer symbiosis (Licklider 1960) and later through the lens of socialist-feminism, a cyborgism born of liberation from the patriarchy coalesces as realised consciousness according to Haraway (1991) likening the cyborg as a ‘fiction mapping our social and bodily reality’, also asserting that “... Michael Foucault’s biopolitics is a flaccid premonition of cyborg politics, a very open field (...) we are all chimeras, theorised and fabricated hybrids of machine and organism; in short, we are cyborgs" (Haraway 1991).

> "... I extend to 'the digital cyborg assemblage' to denote the body that is enhanced, augmented or in other ways configured by its use of digital media technologies" (Lupton 2013 p.2).

Lupton relates how 'restorative, normalising, reconfiguring and enhancing' capacities of cyborg technologies as described by Gray et al. (1995) have now entered into a realm of ubiquitous digital reality of 'surveillance, monitoring and communication', especially in medical fields facilitated by "... digital technologies (which) include devices that may be worn upon the body, such as smartwatches, wristbands, headbands, augmented eyewear (the Google Glass)…" (Lupton 2013 p.7).

In the present day according to Meghan Han (2017) in an article titled '*1960s-2010s: Humanistic Intelligence and History of Wearable Computing*' "... in the context of wearable computing, the human body is becoming the new medium that communicates new messages (...) in the future, the cellphone as a medium may be replaced by wearable or other forms of brain-computer interface" (Han 2017).

> "... One of the key conceptual frameworks is "mediated reality," which helps us to understand interrelations between VR and AR. In mixed reality (MR) the system supports both virtual and augmented realities (…) Reality is by default 'mediated'" (Han 2017).

An illustration developed by Meghan Han and Hideaki Ishii titled '*Humanistic Intelligence (HI) in Relation to Wearable Computing, Human-Computer Interaction (HCI), and Brain-Computer Interface (BCI*)' depicts elements presented stylistically in a Venn figure incorporating eight (8) fields all interlocking with HCI including (from the centre):

1. *Virtual Reality* as core encapsulated within;
2. *Augmented Reality* both encompassed by;
3. *Mixed Reality* which interlocks on the same scale;
4. *Modulated Reality* (modified, diminished etc.) all within the greater;
5. *Mediated Reality*.

Three further high order sector specific Venn circles overlap and interlock containing those aforementioned realities being;

6. *Wearable Computing* encompassing;
7. *Humanistic Intelligence* which contiguously engage as ‘Merge of Man and Machine’ through a;
8. *Brain Computer Interface* (BCI).

Noticeably missing from the figure is the historical role of Hyperreality, also what First Nations people consider as the ‘animistic’ in which everything is interconnected, congruent with Nyikina Traditional Custodian, Dr. Anne Poelina from the Kimberley region of Western Australia who refers to each person’s ‘liyan’, a moral consciousness guiding humanity in acceptance of duality as one part of a greater reality in an infinite expanse of possibility” (Poelina 2018a; Poelina 2016).

These realities as digital constructs, all collide spectacularly when contemporary theorists and philosophers who extoll a technological Singularity as absolutism, often declare themselves as of advanced intelligence, which unrestrained ignores or negates Indigenous values and cultural understandings by promulgating (as artificial intelligentsia) a ‘smart’ totalitarian state of Uberveillance according to (Michael 2014a; Michael & Abbas 2015).

> “... inventor and futurist Raymond Kurzweil made a public bet with Mitchell Kapor, the founder of Lotus, that a computer would pass the Turing test by 2029. Kapor’s reply was that human beings differed so totally from machines as they were housed in bodies that felt pleasure and pain, they accumulated experience, they felt emotion, much of their knowledge was tacit rather than expressed and that computers would not pass the Turing test by 2029, if ever" (Fallows 2006).

Hyperreality

According to Keiichi Matsuda, designer and filmmaker "...the latter half of the 20th century saw the built environment merged with media space, and architecture taking on new roles related to branding, image and consumerism" (Matsuda 2010)

> "... Augmented reality may recontextualise the functions of consumerism and architecture, and change in the way in which we operate within it (Matsuda 2010).

A film Matsuda (2010) produced titled 'Augmented (hyper)Reality: Domestic Robocop' depicts life for humans enmeshed by BWCs and HMDs in a technological hyper-social architecture, a consequences of new media and augmented reality according to (Matsuda 2010; Bonanni 2006).

> "... the Internet is fitting its users with mental eyeglasses and letting them see new vistas of knowledge in the process" (Fallows 2006).

An important distinction though must preface discussion regarding the 'realities' and digital cyborgism interfuse, grounding this investigation in semiotics by acknowledging the influence of significant theorists such as Jean Baudrillard (Luke 1991), Albert Borgmann (Tijmes 2001), Daniel J. Boorstin (Diggins 1971), Neil Postman (Stephens 2014) and Umberto Eco (Sørensen & Thellefsen 2017) in the contemporary discourse of the 'hyper-real'. Aligned with Heideggerian philosophy, the concept of hyperreality is epistemologically post-Cartesian, as Baudrillard systematically argues in '*Fatal Strategies and Simulacra and Simulation',* which, by critique many consider more a "... sociology of postmodernism" (King 1998).

> "... every dimension of social existence today essentially is a complex simulation of reality, designed specifically to sustain the fragile cycles of political, economic and cultural reproduction" (Luke 1991).

As power and politics play out in hyperreality, BWCs can therefore be considered symbolically as co-mingling; (1) physical reality with; (2) Virtual Reality (VR) through body worn computers (in this context BWCs) arguably negating human intelligence as secondary to; (3) Artificial Intelligence (AI). When considering the

‘*mechanics of hyper-praxis*’ as described by Wilson (2006) all extrapolations of reality including the ‘augmented’, ‘virtual’, ‘augmediated’, ‘mixed’, ‘modulated’ culminating in surely the most dystopian ‘Singularity’, are perhaps why opponents consider BWCs as the panoptic ‘authentic fake’, an apt term coined by Umberto Eco.

Parodying McLuhan’s ‘the medium is the message’, according to Luke (1991), Baudrillard reinforces that in technologically advanced postmodern societies, humans are increasingly lacking consciousness through the inability to distinguish reality from a simulation of reality, therefore, from the higher meta vantage, “... the mass and the media are the same process today, or ‘the mass (age) is the message.’ (...) the historical resistance of the masses to social control by capital and the state now is turning into a hyper-conformity" (Luke 1991).

These historical underpinnings of Baudrillard’s contributions to understanding hyperreality are important as precursor to critique of BWCs through a Heideggerian ‘reframing’, relational examinations of power discourse referencing Foucault and the cogent realities which emanate as critique of ‘street level surveillance’ by BWCs theorists (Peterson & Lawrence 2019; Lawrence 2017; J. Murphy 2018b; Murphy 2019; Brucato 2014).

Augmented Reality

A detailed conceptual framework described in a report carried out at Stanford Research Institute under the joint sponsorship of the Institute and the Directorate of Information Sciences of the US Air Force Office of Scientific Research, titled ‘*Augmenting Human Intellect: A Conceptual Framework*’ and authored by D.C. Engelbart builds on ‘what Vannevar Bush proposed in 1945’, with distinctions that preface what we know of Augmented Reality (AR) considering “... the whole system of a human and his augmentation (...) a proper field of search for practical possibilities" (Englebart 1962 p.1).

> “... an integrated domain where hunches, cut-and-try, intangibles and the human ‘feel for a situation’ usefully co-exists with powerful concepts,

> streamlined terminology and notation, sophisticated methods and high powered electronic aids.' (Englebart 1962 p.2).

In the transition from luggable-to-wearable in the BWC context is a mix of augmented reality and first forms of head-mounted stereoscopic display, built by Ivan Sutherland in 1968 "... called the Sword of Damocles, because it was suspended from the ceiling to reduce the weight pressing on the wearer's head" (Gonçalves 2015).

The phrase '*Augmented Reality*' though was purportedly not coined until 1992 by Thomas Preston Caudell, a researcher at Boeing (Caudell & Mizell 1992) and soon prototypes of augmented reality wearable computers systems emerged include the backpack terrestrial navigation computer (Thomas et al. 1998), the 'Mobile Ar' touring machine that incorporated GPS, head mounted display, tablet input and orientation sensor (Feiner et al. 1997), the Remembrance Agent (Rhodes 1997), as well as advances in telepresence (Garner et al. 1997). These developments all culminated in incremental steps towards 'pervasive', 'ubiquitous' and 'contextually aware' mobile computing as explained by (Höllerer & Feiner 2004).

> "... With heads-up displays, unobtrusive input devices, personal wireless local area networks, and a host of other context sensing and communication tools, the wearable computer can act as an intelligent assistant, whether it be through a Remembrance Agent, augmented reality, or intellectual collectives" (Starner et al. 1995).

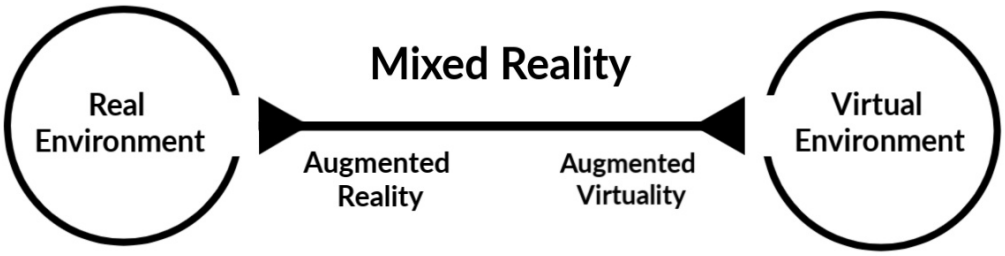

Figure 21: Milgram's 'Reality-Virtuality Continuum'
(Figure 2 in Milgram & Kishino 1994)

A taxonomy explaining augmented reality as it interrelates with virtual reality (Milgram & Kishino 1994) leverages the term 'environment' as the distinguishing factor, as illustrated in Milgram's 'Reality-Virtuality Continuum' (Figure 2 in Milgram & Kishino 1994) which is perhaps the most misunderstood yet cogently accessible blueprint through which all classical understandings could be benchmarked. Milgram's Reality-Virtuality Continuum remarkably and simply renders a theoretical perspective in which; (1) 'real environment' is pitched visually as hard left and; (2) 'virtual environment' as hard right with; (3) 'augmented reality' closest related to 'real environment' whereas; (4) 'augmented virtuality' as closely aligned with 'virtual environment' theoretically conjoined as; (5) Mixed Reality (MR).

According to James R. Vallino, now professor of Software Engineering, Rochester Institute of Technology, "...augmented reality presented to the user enhances that person's performance in and perception of the world…" (Vallino 2020).

> "… an augmented reality system augments the real world scene and attempts to maintain the user's sense of being in the real world (...) Virtual reality strives for a totally immersive environment" (Vallino 1998 p.7).

A multitude of applications for AR include medical, entertainment, military training, engineering design, robotics and telerobotics, manufacturing, consumer design,

manufacturing, maintenance and repair, mindful that “...the fields of computer vision, computer graphics and user interfaces are actively contributing to advances in augmented reality systems" (Vallino 1998 p.7).

> “… An augmented reality system could be considered the ultimate immersive system. The user can not become more immersed in the real world. The task is to now register the virtual frame of reference with what the user is seeing" (Vallino 1998 p.10).

By contrast, the term ‘Augmediated Reality’ (Steve Mann 2013a) as coined by Steve Mann must also be considered as underpinning and prefacing what was later popularised by Caudell as ‘augmented’, yet by examination of AR experts nomenclature ‘augmediated’ semiotically differs because, “...the words are often used interchangeably but the two are fundamentally different. AR is distinguished from VR in that it mediates the real world. VR, on the other hand, shuts out the real world" (MaRS 2015).

Steven Feiner (2002) defines Augmented Reality as, “... computer displays that add virtual information to a user's sensory perceptions" (Feiner 2002).

At the turn of the century, with the onset of mobile augmented reality systems (MARS) and applications which provided access to augmented reality through mobile cell phones, an avid consumer base (as predicted) with the proliferation of 4G and 5G ‘smart technologies’ were led to believe that ‘the world becomes the user interface’, in effect, these wearable devices are the route to a mediated reality, connecting with integrated telegeoinformatic applications, otherwise known as location-based computing and services. (Karimi & Hammad 2004; Höllerer & Feiner 2004). According to the ANIWAA group, AR has shifted almost exclusively to BWC devices connected through smart frameworks as “...a wearable glass device, head-mounted device (...) overlays digital content on top of the real world (...) enhances the user’s experience in the real world rather than replacing it" (Cherdo 2020).

> "... AR has the backing of investment of huge tech giants (…) AR can be delivered on hardware that we already own and use: smartphones" (Cherdo 2020).

Mark Billinghurst, of the University of South Australia, Adelaide co-author of 'Empathy Glasses' (Masai et al. 2016) and Rob Manson, AR and VR open standards evangelist as invited expert with the W3C and Khronos Group are both (IEEE 2013) International Symposium on Mixed and Augmented Reality (ISMAR) (ISMAR 2020) members and leaders in this Augmented Reality field, Manson legacy as launching BuildAR, the world's first AR Content Creation platform in 2009.

Mediated Reality

The term Mediated Reality (MR) is directly attributed to Steve Mann, Toronto University who built a wearable computer prototype called 'EyeTap' or electric glasses which integrates with a welding helmet delivering to the wearer 'High Dynamic Range (HDR) "... in the context of a seeing aid designed originally for task-specific use e.g. electric arc welding" (Mann et al. 2012, p.1).

> "... The result is an essentially self-contained miniaturised hardware HDR camera system that could be built into smaller eyeglass frames, for use in various wearable computing and mediated/ aug-mediated reality applications, as well as to help people see better in their everyday lives" (Mann et al. 2012, p.1).

Mann reinforces repeatedly throughout literature that HDR as a general purpose 'seeing-aid' has wider potential application replacing security cameras including BWCs, reinforcing that augmented reality "...is limited in the sense that what we really wish is a *diminished reality"* (Mann et al. 2012, p.3).

> "... The point-of-view of the cameras is the point-of-eye (PoE), such that each camera operates as if it were the wearer's own eye" (Mann et al. 2012, p.3).

With a continuous play on nomenclature, Mann builds out ‘mediated’ reality to include ‘collaborative mediated reality’, paradoxically at the crossroads of when leaders in this space including Thad Starner, Steve Mann, Bradley Rhodes, Jeffrey Levine, Jennifer Healey, Dana Kirsch, Rosalind Picard and Alex Pentland co-authored together in 1997 titled ‘Augmented Reality through Wearable Computing’ published in journal ‘Presence: Teleoperators and Virtual Environments’ (Starner et al. 1997).

Concepts discussed in this seminal article include ‘augmented memory’, ‘finger tracking as a pointing device’, ‘object recognition’, ‘3D graphical overlays’, ‘geophysical active tags’, ‘aids for the visually disabled’ extolling the virtues of these technological innovations as, “...wearable computing augmented realities are truly personal. The user grows to expect his interface to be accessible continually and unchanging, unless specified otherwise. Such a persistent and consistent interface encourages trust" (Mann et al. 2012, p.15).

Virtual Reality

Virtual Reality has a long and complex association with that of wearable computing beginning with the experiments of Ivan Edward Sutherland, author of ‘Sketchpad, A Man-machine Graphical Communication System’ (Sutherland 1963).

According to Steve Mann (Mann 2002), Mediated Reality though, must firstly be attributed historically predating VR through the works of George M. Stratton who considered constructing ‘special eyeglasses to modify how he saw the world’ presented partially in a reading titled ‘Some preliminary experiments on vision without inversion of the retinal image’ at the Third International Congress for Psychology, Munich, August, 1896 (Stratton 1896). Jaron Zepel Lanier, who coined the term virtual reality ‘to bring a wide variety of virtual projects under a single rubric’ (Steuer in Mann 2002) a pioneer in the field of virtual reality and founder of VPL research, one of the first companies to sell VR goggles and gloves recently expressed:

> "… I am unhappy with the way that digital technology is influencing the world, and I think the solution is to double down on being human" (Adams 2017).

This assertion suggests that a 'mediated reality' of which virtual reality is a subdomain, as reinforced by (Mann 2002) that prefaces a learned natural environmental interaction with other humans using digital technology is a profound challenge to humanity on a number of fundamental levels.

> "… Virtual reality immerses us in the fantastical because the rules of the world don't apply," said Helen Papagiannis, AR specialist and one of the panellists at the meetup" (MaRS 2015).

Within the context of this research virtual reality head mounted displays (HMD) such as the Oculus Rift (Oculus 2017), Fove VR (FOVE 2017) or Google Cardboard (Google 2017b) are not included in this assay nor are complete vision mediate reality (CMVR) devices technologies nor digital corneal implants. These VR technologies have a long wearable computing historical association, however to address this topic with any voracity would require another thesis to address the socio-ethical implications of a virtualised reality on society. The closest example to a fusion between these realities is the work of Steve Mann and his Metavision team (Metavision 2017) who states, "...augmented reality (AR) will only find success if we can make the experience natural for users" (Djurkic 2015).

Mann reinforces that virtual reality that visually obfuscates and then eliminates a human's interaction visually with the natural world altogether poses a significant risk to society despite what Michael Abrash, Chief Scientist at Oculus asserts as the next fundamental leap developers, attempting to emulate mankind.

> "... Perhaps the most important problem yet to be solved is figuring out how to represent real people convincingly in VR, in all their (human) uniqueness" (Abrash 31 March, 2016).

This concurs with the works of Rob Manson CEO of BuildAR, a member of W3C Media Stream Depth Extensions Specification and an Invited Expert with the ISO, W3C and the Khronos Group who asserts that a Mixed Reality (MR) that seamlessly 'combines locative, vision and virtual content into a single experience' as being the way forward in this domain not one to the exclusion of the other taking humanity away from the natural environment.

> "... In a 1995 article, appeared in "Le Monde Diplomatique", the French theorist of technology, Paul Virilio, describes the phenomenon of the loss of orientation experienced by the exponentially increasing crowd which is relentlessly enthralled in cyberspace. Virilio observes that the construction of information superhighways, which are globalized and instantaneously updated, presents us with a threat, a menace to our perception of what reality is, of what it means for us to exist, as individuals, here and now" (Sparacino et al. 1999).

Of much interest to the researcher, a chance find using the Australian online library database aggregator 'TROVE' using the search terms 'Aboriginal' and 'VR' led to the works of Aboriginal Martu filmmaker and artist Curtis Taylor. In a conversation with filmmaker Lisa Stefanoff, in the production and international promotion of Lynette Wallworth's 'Virtual Reality Film Collisions', Curtis "...tells the story of his grandfather Nyarri Nyarri Morgan's experience of the British atomic bomb tests at Maralinga and ongoing care for his country" (Stefanoff & Taylor 2018, p.1).

> "... Curtis reflects on the value of different art and media forms for conveying Martu stories, enduring traditional knowledge and contemporary concerns, and discusses his own cinematic reflections on the powers, risks and roles of new media in Martu communities" (Stefanoff & Taylor 2018, p.1).

As Stefanoff relates, Curtis was employed within the project in multiple roles; (1) as Director's Attachment; (2) as a camera assistant; (3) as a cultural liaison; (4) one of the narrators and Stefanoff reinforces, "...Curtis' cultural liaison work was crucial to the creation of the film, and entailed multiple kinds of mediation (...) translating back and forth between director and storyteller (...) between Martu Wangka and English

languages (...) working with the multi-lens cameras during the shoot (...) sound in post-production (...) melding his and Nyarri's knowledges and senses of country with the prosthetic sensory capacities of the VR technologies used in the project" (Stefanoff & Taylor 2018, p.1).

Mikaela Jade is also a leading figure in the contemporary VR space, as an Aboriginal Cabrogal woman, member of the Microsoft Australia Reconciliation Action Plan Advisory Board and CEO of Indigital, creators of Indigital Storytelling app, "...which aims to connect people with the past through new technology (...) users simply download it, hold their mobile device up to a pre-programmed object, artwork or place, and the traditional owner associated with the site comes to life in a 3D animation, sharing ancient knowledge or Dreamings" (InStyle 2018).

> "... the idea was to make sure that when we're standing in a cultural place, we have an authentic experience of Aboriginal history (...) I'm really passionate about making sure that our people have opportunities in this space not just to consume tech but create it" (InStyle 2018).

At the point of publication, congruent with the avid (yet contestable) attestations by Jade (2018) the 'best' of consumer accessible VR headsets are touted as led by corporations such as Microsoft, marketing 'Mixed reality is ready for business'. (Microsoft 2020).

Mixed Reality

As illustrated in (Figure 2 in Milgram & Kishino 1994) Mixed Reality (MR) is the 'merging of real and virtual worlds in order to produce new environments and visualisations' distinguished from by AR or VR in which physical and digital objects co-exist and interact in real time, MR isn't locatively exclusive, rather a hybrid of the physical and virtual worlds.

> "... Mixed Reality (MR) visual displays, a particular subset of Virtual Reality (VR) related technologies that involve the merging of real and virtual worlds

somewhere along the "virtuality continuum" which connects completely real environments to completely virtual ones" (Milgram & Kishino 1994).

The educational applications of MR with learning and teaching frameworks are numerous, although Grant et al. (2019) warns the “...depth of experience that should be the goal of pedagogical design (...) of mixed reality frameworks for learning and teaching" (Grant et al. 2019). Likewise, in the context of application, current research suggests that large gaps exist in the domains of ‘User Experience’, MR and ‘Digital Retail’ yet “...the Retail sector is moving towards Omnichannel Retail model which is centred around customer holistic experience which includes hedonic and utilitarian experience of customers" (Jain & Werth 2019).

In the collision between extended MR by blending light-field technologies with BWCs in HMDs form, current discourse also engages a wide array of interdisciplinary stakeholders focussed on, the ‘Potential of Blockchain Technology as Protocol of Universal Virtual Reality’ described by Alex Ramond (2019), PhD graduate from Stanford University who warns, “...there may be potential problems that arise with the complete move away from the traditional banking system. The foundation remains a move to cryptocurrency because of the libertarian ideology that defines Virternity" (Ramond 2018).

When considering the ‘smarts’ of blockchain which transform wearable technology from a convenience into a necessity, according to Ramon (2018) issues such as ‘control’, ‘trust’, ‘privacy’ and ‘security’ arise (Perusco & Michael 2007), notwithstanding that promises user autonomy as “...it does this by decentralising the data it collects and making it accessible, when the owner permits it, to others" (Ramond 2018).

Diminished Reality

The term ‘Diminished Reality’ (DR) is attributed to Steve Mann (Mann 2002) who asserts that ‘Augmented Reality’ and ‘Virtual Reality’ as well as ‘Mixed Reality’ all fall within the meta-domain of ‘Mediated Reality’.

An illustrated by Mann (2002) in an article titled ‘Mediated Reality with implementations for everyday life’ specifically *Figure 2: Taxonomy of Reality, Virtuality, Mediality* also includes a Venn sector tiled ‘MODulated Reality’ which Mann explains as a result of considering the ‘MODulated’ and ‘DIMinished’, “... when virtual, or PC created, data is merged with what the client would somehow or another typically observe" (Mann 2002).

Notably, Mann (2002) quotes S.K. Feiner (2002) as making the core distinctions between VR and AR as ‘a new way of seeing’ within the realm of MR as modifier, arguing that “… virtual reality brashly aims to replace the real world, augmented reality respectfully supplements it.’' (Feiner 2002).

Singularity

The realm of Singularity as coined by Vernor Vinge, author and futurist is a state of technological ‘reality’ as ‘capable of rupturing the fabric of human history’ (Magee & Devezas 2011) a perspective also mirrored by Ray Kurzweil, inventor and futurist (Kurzweil 2011) stating that we are at the tipping point of a technological singularity “...where the accelerating pace of smarter and smarter machines will soon outrun all human capabilities" (P. G. Allen 2011).

Numerous interactions with those closely associated with this school of thought (Socrates 2014) and embracing the Sans Ceiling hypothesis (Hughes 1998) that fundamentally there are ‘no limits to the possibilities and or capabilities of intelligence’, simply raises more questions as to whether humanity as a result of reaching this hypothetical state is likely or any closer to resolving of the Fermi

Paradox (Verendel & Häggström 2017). It would remiss therefore of the researcher to simply list a whole range of resources (of which there are many) which reinforce this hypothetical futures facing interpretation of human reality, omitting any discussion of the counterposition for this hypothetical, firstly as richly described in Critical Theory (CT) which, through a Marxist philosophical position critiques this notion as further perpetuance of economic and political 'commodification, reification, fetishisation of mass culture' (Corradetti 2013).

Likewise, in counteract to assertions of super-human intelligence by Paul Gardner Allen, American investor and philanthropist best known as the cofounder of Microsoft argued in his 2011 seminal MIT article '*Paul Allen: The Singularity Isn't Near*' that "... for the foreseeable future, it is the 'complexity brake' and arrival of powerful new theories, rather than the Law of Accelerating Returns, that will govern the pace of scientific progress required to achieve the singularity" (P. G. Allen 2011).

> "... The amazing intricacy of human cognition should serve as a caution to those who claim the singularity is close. Without having a scientifically deep understanding of cognition, we can't create the software that could spark the singularity" (P. G. Allen 2011).

When BWCs are considered as 'eyes of the machine' though, namely the Internet, the world's largest digital entity, the true nature of 'reality' devolving into an anti-paradigm as end to the anthropocene must be balanced according to (Poelina 2018a) through a pedagogy of hope, ecologically responsible, with a consciousness which is currently and always prone to attack Poelina claims by those presenting culture as driven by a pedagogy of oppression. This notion of duality, nonlinear or reticular thinking Barbara Glowzcewski (2005), anthropologist and a professorial researcher reinforces, like Poelina "... the fact that there is no centrality to the whole but a multipolar view from each recomposed network within each singularity, a person, a place"(Glowczewski 2005).

> "... Reticular or network thinking, I argue, is a very ancient Indigenous practice but it gains today a striking actuality thanks to the fact that our so

> called scientific perception of cognition, virtuality and social performance has changed through the use of new technologies" (Glowczewski 2005, p.24).

Preying on others through the allure of techno-centricisms and existential wrangling of the deterministic ‘Aletheia’ state of disclosure (not truth rather transparency) in the Heideggerrian state of ‘in-waiting’, Singularity will more likely be a fourth industrial revolution driven by strategic intelligence (World Economic Forum 2020) incorporating Embodied Computing (EC) on a trajectory to a state of Uberveillance according to (Michael et al. 2015; Michael et al. 2013).

> “... to some degree we have already been disembodied by the technological interventions we are using (...) we have less physical contact with those we love and we have more contact with inanimate objects even if we're using them as vehicles of communication" (Michael, K. in Windes 2019).

4.4.3 Virtual Futures

For the most part, the workings of the great minds of those in institutions such as MIT who are experimenting or rapid prototyping in the wearable computing domain are published via open access or publicly made accessible through the web. The importance of keeping knowledge open and humanely accessible according to Joi Ito, academic at MIT (Ito 2019) is well documented yet, there remains a perpetual challenge of ‘science-stymying academic paywalls’.

Despite the seemingly arcane world of academia and the peer reviewed sciences, much of the eventual and actual (versus perceived) outcomes of BWCs impact on humanity are captured and made eventually accessible for further analysis, rarely the case other than an expose of historical rhetoric from BWCs developers and marketers.

> “... Mann hit the stage yesterday at We Are Wearables, the biggest wearables meetup in the world. With AR and virtual reality (VR) dominating tech headlines (…) the days of widespread digital glasses are coming" (Djurkic 2015).

The reality of virtual futures in the wearable computing development context is rarely exposed as countless startup ventures, unpaid internships and massive marketing often crash after product alpha launches and lavish lunches such as the ‘WeAreWearable’ initiative (AWE 2015). Likewise, best case examples of invention are sadly also often rendered inaccessible due to administrator abandonment such as the infamous Glogger.mobi website which by 2016 boasted two-hundred and forty-thousand, eight-hundred and thirty (240, 830) ‘Gloggers’ now only accessible via the Internet Archive ‘Wayback Machine’ (Mann 2014). In the case of CastAR (Crecente 2017) employees whose employment base just evaporated suggests that perhaps, despite all the fanfare and excitement there are serious cracks in the virtual reality foundations.

Humanistic Intelligence

The term Humanistic Intelligence (HI) coined by Steve Mann (2013) is often used in the wearable computing context when examining the manner in which humans interact with the device, in essence the ‘intertwining’ shift in human-computer interaction, from handheld and portable, through to wearable (Steve Mann 2013c).

With ties to a projected state of ‘bearable computing’ now more commonly referred to as Embodied Computing (Pedersen 2020; Veyrat et al. 2008), Humanistic intelligence is defined by Mann (2013) as intelligence in humans, especially as a result of interaction using ‘smart eyeglasses’ which arises from “...the human being in the feedback loop of the computational process" (Mann 1996b; Mann 2006).

> “...In this sense, wearable computing can be defined as an embodiment of, or an attempt to embody, Humanistic Intelligence (...) it is always running in the background, so as to augment or mediate the human's interactions" (Steve Mann 2013c).

An illustration titled ‘Six Signal Flow Paths of Humanistic Intelligence’ by Mann (Mann 1998a; S. Mann 2001) clearly outlines six (6) attributes which have resonance

when considering BWCs, although classical ‘ideals’ as expressed by Mann differ markedly from examples of contemporary automated and Internet networked BWCs:

1. *Unmonopolizing* - The device does not necessarily cut you off from the outside world as a virtual reality game or the like does;
2. *Unrestrictive* - You can do other things while using the device—for example, you can input text while jogging or running down stairs;
3. *Observable* - The device can get your attention continuously if you want it to. The output medium is constantly perceptible. It is sufficient that the device is almost always observable, within reasonable limitations, for example, as when a camera viewfinder or computer screen is not visible when you blink your eye;
4. *Controllable* - The device is responsive. You can take control of it at any time. Even in automated processes, you should be able to manually override the automation to break open the control loop and become part of the loop;
5. *Attentive* - The device is environmentally aware, multimodal, and multi-sensory. This ultimately gives you increased situational awareness;
6. *Communicative* - You can use the device as a communications medium when you wish. It lets you communicate directly to others or helps you produce expressive or communicative media.

Of great interest to the researcher, Mann (2017) reveals through an research article titled ‘Big Data is a big lie without little data: Humanistic intelligence as a human right’ a number of concepts which have legible integrity and transferability into how BWCs impact upon humanity, especially as Brucato (2015) considers, the rollout of BWCs as much a backlash to sousveillance via consumer cell phones equipped with high resolution cameras as ‘transparency’ considering:

> “... the utility of surveillance video is conditioned by point of view. Police agencies in the U.S. are rapidly adopting on-officer camera systems, because they acknowledge ubiquitous surveillance and that these devices aid in nullifying third-party documentation in their own favour. As such, these cameras serve, in fact, as counter-sousveillance technologies" (Ben Brucato 2015, p.455).

Aside from the mountain of nomenclature that Mann (2017) is known to generate as a result of domains and definitions colliding within his research endeavours, the key importance Mann asserts is understanding, "...transparency by way of Humanistic Intelligence (HI) as a human right" (Mann 2017).

> "... ''Little Data'' is to sousveillance (undersight) as ''Big Data'' is to surveillance (oversight)" (Mann 2017, p.1).

The domain of Human-Computer Interaction Mann (2017) maintains is also informed by the identity awareness of research data (A. Hayes et al. 2013) and its reuse in a social computing context, where "... Veillance (Sur-and Sous-veillance) is a core concept not just in human–human interaction e.g. people watching other people" (Mann 2017, p.1).

> "...Veillance is the core of Human-in-the-loop Intelligence (Humanistic Intelligence rather than Artificial Intelligence), leading us to the concept of ''Sousveillant Systems'' which are forms of Human-Computer Interaction in which internal computational states are made visible to end users, allowing users (but not requiring them) to ''jump'' into the computational feedback loop whenever or wherever they want" (Mann 2017, p.1).

Artificial Intelligence

The onset of BWCs imbued with Artificial Intelligence (AI) that is capability driven through networked BWCs devices in the military, national security and policing sectors is of most relevance when considering the research focus of this investigation, publicly visible through reviews and reports of ethical restraint urged by civil and human rights groups (The Leadership Conference on Civil and Human Rights 2018).

John McCarthy, computer scientist and inventor, is often attributed as the key pioneer of AI at Stanford University, conducting the academic 'Dartmouth Conference' as early as 1956 (Childs 2011), at which Hungarian-American mathematician, physicist, computer scientist and polymath John von Neumann's conjectures of self-replicating automata were tested, ostensibly "....the concept of machines building more machines,

in an exponential and perhaps uncontained explosion that could simply swamp other life forms that get in the way. (Scharf 2016).

With ties to the hypothetical and rhetorical state of a technological Singularity as expounded by (Kurzweil 22 Sep, 2005), with the ‘society of intelligent Veillance’ works of (Minsky et al. 2013) and definitively informed by the path-breaking works of Alan Turning (Copeland 2012), the fact is AI is now irrefutably having a human impact on many sectors including mining (A. Hayes 2017a), law enforcement (Griffith 2017), medical (Mitchell 2006) and financial sectors (Gabberty & Vambery 2007). The counter position is claims that the term ‘artificial intelligence’ is reductionist, nor the emergence of a new kind of intelligence, rather “... marketing hype (...) beyond its inherent vagueness, a new, *sui generis* ontological entity created by humans but somehow outside of our control" (Karachalios & Ito 2018, p.1).

> “... Intelligence and autonomy are phenomena of human activity with dimensions that go beyond what can be captured by the reductionist methods used to establish logical/scientific frameworks" (Karachalios & Ito 2018, p.1).

Complex and sophisticated mobile cyber-physical systems relates (Mitchell 2006) of which BWCs are now an enmeshed intelligence gathering tool profile “... involve big instant data from multiple complex sensors or other systems, and are required to provide continuous autonomous service (over) in a long time (Jóźwiak 2017).

> “...it is prudent to provide “smartness” to the camera front-end. This requires hardware assisted image recognition and template matching in the front-end capable of making judicious decisions on when to trigger video capture or streaming" (Desai et al. 2016).

Consumer attention for AI driven life-logging automated cameras such as ‘Google Clip’ was short lived as was the Oxford Metric Group inspired ‘Autographer’ wearable camera device, with consumers citing privacy concerns as their law enforcement counterparts, which are now according to Manes (2018) “...biometric tracking devices equipped with artificial intelligence (...) automatically reconstruct the comings and goings of anyone they choose to target" (Manes 2018).

> "... These kinds of innovations in police tech raise profound questions about privacy, personal freedom, the powers of police, and their potential for abuse. They often test the constitutional limits on surveillance. Yet the government shrouds many of them in secrecy" (Manes 2018).

These surveillance practices and related AI developments are central to the research of David Lyon, Queen's University (Lyon & David 2009), and University of Alberta, Canada criminologist and sociologist Kevin D. Haggerty who cites Mathiesen (1997) when relating that "... the recent growth of surveillance cameras trained on the police themselves, however, accentuates a parallel form of power (...) "synoptic" power" (Sandhu & Haggerty 2017, p.79).

> "... He argues that Foucault's model of panoptic surveillance, where the few watch the many, needs to be supplemented with an appreciation for how modern media also allow the many (assorted mass audiences) to watch the few. (...) This, he suggests, amounts to a different form of disciplinary power, one which "controls and disciplines our consciousness" (Sandhu & Haggerty 2017, p.79).

Of most notable dissension to these 'opaque' human computing practices with powerful cognitive tools that are non-linear such as 'Google Brain'(Google 2020a) that allegedly builds AI 'better and faster than humans can', the European Commission Directorate-General for Research and Innovation in conjunction with the European Group on Ethics in Science and New Technologies has declared the need for a global and shared Ethical Framework for Artificial Intelligence, Robotics and 'Autonomous' Systems (Anon 2018, p.15).

> "... Jigsaw is a unit within Google that forecasts and confronts emerging threats, creating future-defining research and technology to keep our world safer" (Google Inc. 2019).

Capable of immense catastrophic effect if wielded for nefarious purposes, the fact is AI and BWCs are a supercharged surveillance combination according to Vincent

(2018) manifest in products which interface with both the Google and Microsoft policing cloud services like ‘Ella’, (ICRealtime 2020) capable as a cloud-based deep learning solution which “...augments surveillance cameras with natural language search capabilities, Ella is revolutionising video search functionality for the entire industry" (Vincent 2018).

> “... This could be good news for public safety, helping police and first responders more easily spot crimes and accidents and have a range of scientific and industrial applications, but it also raises serious questions about the future of privacy and poses novel risks to social justice" (Vincent 2018).

Machine Intelligence

The quest for intelligent behaviour in machines is according to Kristian Kersting from the Machine Learning Lab, CS Department and Centre for Cognitive Science, at Darmstadt University of Technology, Machine Learning (ML) primarily focussed on how to ‘construct computer programs that automatically improve with experience’, adding that, “... AI and ML are both about constructing intelligent computer programs, and (deep Learning) DL, being an instance of ML" (Kersting 2018).

> “... Machine learning and AI complement each other, and the next breakthrough lies not only in pushing each of them but also in combining them (...) Using the common language of computation, we can fully understand how to achieve intelligent behaviour in machines" (Kersting 2018, p.3).

John McCarthy, computer scientist pioneer and inventor, also known as “the father of Artificial Intelligence (AI)” Kertsing (2018) recounts is known to have passionately pursued an objective within his research of making a machine ‘... that could reason like a human, was capable of abstract thought, problem-solving and self-improvement" (Childs 2011).

> “... He believed that "every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it" (Childs 2011).

Likewise Alan Turing, famously pursued through a framework of reasoning that Complex Systems Theory (Wolfram 1988) could prove that some machines could ‘think’, or as Gottfried Wilhelm Leibniz, (Look 2020) German polymath and one of the most important logicians, mathematicians and natural philosophers had termed, ‘mathesis universalis’ or inanimate mechanising thinking (Mainzer 1997).

In the BWCs context, machine intelligence built on a foundation of data from on-officer, on-human, on-being or indeed in-being (Strickland 2017) context according to Manes (2018) adds to an already frightening array of massive databases that can amount to virtual time machines, coupled with “...innovations (which) threaten to radically reorient the informational balance of power between citizens and the state, giving law enforcement ready access to enormously detailed and intimate data about people’s lives" (Manes 2018, p.6).

The formulation of ethical principles regarding AI as ‘supercharged’ machine intelligence and ‘autonomous’ systems has predominantly stemmed from industry, practitioners and professional associations, includes IEEE (Institute of Electrical and Electronics Engineers) and the ACM (Association for Computing Machinery), contrasting sharply with the private sector including corporations such IBM, Microsoft and Google. According to the European Group on Ethics in Science and New Technologies (Anon 2018, p.15) these corporations operate under their own ethical codes (Google 2020c), with projects such as Google Brain ‘make machines intelligent. Improve people’s lives’ (Google 2020a) coming together with other corporations on broad initiatives (OpenAI 2020) such as OpenAI.

Emergent ‘identity management’ initiatives such as Axon’s Enrolment Software (Axon 2019) combining biometrics and AI powered ‘smart’ machine vision, now boast full scale application conducive to BWCs deployed in national security context, partnering with ‘in-field’ (BioRugged 2020) devices.

Extended Intelligence

The concept of Extended Intelligence (EI) was developed by Joi Ito, in conjunction with colleagues at the MIT Massachusetts Institute of Technology's (MIT) Media Lab, (Ito 2016), providing an alternative route to engage in issues that arise in the AI debate such as perceptions that AI is currently controlled by a 'reductionist' rhetoric emanating from nefarious individuals and corporations "… who actually control(s) people's information and identity" (Anderson & Rainie 2018).

> "... Instead of thinking about AI as separate or adversarial to humans, it's more helpful and accurate to think about machines augmenting our collective intelligence and society" Joi Ito in (Simonite 2018).

Historically, in mid 2018 the IEEE Standards Association (IEEE Standards Association 2020a) and the MIT Media Lab (MIT Media Lab 2020) announced a joint initiative called the Global Council on Extended Intelligence (CXI) (IEEE SA & MIT Media Lab 2018), determinedly pitching "... growth for humanity's future should not be defined by reductionist ideas of speed or size alone but as the holistic evolution of our species in positive alignment with the environmental and other systems comprising the modern algorithmic world" (IEEE SA & MIT Media Lab 2018).

> "... stories must move beyond the "us versus them" media mentality pitting humans against machines. Autonomous and intelligent technologies have the potential to enhance our personal and social skills; they are much more fully integrated and less discrete than the term "artificial intelligence" implies" (IEEE SA & MIT Media Lab 2018).

This initiative was dovetailed with a three-year, globally distributed and iterative consultation process also informed by collaborations on A/IS governance with the United Nations, the European Commission and Parliament, the Organisation for Economic Cooperation and Development, as well as with UNESCO and UNICEF, resulting in versions of publication involving thousands of global experts from "...

internationally recognised by governments, inter-governmental bodies, academia, non-governmental organisations (NGOs) and industry" (IEEE Standards 2019b).

The IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems (The IEEE Global Initiative) produced and publicly released a seminal 500 page white paper on the 25 March 2019, titled 'Ethically Aligned Design: A Vision for Prioritising Human Well-being with Autonomous and Intelligent Systems, First Edition' (EAD1e). (IEEE Standards 2019b).

> "... It is time to move "From Principles to Practice" in society regarding the governance of emerging autonomous and intelligent systems. The implementation of ethical principles must be validated by dependable applications of A/IS in practice" (IEEE Standards 2020).

A workshop hosted by the IEEE Global Initiative, 'Autonomous and Intelligent Systems in the Digital World: Moving from Principles to Practice' held on April 11, 2019, during the 8-12 April 2019 World Summit on the Information Society (WSIS) Forum in Geneva, Switzerland at the International Telecommunications Union in Geneva reinforced aspirations emanating from the EAD1e to, "... inspire its global readership to take action; it is a unique and groundbreaking achievement taking ethical implementation of A/IS from principles to practice" (IEEE Standards 2019b).

Aside from criticisms of 'benign benevolence', praise for the initiative, despite the disastrous PR exercise which railroaded much of the MIT association with this project was extensive including:

> "...How often do you come across a paper from the tech community that says, 'Human well-being is the highest virtue for a society, and human flourishing begins with conscious contemplation'?" (IEEE Standards 2019a).

The principles of the Extended Intelligence initiative have been explored in context throughout this thesis and underpin another form of counterposition in the Discussion chapter to AI, which as Karachalios & Ito (2018) Joi Ito reinforce is 'reductionist thinking', referencing preferentially the MIT Media Labs conceptual framework.

(Karachalios & Ito 2018, p.1).This position of AI currently being driven as a reductionist paradigm is also refutably challenged by the assertions of the Future of Life Institute, producers of the Asilomar AI Principles who assert that “...artificial intelligence has already provided beneficial tools that are used every day by people around the world" (Future of Life Institute 2020).

> “... Its continued development, guided by the following principles, will offer amazing opportunities to help and empower people in the decades and centuries ahead" AI Principles in (Future of Life Institute 2020).

Cultural Intelligence

A critique of Baudrillard’s hyperreality reveals that by traditional association, the Heideggerian theorisations encompassing the cultural phenomenon of BWCs is as Karachalios & Ito (2018) describe also, reductionist and perhaps now “...dialectically superseded" (King 1998).

> “.... Instead of these theories being seen as saying anything insightful about recent social transformations, the epistemological void in which they position themselves should be interpreted as the intellectual expression of the wider cultural and postmodern trend of transgression" (King 1998, p.47).

Correspondingly, according to Joseph le Doux (2019) professor of Science in the Center for Neural Science at New York University (NYU), director of the Emotional Brain Institute of NYU and the Nathan Kline Institute, the importance of the autonoetic which is the capacity to self-reflect and with awareness understand that this is “... the network that underlies human consciousness (...) the basis of the conceptions that underlie our greatest achievements as a species – art, music, architecture, literature, science – and our ability to appreciate them" (LeDoux 2019).

> “... The internet has indeed transformed life in ways worth celebrating but, like most good things, it comes at a cost. It has made it easier to be self-

> centred, facilitating realignments of interests that oppose the common good" (LeDoux 2019).

This paradox, grounded in the capacity to discern between egoic introspection and the practice of the autonoetic self-awareness is perpetually raised by those whose cultural practices have endured tens of thousands of years asserts Glowczewski (2005), as "… computers seem able to facilitate, in their own way, the circulation of cultural knowledge systems" (Glowczewski 2005, p.25).

> "... In order to be transmitted, they (these) have always relied on oral and visual performances as well as the active practice of survival in the environment…" (Glowczewski 2005, p.26).

In 'deep listening' and 'quiet still awareness' as described by (The Lowitja Institute 2012; Ungunmerr 1988) a counterposition and answer exists for those who transmute social value and claim 'quasi-instant' as cultural logic despite this "... paradigm change, particularly in relation to our understanding of the functioning of memory, the relation between matter and spirit, and the actual and the virtual" (Glowczewski 2005, p.27).

> "... As Pat Mamanyjun Torres argues, the location of "place" is vital for an understanding of Aboriginal cultures in any research" (Torres, 2006, p. 22 in McDuffie 2019).

The shift in the way we now relate culturally through technologically mediated devices and networked connection spaces, in reflection, in deep listening "... forces us to consider differently what the so-called 'primitive' populations express about their relation to the world" (Glowczewski 2005, p.27).

These two themes, 'deep listening' and the importance of 'place' as a personal and multidimensional relationship transcending the geo-locative vernacular of 'location' are noticeably absent in the determinist attestations of Neil Postman (2011), educator, media theorist, and social critic. Despite Postman's accounts of humans drowning in a self-created state of 'technopoly', he also reveals laboured insights from Jacob

Bronowski's book, '*The Ascent of Man*' that "… cultural intelligence is thematically impressionable (...) the transcendent belief that humanity's destiny is the discovery of knowledge (...) our unending quest to gain a unified understanding of nature and our place in it" (Postman 2011, p.187).

It is within this research investigation that 'cultural intelligence' can also be considered manifest in the observations of conversational account from experts regarding BWCs as a ubiquitously connected technological device, pervasively oriented in watching the activities of humans in society, however, the limitations are almost tautological when considering "...activity is the minimal meaningful context for understanding individual actions" (Daniels 2016, p.3).

4.4.4 Trajectory Of BWC

The trajectory of body worn cameras as a means through which to 'see' into society are likely to follow, according to (Pedersen 2020) et al. the route of 'embodied computing' or 'insertables' (Heffernan et al. 2017) which in a state of Uberveillance (Hayes 2010b), if anything alike with the trajectory of the auto-identification industry will also likely have "... social, cultural, and ethical implications of the technological possibilities with respect to national security initiatives" (Michael & Michael 2009).

> "... technological trajectories consist in the continuous improvements of products in terms of performance and reliability and in the tailoring of products to specific users' needs, within specific application contexts" (von Hippel 1988) in (Michael 2003b, p.24).

Considering where BWCs will proliferate and occupy further requires an examination of the rise of global authoritarianism according to David Murakami Wood (2017) from Queen's University, Canada, partially explained through Michael Foucault's (1982) views on the subject and power of 'governmentality' through surveillance, with BWCs as a proliferating intervention in civil society also aligning with Hannah Arendt's (1973) identification of 'totalitarianism' in which "... one can see

totalitarianism as a mode of ordering which combines pre-modern and modern: authority with surveillance" (Wood 2017).

> "... No one can predict the future but one thing is certain, if a technology (high-tech or other) is open to misuse, it will eventually be abused" (Michael & Michael 2006, p.13).

One enduring topic which is ever present through much of the literature and resources which relates to the likely or conversely, unlikely trajectory of BWCs is that in a contemporaneous society, 'fear politics' and the exploitation of the 'safe communities' rhetoric is steering what the ACLU consider abhorrent, "... first of all, we don't think that police officers should be routinely present in schools at all (...) more and more police officers are being permanently stationed at schools" (Stanley 2015).

> "…This contributes to the criminalisation of many routine school disciplinary matters that have never before been handled through the criminal justice system, and the strengthening of what we call the school-to-prison pipeline" (Stanley 2015).

Considering the explosion of private prisons in the United States in the last decade the ACLU has a warranted reason for its emphatic assertions that, "... body cameras in schools just don't strike the right balance in terms of oversight versus privacy (...) police officers, when in schools, should not regularly be engaging in the type of law enforcement efforts that would require them to wear body cameras" (Stanley 2015).

From another contestable perspective, from the point-of-view of whether biometric analytics using AI which as a big part of current research methodologies at the Complex Social Interactions (CSI) Lab at Washington State University, abrogates as 'ethically aligned design', the researcher questions partiality according to observations of "... we develop analytics with real world applications for public safety agencies (...) we provide agencies with information that can improve organisational outcomes, while evolving individual-level decision-making on the part of first responders" (Complex Social Interactions (CSI) Lab 2020).

Emphasising the need for private-public partnerships, methodology and technology being developed within the lab, David Makim, Criminologist as CSI Labs openly declared a commercial partnership with likely increasing commercial-in-confidence as "...The CSI Lab received a grant and equipment from Axon" (Gammon 2018).

> "... Makin's CSI Lab has since analysed thousands of police-community interactions on video and numerous records from law enforcement incidents (...) location, lighting, time of day, number of people present, gender, race, verbal and physical stress, and intensity of the interaction are among the contextual factors assessed" (Gammon 2018).

Predictions

With predictions of an accelerated normalisation of embodied computing, technological evolution and computational sophistication of AI in less that decade, Scharf (2016) considers will likely 'supersede' the capacity and capability of our biological minds and bodies, and "... at a certain point we'd want to hop into new receptacles, custom-built to suit whatever takes our fancy" (Scharf 2016).

The Research & Innovation arm of the European Commission however has a far more pessimistic few of the 'Future of Work, Future of Society' reinforcing in a 2018 report that at a fundamental level, BWCs join a 'delegation of complex tasks to robots and AI' which, "... may lead to loss of workers' control over machines, with a consequent lack of some human and professional skills, a decrease of autonomy and dilution of responsibility" (Research & Innovation: European Commission 2018, p.69).

> "... Against this background, it is important to have a clear distribution of responsibilities with a human being or institution always being accountable and responsible for the design, use and governance of the technology and its results" (Research & Innovation: European Commission 2018, p.69).

Another concern expressed by the European Commission is an awareness and prediction that the algorithmic monitoring of workplaces "… becomes highly

problematic if used with the intention to constantly control, register, track or localise the worker (...) workers may be obliged to remain online and be watched even outside working hours and workplaces" (Research & Innovation: European Commission 2018, p.69).

> "...Privacy provides the required time out for intellectual freedom, curiosity, diversity, creativity, initiative, learning and reflection, all of which should be considered as essential elements in re-imagining work in its broadest context" (Research & Innovation: European Commission 2018).

In the state of New South Wales, Australia alone, despite claims that BWCs were introduced four years ago to 'improve evidence gathering and to encourage good behaviour from officers' a likely trajectory for BWCs, Police Commissioner Mick Fuller predicts is a move to deploy the use of bluetooth enhanced firearms that 'speak' with BWCs as "....I certainly do not fear videoing much more often, but I do need to say that the BWV camera will have to be updated, our Glock will have to be updated and then the Taser technology will have to be updated as well" (Hendry 2019).

Public trust, control of officer interactions and improvements to policy have since been hailed as the mainstays for why Fuller is now in capital works request from the Australian Government as "...the force was currently reviewing the BWV policy to ensure officers are using the cameras more often" (Hendry 2019).

The safeguards Fuller describes as 'necessary' do not mention public consultation, privacy advocate nor cultural community review, only prejudicial reinforcement of "...I want officers to use it more; I want the policy to really define when they need to use it more" (Hendry 2019).

This Fuller example is just one of many where the mythical properties of BWCs in the context of policing and law enforcement are predictively gratuitous in justification, as malignant as "... in response to their own question, 'Why use BWV [body-worn cameras] at all?' they answered that cameras were '...an additional option for officers to gather evidence at incidents'" (NT Police (2015) in Palmer 2016).

As the automation of public facing roles in society such as law enforcement, teachers, parking inspectors, nurses increases, so too will the need for ethically aligned empirical evidence be needed to mitigate risks, inform regulatory bodies and predict outcomes should this innovation 'escape' human containment reinforces (Lazar Puhalo in Michael 2014b).

> "... I think in 30 years time though, we will have got used to almost continuous surveillance, even on public thoroughfares, and that to me is really one of the most ominous aspects of the element of technology (Lazar Puhalo in Michael 2014b).

A most troublesome aspect to what Puhalo & Michael (2014) predict is already unfolding according to civil liberties groups in the United Kingdom who claim BWCs have joined live facial recognition cameras (LFR) which feed CCTV systems for the London Metropolitan Police, "… a breathtaking assault on rights" (Dodd 2020).

> "... This is a dangerous, oppressive and completely unjustified move by the Met. Facial recognition technology gives the state unprecedented power to track and monitor any one of us, destroying our privacy and our free expression" (Dodd 2020).

The only independent review of the LMPs public trials by Professor Pete Fussey, a surveillance expert from Essex University identified it was verifiably accurate in just 19% of cases, falsely identifying in as many as one in a thousand cases. The London Metropolitan Police defended the move stating the cameras have a 70% and higher success scouring a database of 'suspects' uploaded using the latest intelligence.

This is effectively heralding according to Allan Hogarth, from Amnesty International UK a continuous state of 'predicting policing', rendering everyone 'guilty', liable for interrogation until proven innocent, much like as depicted in the popular science fiction film 'Minority Report' proving that "... facial recognition technology poses a huge threat to human rights (...) this technology puts many human rights at risk, including the rights to privacy, non-discrimination, freedom of expression, association

and peaceful assembly (...) without adequate transparency, oversight and accountability" (Dodd 2020).

Market Studies

A market report from (Technavio 2015) identifies a vast list of key players who are dominant in the smart glasses, augmented reality and at that point, emergent HUD and HMD market; Atheer, Google, Imagine MobileAR, Konica Minolta, Laster Technologies, Lumus, Meta, ODG, Optinvent, Penny, Recon, Seiko Epson, Six15 Technologies, Sony, Technical Illusions, Toshiba and Vuzix. The report details a growth trajectory peaking at 194% by late 2019 for the global smart glasses market for Augmented Reality including engine providers, software application developers, and smart glasses OEMs.

> "...The adoption of smart glasses is expected to increase significantly among enterprises and individual consumers for various applications in healthcare, industrial use, and logistics, among others" (Technavio 2015).

A more recent market report from Technavio (Technavio 2016) identifies only eight (8) key players remaining in the field of smart glasses and augmented reality HUDs and HMDs as Atheer, Epson, Google, Microsoft, ODG, Recon, Sony and Vuzix. According to (Lange Juky 2016) the Gartner Hype Cycle positioned wearables and augmented reality as 5-10 years away from mainstream consumer adoption, yet by 2017 as cited in (Panetta 2017) AR sat commercially in the 'trough of disillusionment' despite the many AR device types commercially available, Artificial intelligence (AI) as 'everywhere', now conjoins with transparently immersive experiences (VR) and digital platforms such as decentralised business ecosystems like Bitcoin.

The main reason for this lag and main barrier against the sale and use of 'smart' AR or 'intelligent glasses' posits Due (2015) was:

> "...undoubtedly people's discomfort with the idea of constantly being able to be filmed and uploaded to the internet (sousveillance), possibly for

> commercial use or by countries as part of their surveillance techniques" (Due 2015, p.31).

A market survey conducted on behalf of the U.S Department of Justice by the National Institute of Justice and prepared by The John Hopkins University of Applied Physics Laboratory (Hung et al. 2016a) provides one of the most comprehensive overviews of the leading brands and development schedules for body worn cameras available. Robust, miniature, lightweight cameras that can be worn, mounted or body attached with many worldwide manufacturers, developers and related data management services are detailed in this four-hundred and ten (410) page survey.

> "... the incorporation by vendors of new technological BWC features prompts the strong need for clear policies and this is an evolving area of law and some legal issues are currently unclear with regard to BWCs" (Hung et al. 2016a).

The National Institute of Justice later also released a fifty-one (51) page seminal document in 2016 titled 'A Primer on Body Worn Camera Technologies' (Hung et al. 2016b) detailing BWC technology overview, previous market surveys, BWC cross comparisons, data management, user management, security, data storage, policy considerations, legal implications and future considerations.

4.5 Summary

In this chapter, the historical background for body worn computers, specifically BWCs are relationally aligned through further descriptions of their application, innovations and resulting challenges for humanity. Drawing upon resources from numerous online sources, through a constant state of immersion the researcher has presented both a historical account and a contemporaneous state of BWCs through a narrative of additional perspectives to those presented in Chapter 2, Literature Review.

As the Netnography reveals, cohesive links can be derived from the associations and professional collaborations between sectors, interdisciplinary research and globally

networked projects. What is evident when considering how BWCs impact upon humanity from what is revealed in the Netnography, is that of evolving need to consider the social impacts and ethical implications described in detail in Chapter 6, Socioethical Implications. Persuasive elements which accompany the transposition of BWC as an innovation are then detailed in Chapter 7, Discussion.

On reflection, the researcher considers that examining the historical and contemporary associations of BWCs and industry, the resultant etic perspective is a more realistic appraisal and liminal approach to gaining a full understanding of body worn computers and by direct association, also a more holistic understanding of BWCs. The theoretical underpinnings and conceptual frameworks within which BWCs occur as discussed in Chapter 3 also emerge within the associations of key figures, organisations and indeed whole sectors as they coalesce.

Making meaning of power relations derivative of these historical underpinnings emanates from the direct application of BWCs which will feature in discussions with interviewees mapped through critical discourse analysis in Chapter 6, Socioethical Implications.