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ABSTRACT

The article develops the conjecture that automated mobilities are particularly characteristic of the digital era. Acknowledging that the development of the mobilities paradigm has been especially fruitful for the social sciences, the article contends that the advent of artificial intelligence, advanced robotics and accelerating automation makes new conceptual and methodological demands on mobilities research. In the first section of the article, I briefly review aspects of the ongoing development of the mobilities paradigm, with particular emphasis on the emergent contours of what I shall term “mobilities 3.0”. The second section focuses on several key aspects of complex automated systems, with specific reference to the advent of AI, advanced robotics and accelerating automation, along with how some of the mobilities transitions attendant upon these are registering in mobilities research. In the final section, I turn to analyse one particular instance of automated mobilities: namely, AI military technology and weapons systems. I conclude by setting out some conjectures on the relations between AI, automated mobilities and the paradigm of mobilities.

KEY WORDS: AI, mobilities 3.0, automaticity, robotics, warfare, globalization

AUTOMATED MOBILITIES: FROM WEAPONIZED DRONES TO KILLER BOTS[1]

Introduction

It seems that issues of movement – of people, information, ideas, communications, and objects – have been profoundly impacted because of the digital revolution, particularly technological innovations in artificial intelligence, advanced robotics and accelerating automation (Urry 2016; Elliott 2016; Schwab 2016). As the wave of AI breaks across the world, the living of everyday life – people's movements, mobilities, proximities – is becoming digitally embedded in new ways of interacting and communicating "on the move". AI is not so much geared to the future as now anchored in the present, applied as a general-purpose technology which underpins everything from the daily travel paths of individuals through GPS navigation to the circulation of money via check-scanning machines at ATMs. AI has, in short, become crucial to the reordering of everyday life and deeply permeates people's mobile lifestyles – from receiving Amazon recommendations to requesting Uber, and from getting information from virtual personal assistants to talking with chatbots. Digital technologies and AI thus engender new modes of everyday living - of identity and personhood, social relationships, family and friendship formation, gender and sexuality as well as power imbalances - through its lightening-speed delivery of big data, self-referential calculations, sentient environments, location tagging, complex algorithms, sensors and robots (see Elliott, 2019).

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The diverse, intersecting mobilities of travel, transport and tourism are similarly undergoing transformation as a result of intensive automation. New forms of automated travel are well underway because of technological innovations in camera technology, GPS, accelerometers and gyroscopes when coupled to smart transportation development blueprints and the commercialization of driverless technology. Technology giants from Google to Uber, along with automotive manufacturers such as Tesla, GM, Volvo, Daimler, Ford, Jaguar, Audi and BMW, have been developing self-driving vehicles. One estimate is that 10 million self-driving cars will be on the world's highways by 2020, with one in four cars being self-driving by 2030. There are already driverless trucks at the port of Rotterdam and automated lorries on the M6 in the UK (Lipson and Kurman 2016). Other novel forms of automated vehicles are also emerging. Automated flying taxis have been piloted over the skies of Dubai; computerized mapping drones (or UAVs) have provided accurate, up-to-date geographic data for various humanitarian agencies providing emergency aid to disaster zones (Flood 2016); and, autonomous weapons systems that can identify targets without human input (Asaro 2013): these are just some of the most recent technological advances which are re-mobilizing social life today.

Simultaneously the Internet and social media have rapidly expanded as a result of innovations in AI, with significant impacts in terms of the restructuring of "communicative" and "virtual" mobilities, as well as novel blends of "online" and "offline" social worlds. Social media, cloud computing and supercomputers more broadly play a central role in this respect. But so too do smart products, services and devices, 3-D printing, intelligent ecosystems, virtual reality, augmented reality, and complex algorithms. This is what Nigel Thrift (2011) has called the "informational overlay" of contemporary societies, and it is an overlay which re-orientates social life away from face-to-face interaction and instead

generates new forms of digitally mediated interaction which transforms our basic coordinates of time and space. For example, it is more and more evident that people will be unlikely to interact with intelligent machines in the future through keyboards and mice—natural language is already making headlines as a game-changing technology for personal assistant devices, though is still in its infancy. An increasing number of consumer devices have recently appeared on the market that dispense altogether with conventional interfaces, such as Amazon's Alexa and Google's Home. Instances of other novel interfaces include augmented and virtual reality, interactive holograms, consumer-level EEG, RFID implantation, computational mood analysis and prediction, and wearables. Other emerging interfaces (still some years away from widespread commercialization) include immersive haptics, implantable EEG or ECG, multi-function implants (the beginnings of cyborgs), human augmentation and exoskeletons (Warwick 2018).

These developments directly impact aspects of economic, social and cultural life that are in some sense mobilized, or "on the move". What is new about the current conjuncture is the way in which the global digital economy is mobilizing the massive pool of networked intelligent machines, of interconnected AI self-learning and sentience, for the re-grooving of both institutional life and processes of self-constitution. In the past, industrial processes of automation were fixed in place and programmed for specific repetitive tasks. But, more recently, digital technologies which link deep learning, neural networks, pattern recognition and machine decision-making have become increasingly central to the process of organizational life, often displaying a kind of automaticity which is mobile, situationally-aware and which can adapt to and communicate with socio-technical environments (Baldwin 2016). This quantum leap in machine intelligence, which is characterized by data-driven computing rather than instruction-driven computing, has emerged through exponentially

growing quantities of data and processing power together with the development of complex algorithms, leading to new capacities for self-organization, sense-making, insight extracting, and problem solving. Advances in cloud computing, machine-to-machine communications and the Internet of Things have simultaneously developed incredibly rapidly, faster than previous technologies and with huge consequences for mobile lives as well as the complex mobility systems upon which enterprises and institutions depend. Some recent research has underscored the centrality of automated mobilities to the global digital economy and includes contributions from sociology, geography, cultural studies, science and technology studies, anthropology, and tourism and transport studies (Stiegler 2015; Elliott 2016; Elliott 2019; Pink et al 2018; Freudendal-Pedersen and Kesselring 2018; Kellerman 2018; Bissell and Del Casino Jr 2017; Bissell 2018).

In this article I shall analyse some of the key characteristics, dimensions, and consequences of automated mobilities, to reflect on the development and deepening of the mobility turn within the social sciences which I shall argue is increasingly necessary. My central premise is not only that new digital technologies are merging physical, communicative and virtual mobilities in ways not previously anticipated, but that advances in AI, robotics and automation are increasingly networked, mobile and global. In the first section of the article, I briefly review aspects of the mobilities paradigm, with particular emphasis on the contemporary contours of what I shall term "mobilities 3.0". In the second section of the article, I focus on several key aspects of complex automated systems, with specific reference to the advent of AI, advanced robotics and accelerating automation. In the final section of the article, I turn to analyse one particular instance of automated mobilities: namely, AI military technology and weapons systems.

Mobilities 3.0: Stretching the Paradigm

In sociology and the social sciences more generally, the arrival of the 2000s witnessed a "mobilities turn" (Hannam et al 2006), the development of "critical mobilities research" (Söderström et al 2013) and a "new mobilities paradigm" (Sheller and Urry 2006; Urry 2007), to grasp the social conditions and consequences of dramatically increased movements of people, objects, goods, services and information around the world. These and other studies highlighted an increasing mobilization of daily life throughout the rich North in conditions of globalization – for example, the increased distances travelled by work colleagues, members of leisure organizations, families and friends in order to sustain 'distanciated' patterns of everyday life – whilst simultaneously underscoring that mobilities are always deeply interwoven with immobilities and moorings. This new paradigm sought to address questions of movement, immobility, friction, turbulence, scale, tempo, rhythm, history and power coming to the fore with the spread of global mobility systems (Adey et al 2014).

Urry's (2007) pioneering research on mobilities identified five interdependent fields of mobility that produce social life organized across time and space and which form (and re-form) its contours. These fields are (1) the corporeal travel of people for work, leisure, family life, pleasure, migration and escape, organized in terms of contrasting time-space modalities (from daily commuting to once-in-a-lifetime exile); (2) the worldwide physical movement of objects to producers, consumers and retailers; (3) the imaginative travel effected through the images of places and peoples appearing on and moving across multiple print and visual media; (4) the virtual travel often in real time thus transcending geographical and social distance; and, (5) the communicative travel through person-to-person messages via messages, texts, letters, telegraph, telephone and fax. The principal focus in this paradigm, what I shall term *mobilities 1.0,* concerned the linkages of these fields within complex mobility systems.

As Sheller has argued, this research agenda focused on "the study of various complex systems, assemblages and practices of mobility" (2014: 45). Research from the *mobilities 1.0* paradigm included, for example, studies of infrastructures and networks that produced, enabled and transformed aeromobilities (Cwerner et al 2009), automobilities (Merriman 2004), rail mobilities (Stilgoe 2007) and urban mobilities (Graham and Marvin 2001). Urry's (2003) underscoring of the powerful spatial "fixities" (airports, rail networks) that – as "moorings" - enable and structure mobilities in specific forms was especially consequential. Adey (2006), for example, reworked Urry's "mobilities/moorings dialectic" to develop a suggestive account of how mobilities are always deeply interwoven with immobilities, differentiated according to speed and slowness, while Sheller's (2018) research on the 'politics of mobility' explored the complex ways the mobility – and motility – of some groups of people linked with the immobility (and immotility) of others.

If the paradigm of *mobilities 1.0* addressed complex systems and practices of mobility (automobility, aeromobility, etc.), the arrival of *mobilities 2.0* research addressed anew the intersections of institutional mobility systems on the one hand and the mobilization of everyday, ordinary lives on the other. Elliott and Urry (2010) signaled this shift in the title of their book *Mobile Lives,* in research which connected "the sociological analysis of different forms of travel, transport, tourism and communications with the multiple and sometimes novel ways in which identities are constituted, performed and organized across various spaces and through times". This critique of how complex, contested mobility systems are intricately interwoven with the transformation of ordinary lives "on the move" included the coinage of various neologisms – "miniaturized mobilities", "network capital", "affect storage" and "portable personhood" – which significantly influenced the field of *mobilities 2.0* research. A range of new insights were produced. Kesselring (2008) wrote of

"cosmobilities", and in his influential study of "mobility pioneers" catalogued techniques of 'networked mobility management', the skills and strategies used by mobile persons to manage the demands of being "on the move" and interacting socially at a distance (Kesselring 2006). Other *mobilities 2.0* research addressed the interlock between systems and lifestyle through the lenses of atmospheres, experimentation, acceleration and deceleration, habits and disruptions. This research ranged across the study of passengers (Bissell et al 2011), stillness and waiting (Vannini 2011), sleep in transit (Hsu 2014), the multiple processes of bordering (Rumford 2010) along with the differential ease with which these may be traversed (Birtchnell and Celetrio 2014), as well as the ambivalence of freedom and unfreedom that inheres within everyday routines of mobility (Freudendal-Pedersen 2009).

Appropriately enough for a paradigm concerned with tracing the interrelations between systems and lifestyles, the major emphasis of much *mobilities 2.0* research focused on mobile devices, mobile connectivity, and the spread of "miniataurized mobilities" such as smartphones, tablets, laptops and so on (Elliott and Urry 2010). Historical and contemporary theoretical research in sociology, cultural geography and cultural studies underscored changing constructions of space, place and movement through mobile telecommunications and new information technologies, resulting in the "compression" of time and the "distanciation" of space across the globe. Sociological research of tele-presence – such as Boden and Molotch's (1994) research on the Internet – highlighted that the 'collapse of distance' has made possible many social relationships associated with contemporary urban life. Townsend (2000) demonstrated, for example, that urban office towers critically depend on ICT for the coordination of their internal spaces. The development of telecommunications requiring no connection at a fixed location, and of digitalization more generally, spelt major changes to what is meant by presence, proximity, distance and mobility (Strengers 2015).

These and other studies documented the dizzying scale of communicative mobilities around the world. However, none explored the digital revolution which is AI, advanced robotics and accelerating automation, and which is today "re-booting" the production, reproduction and transformation of mobilities in many significant ways.

This focus on the digital revolution hints at the vexed question of how automated mobilities might stretch *mobilities 2.0* research to breaking point. How might we best understand today's worldwide mobilization of advancing AI, massive data and code, blockchain technology, transactional interoperability across networks, protocol leverages and the Internet of Things? One possibility is to argue that what we have arrived at a mobile global order characterized by big data. This has become an increasingly common standpoint in the literature (see Lupton 2015). Big data has been increasingly bound up with the production and performance of mobilities, as illustrated in Dodge and Kitchen (2005) studies on how everyday mobilities intersect within coded infrastructures to Gordon and De Souza e Silva's (2011) more recent work on the implications of digital spatial technologies and geo-referenced data for the ways spatiality and mobilities are produced.

But what is often neglected is that data is itself a key ingredient in the development and deepening of AI and machine learning, and big data is now threaded throughout a wide variety of AI deployments, from automated stock-trading and chatbots to self-driving cars and Industry 4.0. I want to argue that what is happening consequently is something quite different, which is a shift into the terrain of *mobilities 3.0* where AI is reshaping the contours of contemporary societies and transforming how societies are 'mobilized'. AI is bringing into being a society held in thrall to a *new protological infrastructure* which triggers the *contactless contact* (communicative, digital, virtual) that mobilizes and re-mobilizes people

and machines, and which converses the machine-to-machine connections which are beginning to dramatically impact on institutions, organizations, companies, states, regions and global actors. A prevailing assumption has been that various forms of technological mobility are relatively self-contained, with only limited consideration of how interaction between physical, communicative and virtual mobility may have profound and long-term impacts on socio-spatial structures. The reverse side of this coin is the position that new information technologies foster virtual mobility as an alternative to, or substitute for, physical mobility. The age of AI, I am suggesting, significantly challenges both of these assumptions, as it rewrites mobilities. Yet a sophisticated treatment of the redistribution of geographic mobilities resulting from the digitally enabled intersection of physical, communicative, and virtual orders of today's technological tsunami has not yet been developed.

AI and Complex Automated Systems

So, the mobilities paradigm today faces a world where a shift is taking place in the fabric of the global digital economy as a result of the rising prevalence and profusion of AI, big data, advanced robotics and accelerating networks of automation. This shift, I will suggest, involves a deepening of the mobilization of digital life, where organizations and modern institutions become loaded with intelligent machine learning, and along with that everyday life becomes suffused with automaticity. Such a world of automated digital technology arises out of various sociotechnical tendencies, which have come into existence over the last thirty years or so. In what follows here, I shall briefly touch on four key tendencies (many others have been identified in recent social theory including science and technology studies) and which, when taken together, point to a necessary reconstruction of the field of mobilities. The first and most palpable of these tendencies is the sheer extensity of the economic dimensions of AI and the digital revolution. AI has its origins in geopolitics, which it

simultaneously impacts and transforms, and constantly interlaces with the the contemporary phase of globalization and the global economy. In the sphere of geopolitics, the main narrative for AI has been about power - the power to shape the worldwide race in AI-driven economic growth, as well as research and development initiatives to remain globally competitive. Innovation underpinned by monetary investment and public policy initiatives lies at the core of the digital revolution. Globally the most important AI hubs are in Silicon Valley, New York, Boston, London, Beijing and Shenzhen. In terms of national investment in AI, for example, the UK has committed $1.3 billion over 10 years and France $1.8 billion over five years, and the EU estimates a total public investment of $20 billion by 2030 and China calculates it will spend $209 billion by 2030. Small wonder that some estimates of productivity-driven economic growth conclude that AI could contribute approximately $16 trillion to the global economy by 2030.

The second tendency is that human-to-machine and machine-to-machine interrelations become increasingly overdetermined by *automaticity*. There is a collective profusion of auto-authoring – the automated production of large tracts of everyday life - taking place now across big data streams, human-to-machine conversation and machine-to-machine interrelations. Economist Brian Arthur (2011) calls this the new "second economy" of intelligent, automatic machines, where automaticity provides a "neural layer" for the physical economy. Software-based, AI-driven automation, writes Arthur, "is running an awful lot of the economy. It's helping architects design buildings, it's tracking sales and inventory, getting goods from here to there, executing trades and banking operations, controlling manufacturing equipment, making design calculations, billing clients, navigating aircraft, helping diagnose patients and guiding laparoscopic surgeries". The critical point here, as Nigel Thrift noted as early as 2014, is that "half of internet traffic now comes from

nonhuman sources" (Thrift 2014: 9), underscoring the rise of chatbots masquerading as flesh-and-blood human agents. The rise of automaticity impacts substantially on inherited notions of human autonomy and sets huge challenges for researchers of the global mobile order.

The third tendency is that today's interdependent digital systems of AI, advanced robotics and accelerating automation are everywhere transferring, coding, sorting and resorting digital information (more or less) instantaneously across global networks. With systems of technological automation, things and objects become coded, tagged, scanned and locatable, as AI becomes the pervasive architecture of our densely networked environments. Complex automated systems of digital technology emerge as the 'surround' to both everyday life and modern institutions. Today's interdependent, informational systems of digitization are, to invoke Adam Greenfield (2006), both "everywhere and everyware". From GPS to RFID tagging, and from augmented reality to the Internet of Things, these complex, interdependent systems are the architectural surround or operational backcloth through which airport doors automatically open, credit card transactions are enabled, SMS is enacted, and big data is accessed. As Greenfield contends, this increasingly pervasive digital surround scoops up "all of the power of a densely networked environment, but refining its perceptible signs until they disappear into the things we do everyday" (26).

To invoke the possibility of disappearance in this context, as Greenfield does, is to raise the question of the hidden and the invisible as concerns systems of digitalization. Digital life inaugurates a transformation in the nature of invisibility – operationalized through supercomputers, big data, and artificial intelligence – and the changing relation between the visible, the hidden and power. My argument is that the rise of complex digital systems generates a new form of invisibility interwoven with mobility/immobility, and which is

linked to the characteristics of software code, computer algorithms and AI protocols and to its modes of information processing. The invisibility created by digital technologies is that of a protocological infrastructure which orders and reorders the many connectivities, calculations, authorizations, registrations, taggings, uploads, downloads and transmissions infusing everyday life. So, where does the mobility of AI lead in this case? It leads, among other directions, to the notion of the algorithm itself – connoting efficiency, precision and dispassionate, calculative objectivity. These mobilizations undergird (as much as reveal) a particular cultural faith and trust in ostensibly neutral technological systems (Beer 2017). Behind the dazzling appearance of AI and advanced robotics, and the sophisticated technicalities which underpin them, lies the fundamental social process of algorithms charged with finding and assessing worth: classifying, sorting, ranking and otherwise organizing and rendering manageable today's mass of digital data, and of the complex ways this conditions understandings of what is or is not of significance, relevance or value.

Codes, algorithms and protocols are the invisible surround which facilitates our communications with others and our sharing with others of personal data through the array of devices, apps, bots and wearable technologies and self-tracking tools which monitor, measure and record people's personal data. AI thus creates a new form of mobility, based on a distinctive kind of invisibility, which touches on and tracks identities and bodies and constitutes and reorders our social interactions through ubiquitous contactless technologies. But the digital mobile field is, of course, much more extensive in scope, enabling also smart objects (or, anti-wearables) and other digital data-gathering technologies. Many objects and environments have been rendered 'smart' through embedded sensors, interactive visualizations and digital dashboards – again, with an invisible protological infrastructure and

the kinds of social relations spawned by it, touching upon the operations of shopping centres, airports, road toll systems, schools and many more (Ash, 2018).

Finally, as a fourth tendency, these systems which are ordering and reordering socio-technical life are becoming more complex, and increasingly complicated. This growing complexity has powered the rise of ubiquitous computing and AI and has been underpinned by exponential rates of technological and associated social transformations. 'Moore's Law' has been the guiding maxim of innovation since the mid-1960s and refers to the so-called doubling of computing power every two years. Computing power is based on the number of transistors in an integrated circuit; and against the backdrop of ever-shrinking computer circuits, engineers have been able to fit exponentially more onto microchips. This has made computers more complex, powerful and cheaper: it is estimated that a smartphone, for example, possesses the computer power previously only available in large mainframe computers. More recently, reports from various technology companies – such as Samsung and Intel – have suggested that beyond 2021 it may not be feasible to shrink transistors any smaller. The limits to technological miniaturization has thus propelled a debate on whether Moore's Law has reached an end; some analysts argue that quantum computing, along with greater exploitation of cloud computing, will provide the new route forward for the continued expansion of computing processing power (Pratt, 2015). And many people believe that ubiquitous computing and AI, when viewed in the context of convergence with nanotechnology, biotechnology and information science, will continue to propel exponential rates of technological complexity, socio-economic innovation and social transformation. Certainly, the ubiquity of digital technology, and especially complexity in AI and robotics, involves multimodal informational traffic flows, which in turn substantially depends on technical specialization and complex expert systems.

The mobilization of social life, I am suggesting, does not surrender easily. It increases with ever-growing technological complexity and densities of digital interactions. Mobilities researchers are not unaware of these transitions, and some perceptive analysts have sought to underscore the importance of AI-enabled technologies for the re-mobilization of social life. Kitchen (2014), for example, elaborates on his earlier studies of coded infrastructures to take account of the development of smart systems, while de Souza e Silva (2013) explores the impacts of location-aware technologies on spatiality and sociality. It is, however, the emergence of automated automobilities - driverless vehicles and their attendant opportunities, risks and challenges - which has, unsurprisingly, attracted perhaps greatest attention from mobilities scholars (Kellerman 2018). Central to many of these studies is speculation about new possibilities for human-machine interaction, especially engagement with automated mobile technologies. Laurier and Dant (2016), for instance, consider the ways 'social life in the car' might change once unmediated by the action of driving. Bjørner (2017) contrasts the pleasures of driving oneself with possible pleasures associated with self-driving vehicles. Weber and Kroger (2018) reflect on possible futures for well-established gendered and racialized car cultures with the advent of autonomous automobilities. For other researchers, the unplanned character of many of these human-machine interactions serves as a salutary check on any strong technological determinism. Pink et al (2018) consider gaps in technological designs and solutions as providing possible spaces for improvisatory user actions. Stilgoe (2018) shows that accidents involving self-driving vehicles have been treated as moments of encounter between social learning about technology and machine learning about society. Bissell (2018) sees such accidents rather as empirical sites through which understandings of the multiple and dispersed material politics of automation might be explored. Others still argue that the most far-reaching mobilities transformations entail the

intelligent infrastructures and infostructures that are enabling the development of seamless, safe, efficient and sustainable multimodal transport systems (Canzler and Knie 2016), even as these may be seen to distribute agency 'ominously' across the system hardware and software (Sheller 2008).

These contributions to mobilities scholarship provide clear indication of a nascent grasp of how AI is prompting a shift in relations between physical, communicative and virtual mobilities – a movement away from 'substitutist' or 'complimentary' modes and towards what Kellerman (2018; 1-8) refers to as the 'additive' mode - and a recognition that this is producing far-reaching consequences for socio-spatial structures. These changes remain, however, undertheorized. This may, in part, be attributed to the fact that, at least as far as automated automobilities are concerned, the disruptive impacts to social and political relations remain in the early stages. After all, the introduction of widespread driverless vehicles is not anticipated to occur throughout the Global North until the early 2020s, with full deployment of self-driving cars an additional 10 years beyond that. There is, nonetheless, one area where AI, robotics and a range of AI-enabled automated mobilities systems have been in use for a considerable period, and which accordingly can provide valuable insights for the development of an emergent *mobilities 3.0* research programme.

AI, Mobilities and New Warfare

Mary Kaldor coined the term "new wars" to capture the impacts of globalization, privatization and technological advances in the post-Cold War era. The rise of AI and advanced robotics has been especially consequential in recent decades to the means of waging new wars as well as the novel development of sophisticated weaponry. The

militarization of drones and associated capture and organization of information by algorithms is now a direct means of waging war. Much of the research on new military technologies has been based on investigations of drone operating teams (Asaro 2013), from computer technician's programming of code to automated software programmes and algorithms used to ensure that target combatants are accurately identified on "kill lists". Derek Gregory (2011) argues that drone warfare has inaugurated "a militarized regime of hypervisibility", one in which the extraction and archiving of data underpins the identification, targeting and execution of combatants. In the US, for example, a key database, the 'disposition matrix', aggregates and harmonizes the various 'kill-and-watch' lists generated by a diverse array of government agencies. For Jutta Weber (2016) the development of this database signals a change in prevailing technorationality, one increasingly geared to anticipating unknown unknowns by shifting analysis away from the statistical calculation of probabilities towards the use of advanced data-mining algorithms to array all conceivable possible dangers. This represents, she argues, the emergence of a new cultural logic of warfare, "not one of cause-and-effect but rather one of preemption and possibility" (120) wherein anyone and everyone can be targeted as a possible danger.

This AI, data-driven mode of war, rich in visualization through an array of cameras, screens and surveillance, is one in which computer progammers, sensor operators, mission intelligence coordinators and drone pilots (based at their desk behind a computer) work together on "precision targeting" as part of team "kill-chain" (see Mindell 2015: 114 – 156). This process of global restructuring of military warfare in terms of AI and algorithms institutes a fundamental shift in the social and political character of organized violence. Aspects of these global transformations can be captured through reference to four interrelated developments.

First, the stupendous scale of military expenditures in the global economy on unmanned ground vehicles, autonomous weapons systems and weaponized drones provides an important insight into the political and social changes fostered by AI imperatives. As indexed by officially published statistics in the US alone, the Department of Defense possesses nearly 11,000 unmanned aerial systems of many different types and capabilities, including unmanned surface vessels and unmanned underwater vehicles (US Defense n.d.). So how many unmanned aerial systems do other countries now possess? The answer is nuanced, depending on what exactly constitutes a "weaponized systems", and what figures there are should be considered estimates at best. In 2012, *The Guardian* identified 56 different types of UAVs used in 11 different countries. Taken on their own, such figures might only serve as a snapshot of the influence of AI in the current global military order. It is perhaps of greater use to consider armed drones, on which there are some more comparative figures. According to an influential 2015 report, there are over 10 countries now deploying armed drones, including the US, the UK, China, Israel, Pakistan, Iran, Iraq, Nigeria, Somalia, and South Africa, as well as two non-state organizations - Hamas and Hezbollah (Dillow 2016). The weaponized drone club, according to the report, reached double-digit membership primarily as a result of easy access to Chinese technology, which is less expensive than US drone technology. In 2017, it was estimated that UAVs market for the military market will reach $13.9 billion by 2026 and will increase 39% from 2016 to 2022. By contrast, military drone markets at $3 billion in 2014 are anticipated to reach $11 billion by 2021 (Aero-news 2016).

Such figures at once dazzle and depress. But, again, to understand how AI imperatives have become one of the main organizing axes in global military affairs, these figures need to be contextualized in wider social, cultural and political terms. Take as an example the perceived imperative of nation-states today for preserving or enhancing strategic advantages over adversaries on global or regional scales, along with the perceptions of near chronic existential threat and the concomitant security cultures that underwrite this massive investment of resources (Weber 2016). The socio-technological entailments of these systems – most notably the affinities between the military simulation and/or operating systems and digital gaming systems - has led theorists to develop the concepts of a 'military-entertainment complex' (Lenoir and Caldwell 2018) or the more extensive 'security-entertainment complex' (Thrift 2011), an "era of permanent and pervasive war and permanent and pervasive entertainment" (10). What is significant in these developments - in addition to this melding of the security and entertainment sectors (often occurring inside the same corporation) as well as a penetration of commodified violence into everyday life, is how these emergent systems entail reworkings of human-machine relations that render communicative, physical and virtual mobilities co-extensive.

Second, the role of technology in promoting the shrinkage, variety and sophistication of drones means that their impact on organized violence is bound to be considerable. One of the most popular smaller drones is the Raven, a remote controlled three-foot-long plane designed for the US military. Used extensively in battlefields across Afghanistan, the Raven has been widely adopted by defence departments throughout the world. Newer micro-drones have become so small that they resemble children's toys, and the names of such aerial vehicles – MicroBat, SLADF, and Black Widow – might have come straight from science fiction. One particularly intriguing development has been the compression of drones to such

tiny sizes that their functioning can now mimic insect flight. Drones recast in the shadow of a dragonfly or wasp, with the aim of getting up close and personal to enemies with tiny sensors and video cameras, has guided the direction of recent research developments. The arrival of various "parasite UAVs", such as the Wasp and Wing-store UAV, are creating "the most sensitive installations for processing, exploiting and disseminating a tsunami of information from a global network of flying sensors" (Bumiller and Shankerjune 2011). This is rightly considered a tsunami of data because, whilst automatically operating algorithms process this information, there is simply too much big data - with defence and security forces now overloaded. Paradoxically military commanders now possess an AI-enabled and enhanced capability to oversee battlefields far more distributed, dynamic and diffuse than ever before, yet precisely because of the ways this enabling technology collates, analyses and fuses the data that constitutes this field of vision these commanders find their decision-making autonomy compromised (Freedberg 2018).

The advent of miniaturized, semi-autonomous weapons systems also becomes increasingly treated as the automated instrument of warfare. The result is a complex series of technologically based transmutations of the military parameters of modernity far beyond anything previously witnessed. In early 2017, for example, it was widely reported that the US military had successfully tested micro-drones as part of the future development of intelligent, autonomous weapons systems. Approximately 100 Perdix micro-drones were dropped from three F/A-18 Super Hornet fighter jets over California, and these remarkably small 16cm machines were able to swarm. According to a statement released by the Pentagon: "The micro-drones demonstrated advanced swarm behaviours such as collective decision-making, adaptive formation flying and self-healing" (US Defense 2017). Once constituted in this way, with each micro-drone able to communicate with the other micro-

drones, the UAVs operate as a kind of collective organism, swarming throughout designated environments without being monitored or attacked. These developments are in various ways quite decisively influenced by the expansion of AI, and the strategic military objective is to overwhelm the defence capabilities of opponents with the sheer numbers of micro-drones. In turn, through reconfiguring what is possible – and hence meaningful – in terms of relations of presence and absence, near and far, these developments influence the spatial intelligibility of war.

Finally, the spread of AI technology has led to the further expansion of weapons development in the form of "killer robots", or Lethal Autonomous Weapons Systems (LAWS). These are weapons mediated by AI which can autonomously select, target and strike (potential) enemies without any human intervention. There has been a massive global debate on weaponized AI and deadly autonomous weapons, with many scientists, industry leaders and agencies demanding a pre-emptive ban on such technology. Whilst there have been very significant levels of investment in the research and development of killer robots in the main centres of the arms industry (most notably in the USA and Europe), this has also been a development which has affected a growing number of nation-states as well as non-state actors. Russia, Israel and other advanced militaries are pursuing killer robot technology for weapons development. China, according to various reports, is exploring the use of AI weaponry for the production of its next generation of cruise missiles (McDonald 2016). In South Korea, an arms manufacturer has designed and built a gun turret which can identify, track and shoot targets, theoretically without the need for human intervention. Automatic military defensive systems, such as the German 'AMAP-ADS', the Russian 'Arena', and the Israeli 'Trophy', can autonomously identify and strike oncoming missiles, rockets, artillery fire, aircraft and surface vessels. The diffusion of automated weaponry from the advanced

societies to a growing number of other states has unfolded more recently, with many countries – and also non-state actors - seeking to join the LAWS race. At the World Economic Forum in 2016, Sir Roger Carr, the chairman of British weapons manufacturer BAE, stated that 40 countries are currently working on killer robot technology (Styles 2016). Whilst the application of the technological development of autonomous systems to the delivery of military weapons is only one aspect of a battery of technical advances in this area, the crucial point is that there is no agreed international relations framework specifying how these weapons might be used in times of armed conflict, and nor are there global governance mechanisms for the regulation and control of autonomous killer bots. In this context AI-enabled dataveillance and weaponry – especially when miniaturized and co-extensive with other everyday AI applications - is rewriting the mobilities of contemporary warfare. As Der Derian (2013: 575) argues, war is now taking on "a multispectral, densely entangled, phase-shifting character", one that defies "fixed definition (Syria: civil or international?), empirical verification (Yemen: open or secret?) and normal legal standing (drones: sub- or extra-judicial?)".

Conclusions

It is far from straightforward to detail conclusions to an article which aims to specify socio-technical changes that are still currently unfolding. What I have tried to suggest is that, if *mobilities 1.0* addresses complex systems and infrastructures of mobility, and *mobilities 2.0* emphasizes the interrelations between mobile systems and lifestyles, the emerging *mobilities 3.0* research programme focuses on the intricate interconnections between intelligent machines and digitalized subjects which are "on the move" in ever increasing mobile combinations. This demands a reworking of mobilities hitherto unthought of. In these partial

and provisional conclusions, therefore, I want to make two points, one sociological which addresses the transformed relation between subjects and systems, and one theoretical which addresses how human and nonhuman forces continually interweave in today's automated, atmospheric dynamics of mobilities and perennially shifting social interaction. These critical reflections are offered as constructive remarks towards a *mobilities 3.0* standpoint; these ideas, if they merit further attention, will need to be developed and incorporated into a more systematic theoretical account of automated mobilities.

First, *the mobilities paradigm must acknowledge, as it has not done previously, human-machine intersections as essentially involved in the production, reproduction and transformation of mobile social life*. I refer here, above all, to the complex ways new AI-enabled sociotechnical systems radically shift humans and machines around in spatial and temporal configurations and relative to one another. What we see occurring today is the redistributing, reconfiguring and remodeling of human-machine relations and their multiple feedback loops and indirect relations of cause and effect, which play out at different speeds and timescales. Reflecting upon extensive experience of engineering robotic technologies geared to extreme environments and relating these to current and pending deployments of AI in, among other things, vehicle systems, health care and education, Mindell (2015) has detailed various transformations of human-machine intersections arising in conjunction with automation. He writes, for example, of the emergence of new forms of experience as these systems enable both human and machine presence and co-presence to be distributed across space - at once physical, communicative and virtual, local and global - and as human-machine interaction capabilities deepen and become further mutually imbricated and coactive – "delicately switching in and out of automatic modes" (198). Intelligent machines are drawn upon by actors (both discursively and non-discursively) in the production of mobile social life, but at the same time are the media of new forms of distributed co-presence across time -

for example, with ongoing customer engagements with designers and programmers whose traces remain 'inside' machine systems, framing their operations for months or years. From a more critical vantage point, a focus on the reconfiguration of human-machine relationships allows for more nuanced views of the disruptive impacts of these new technologies, including the displacement of large numbers of people through microwork or crowdsourcing applications, social media or online video games to roles as indispensable system mediators, yet at the same time marginal, "hidden, poorly compensated, or uncompensated, and naturalized as part of what it means to be a "user" of digital technology" (Ekbia and Nardi 2017: 1). In making this move to take in intelligent machines in the reconfiguration of digitalized subjects, the relation between self and system, or agency and automation, is radically recomposed (see Elliott 2019).

Second, the sociology of mobilities must focus upon the *patterns of smart technology and automated infrastructures underlying physical or communicative interactions that orchestrate social, economic and political life*. Smart technologies, including both computational infrastructures and wearables, mark the new edge in our understanding of mobilities; social systems are beset and energized by the non-linear dynamics of smart objects interacting with each other, and whether human subjective judgement is involved or not. Smart technologies, powered by AI, increasingly comprise the basic frameworks that move "subjects" and "objects" within interaction or structures. Galloway and Thacker (2007: 25 -47), for example, capture how non-human objects shape, enable and interfere with networks engendered by new software. Building upon this insight, and drawing upon Simondon and Heidegger, Ash (2018: 36-48) contends that smart objects possess both intentionality and protentionality – that is, respectively, the ability to actively perturb other objects, and to await and respond to perturbations. Using the example of a range of existing mundane technologies – among them the Sun app, Nest Cam, Lumo Run, Drift Lightbulb and

the Dyson 360 Eye – Ash claims that through their capacity (and at times incapacity) to perturb one another, smart objects create different spatio-temporal logics of near and far, and now and then, thereby modulating the ways space and time become intelligible to both humans and other non-humans (65). While Ash concedes that this capacity of smart objects to shape intelligibility and organize human life through framing space-times can lend itself to a view of smart objects as instruments or agents of economic and political interests, he is also keen to point up the ways these technologies – in conjunction with human initiatory action – shape potentials for action in ways not anticipated nor controlled by their designers and manufacturers (38-39). Relations between smart objects are thus implicated in the production of social life as a kind of "technological unconscious" according to Thrift, at once underpinning and proliferating technology with the life world.

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