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Submission to journal *History and Technology*

Special issue: *Listening in combat - surveillance technologies beyond the visual in the First World War*

*Editorial Introduction* by Elizabeth Bruton<sup>1</sup> and Graeme Gooday<sup>2</sup>

The arts of combat have long motivated humans to extend the range of, and refine the capacities of, their senses. For centuries, innovations from both military and civilian origins have extended and enhanced those capacities in ever-escalating strategic efforts to secure crucial intelligence both to win battles and win new markets. Much is known about the visual technologies that co-evolved between civilian and military usage: the telescope in the seventeenth century, the observation balloon in the eighteenth century, and the submarine periscope in nineteenth century, extended to trench usage in the First World War.<sup>1</sup> These innovations helped either to extend the optical capacities of armies and navies beyond the conventional horizon, or to lessen the vulnerability of those obliged to scrutinize enemies at close hand.

Yet the sensory palette of combat has surely been broader than the visual faculty alone: while being the most easily and directly recorded, it was not necessarily the most important in all conflictual situations. The sense of smell (in sensing gas attacks) and of touch (in sensing approaching vehicles from the ground) have sometimes been essential in certain combat contexts.<sup>2</sup> The visual faculty could also be combined with that of hearing as epitomized in the electric telegraph, widely deployed in the American Civil War and the South African “Boer” wars: incoming messages in Morse code could be interpreted either by reading the dots and dashes on paper, or (more speedily) by hearing the sounds of those dots and dashes being made.<sup>3</sup>

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We focus here on the sense of hearing, its technological enhancements, and its interplay with other senses, thereby to explore the sensory interplay of vision and sound in extreme human combat situations. We argue that, both for those at the battle front and those remote from it, the significance of this increased significant of hearing in the early twentieth century cannot be understood without reference to the combat experiences and technological initiatives of the First World War. Our core claim is that the rise of listening cultures of various forms during and after the First World War owed much to the changing technologies, strategies and behaviours, cultivated in the context of military endeavours.

As an example of traditional view that passes over potentially significant aspects of the First World War context, Emily Thompson presents the rise of US cultures of sound-consciousness, interplaying with vision, in the first three decades of the twentieth century as exclusively a *civilian* phenomenon. In her 2004 article '*Wiring the World: Acoustical Engineers and the Empire of Sound in the Motion Picture Industry, 1927-1930*' she argues cogently for the role of the new breed of acoustical engineer in synchronizing sound and vision in early cinema; dating this plausibly back to Thomas Alva Edison's mixed success with the Kinetophone in 1913. A crucial part of her story is that the debut of triode vacuum tubes developed by Lee de Forest enabled him to unite sound and pictures in the Phonofilm Corporation. In her account the main story is dated from the Radio Corporation of America's 1919 merger of the radio-related resources of GE and Westinghouse to synchronize the recording of music and speech for delayed radio broadcast; although widely regarded as successful in that domain, this synchronization technique was not applied to motion pictures. For Thompson the expertise, the resources and the imperatives to cultivate technologies integrating sound into contemporary culture were purely internal to the cinematic industry. Passing quietly over the gap in her chronology from 1913 to 1919, she draws no inferences about whether the exigencies of the First World War influenced this development. Our authors point instead to how experiences of the First World War made some direct and indirect contribution to the growth

of the relevant skills and technologies across the spectrum of combat and civic cultures after hostilities had ceased.<sup>4</sup>

One helpful source to consider in understanding the new priority for the aural created by the demands of warfare is the autobiographical study '*Listening In*' by Ernest H. Hinrichs, a US civilian telephone engineer. This diary, edited by his son, documented Hinrich's bilingual (German-English) participation in the battlefields of First World War France from late 1917. As an experienced engineer assigned to listening stations near the German frontlines, he learned speedily how to intercept the enemy's telephonic and wireless communications by various techniques referred to as "listening in." More broadly during the war the new 'listening in' enterprise commenced by the US military in 1917, was cloaked in the same secrecy as the new "Black Chamber" crypto-analytic bureau developed concurrently. Back in the USA after the war his private Cable Code business did not last long, but Hinrichs' experience reflected a larger move in the US towards surveillance using electrical communications devices nurtured in the European battlefront.<sup>5</sup>

As we shall see, the USA was far from alone in cultivating both individual and national expertise in "listening in" to hostile – and indeed friendly – communications during the Great War. The First World War provided the opportunity for both combatant and non-combatant nations to develop large-scale surveillance operations using recent telecommunications innovations that long outlasted the exigencies of Great War combat. As we shall see in Marklund's essay below, even neutral Denmark exploited the strategic opportunity of monopolising Northern European international telecommunications to extend the listening ear of the state to an unprecedented and long-lasting extent.

This kind of theme has long been construed within the historiographical paradigm of 'dual usage': that some specific technologies such as the aeroplane, real-time computing and the internet, have

developed through mutually supporting deployments in both military and civilian domains. For the subject of telecommunications, Helge Kragh has argued that telephonic services in particular have evolved in both civilian and military contexts, with strong mutual interaction between these domains in the First World War period.<sup>6</sup> Such framing of “dual usage” claims rests, however, on the assumption of a clearly identifiable distinction between civilian and military domains: the viability of such an assumption is increasingly questionable. This is particularly significant given David Edgerton’s contention concerning the emergence of a “Warfare State” in the interwar period. On his account, such boundaries were structurally blurred and arguably erased, even if the military/civilian dichotomy was rhetorically sustained for certain propaganda purposes within the UK.<sup>7</sup>

Edgerton’s analysis does not, in fact, directly address issues of sound technology. Yet if his overarching thesis is correct, then one would naturally expect many technologies to evolve with all kinds of overlapping military and civilian purposes in the interwar period. Artefacts without usages in both contexts would on his account be the exception rather than the rule, thus undermining the rationale for picking out exceptional cases of “dual usage”. This theme is one that we emphasize throughout this essay in particular, and through the essays which follow, echoing Edgerton in seeing that sound cultures and technologies were shaped by both civilian and military technologies with often and increasingly unclear (arguably disappearing) boundaries between the two putative spheres.

This historiographical shift is mirrored in a recent move in historical sound studies to explore the reciprocal developments of aural forms of civilian and military technologies in a more fully integrated approach.<sup>8</sup> The arts of listening for the approach of remote or invisible combatants’ sources have long been a part of warfare; and since the advent of the telephone in the 1870s, the instantaneous listening to remote sources has become a major part of civilian life too. But the First World War brought longer-term changes to both the skills and technologies of listening in military

life that had longer-term consequences for non-combatants. This resulted from some distinctive aural features of the First World War noted by previous historians but not hitherto assembled into an over-arching argument about the shifting priorities epistemic and sensory cultures between vision and sound.

For our purposes of investigating technologies of sound, Edgerton is correct in not absolutely privileging the First World War in the development of the Warfare State since the use of aural telecommunication in direct combat had begun with the Russo-Japanese war of 1904-5.<sup>9</sup> The Japanese military stunned the world by using hi-tech modern armaments and naval vessels equipped with field communications via wireless and speech communication field telephony to speedily defeat the much larger Russian Army. That short war was widely publicised, not least because strategic use of the telephone enabled Japanese forces speedily to share verbal reports of movements by Russian combatants, but also after the war they were used swiftly to communicate their military victories to journalists.<sup>10</sup> Having been observed first-hand by military attachés and observers from all major powers, the communications techniques of the Russo-Japanese conflict (among other aspects) became a topic in the curricula of military colleges in the first decade of the twentieth century including those well-respected and influential military colleges in Britain, Germany, and elsewhere. Just two years after the war, a standard British civilian telephone training manual reported admiringly of the ‘clever use’ of the telephone by Japanese forces such that this device had arguably become an ‘indispensable adjunct to military warfare on a large scale’.<sup>11</sup> In response to this, by 1912 the British army had set up the specialist Army Signal Services as a subdivision of the Royal Engineer’s Signal Companies, to manage telephone and wireless communication systems within combat zones.<sup>12</sup>

While telephonic and wireless communications were thus not new in the First World War as a means of instantaneous communication in combat, the scale of their deployment was unprecedented

and massive during that combat.<sup>13</sup> We can see this, for example, in the extraordinary growth of the use of telephony when war broke out in 1914. For the case of the UK, which had seen the General Post Office complete nationalise the country's telephones three years earlier, domestic civilian telephones were taken over for military purposes, not least to deal with early warning communication of approaching Zeppelin attacks in 1915, and the coordination of resource mobilisations. By early 1916, use of the telephony had become universal in the military often with a 'kleptomaniac' appropriation of telephones, exchanges and accessories; the General Post Office soon expanded its supply system of newly manufactured telephones, with exchange systems introduced to handle the unprecedentedly large and ever-growing traffic of telephone calls.<sup>14</sup> Equally, industrial levels of wireless sets were manufactured during the war, both wireless telegraphy as well as radio telephony sets developed during the war and borrowed in the British case from the Marconi patented form. The later, more mobile style of warfare, in particular on the Western Front, increased demand for mobile communications especially wireless sets.

Thousands of combatants on active service used or witness the use of wireless sets, in particular the more accessible voice-based radio telephony, and this increased awareness of the possibilities of wireless communications as well as the accessibility and affordability of redundant wartime wireless equipment available in peacetime on the open market led to a significant interest in broadcast radio from Great War veterans, licensed wireless amateurs, and the general public alike. In 1922, the British radio amateur clubs along with their national representative, the Wireless Society of London, came together to form the Radio Society of Great Britain (RSGB).<sup>15</sup> In December of the same year, the British Broadcasting Company was formed to meet this new demand for broadcast radio. This experimental broadcast service was established by the General Post Office and six leading British wireless manufacturers including the Marconi Company and later became the British Broadcasting Corporation in 1926.<sup>16</sup>

In relation to telecommunications and armaments infrastructure the Great War was indeed the first international and multi-nation war to have access to and use of increasingly powerful and innovative weapons and technological systems, produced on a truly industrial scale. These systems dominated the domain and terrains of warfare in the Great War and had a literal impact on combat – on land, in the air, and at sea. Moreover two developments during the First World War did prompt new forms of telecommunications technologies that augment the sense of ‘listening’ devices beyond simply hearing the voice or signals Morse code. The usage of submarine and aircraft in warfare was completely new in 1914: neither of these had been deployed in the Russo-Japanese war as aeroplanes were but a year old at the outbreak of that conflict, and the Japanese fleet did not use the submarines they acquired near the end of that conflict.<sup>17</sup> As our contributors Judkins, and Bruton and Coleman show, the strategically effective use of these devices required non-visual surveillance of their combatants – ‘listening in’ via an extension of wireless techniques.

In the Great War, however, those who used the initially rather experimental forms of aeroplane and submarine soon found that for effective combat they needed new forms of surveillance, navigation and remote mobile communication under water and or through the air. Given the character of these technologies, there was no possible recourse to static cable systems and line-of-sight methods could only be used for the most basic of signals. Mobile wireless telegraph-based methods of communication and tracking were thus appropriate across large opaque spaces of air and water, rather more so than for static trench warfare. Moreover, counter-attacks against submarines and aeroplanes in turn required them to adopt further innovations in response, with a similar emphasis on wireless techniques and aural surveillance, as described in Phil Judkins’ paper ‘*Sound and Vision in Early UK Air Defence.*’ Hence our special issue dedicates some considerable attention to these new strategic-technological contexts with an eye to their larger cultural implications. In this regard, our focus on the development of wireless communications in the first quarter of the twentieth century is not just a conventional tale of increased scale of operations and ever greater take-up.

Rather it is about how wartime challenges prompted the creation of audible combat intelligence – an adoption and adaptation of wireless signalling technologies and techniques. This growth of auditory knowledge became a critical moment of reorientation that shaped, in a broad way, subsequent decades of technologies across the spectrum of military and civilian contexts.

### **1. Changing sensory epistemologies and the military experience.**

In this special issue dedicated to the development of telecommunications-related technology for non-visual surveillance in the First World War and its aftermath, we focus on how various enhanced forms of telecommunications-related “listening” technologies aided and superseded equivalent visual technologies. These became of critical life-saving significance and remained so after the war, with distinctive implications for the interrelated domains of military and civilian life, creating new opportunities, skills, listening aptitudes and new infrastructure that outlasted the First World War. Our aurally-oriented approach to the history of technology, especially in mapping human interactions (conflictual and otherwise) is grounded on the historical and sociological scholarship of sound studies that investigates the co-construction of aural technologies. Our starting point is the breadth of scholarship represented in two works that are already classics: Emily Thompson’s ‘*Soundscapes of Modernity: Architectural Acoustics and the Culture of Listening in America, 1900-1933*’ (2004), already mentioned, and ‘*The Oxford Handbook to Sound Studies*’ (2011) assembled by Trevor Pinch and Karin Bijsterveld to capture the broader state of the art.<sup>18</sup> We address particularly what Daniel Morat has recently labelled “auditory culture” to characterize new kinds of human aural experience at the important intersections of entertainment and communications, both in civilian and military contexts.<sup>19</sup> Our volume goes further still by locating the impetus for the shift from ocular to aural knowledge in First World War innovation within the combat zones of trench, sea and air – spurred by the epistemological contingencies of engaging in a spiral of ever more technologically sophisticated bilateral conflict. Our argument is thus about the new wartime scale

of aural endeavours and the embedding of this interest in key infrastructures during and after the war. One question is how, in particular, the First World War experience interacted with radio and telephony as cultural experiences with regard to the new audio and electro-acoustic landscape that Emily Thompson has identified in ever greater expectations of combined aural and visual technologies in the interwar period. As indicated above, the sheer number of users of telephones and radio (as well as those who witnessed their use), in combination with the mid-war battlefield introduction of improved valve amplification on an industrial scale created a new widespread expectation of high-quality sound, especially among those who had served in the war.<sup>20</sup>

Our argument is not simply that the technologies of communication changed in response to warfare. Rather, the sensibilities and survival strategies of those in combat grew increasingly oriented to sound as a matter of practical necessity, quite independently of other technological considerations. Our interest is in this specific symbiosis. As Robert Graves pointed out in his autobiography *'Goodbye to All That'*, in First World War trench warfare the mastery of aural knowledge had a greater life-saving potential than deployment of traditional visual skills alone.<sup>21</sup> It was common knowledge then that listening out for the movements of soldiers and weapons was safer than looking inquisitively over a trench – to become a target for gunfire. But there was more to it than that. As a Great War survivor of many overhead attacks involving diverse incoming high speed missiles, Graves noted dryly that the nature of the ballistic threat was audible to acclimatized ears long before it became visible. When the characteristic signature wail of most airborne ordnance was first heard, evasive action could be taken to leap out of the way of more deadly missiles: but by the time the most lethal flying shell was visible, there was no escape. David Hendy has thus observed that First World War trench combat focussed attentions on how day-to-day life often hinged on the sensitive differentiations of auditory skills refined by hazardous experience.<sup>22</sup> And this would connect to the new kinds of emerging technologies as we shall explain below.

Far away from the trenches, another story was unfolding in the so-called Great War: new weapons of submarine and airship operated, respectively, at depths or heights far out of sight from conventional visual scrutiny. Adaptations of wireless telegraphy were thus developed to “listen” for the remote operations of these controversially stealthy vessels of destruction by intercepting their communications or otherwise tracking their motions. And further still from trenches or air/sea attacks, but connected to them, the Great War had implications even for civilian forms of non-visual communication. Transnational suspicions about critical intelligence being illicitly communicated by telegraph and (especially) telephone led to new forms of discreet state communications surveillance that survived long after the end of the Great War. So following Hendy’s observation, we ask: what are the implications of such an epistemic shift in the nature of warfare for the multi-purpose technologies of surveillance, interception and counter-attack?<sup>23</sup>

Overall, our argument is that the activities of military and state personnel were ever more challenged and severely limited by any simple visual approach to watching their targets. As mentioned above in the case of Robert Graves, visual methods were simply not of sufficient speed to secure information in time to act upon it effectively in a new world of combat and temporality with increasingly powerful and near real-time forms of weaponry from above and below and on land, in air, and at sea. So instead they refined their techniques for “listening in” to facilitate their own safer communications and manoeuvres. We specify here 'limited by visual capacity' with the newer and more experimental aural technologies being complementary to older and more reliable visual traditions – the old and the new working used in parallel, as required. For example, while the periscope was a well-established technology and, as such, remained a key technology during and after the Great War both in trench and submarine combat, it was not useful for long-range tracking and had limited use and application in severe weather conditions and in relation to fast-moving objects.<sup>24</sup> Instead, sound-based technologies were required to enable closer to real-time surveillance than was possible with visual methods. A new sense of temporality was thus created

resulting in further time to respond to near real-time intelligence and attack.

In contrast, sound recordings – which were in embryonic form throughout the war so not generally used for surveillance – provided an opportunity to store sound-based intelligence and surveillance content so as to perform more in-depth analysis and decoding. Examples included certain aspects of signals intelligence in which Morse code was recorded and decoded and deciphered at a later time. This was not so applicable to voice recordings with the exception of long-distance experimental wireless telephony signals transmitted by AT&T in conjunction with the US Army and Navy across the Atlantic from Arlington to the Eiffel Tower in Paris from 1915 onwards, prior to US entry into the war. However, all evidence suggests these were for communication purposes rather than surveillance and that these transmissions were experimental rather than practical in execution. Nonetheless, the transmissions were an indicative of the “Preparedness” movement being conducted in the United States at this early stage of the war whereby US scientists and industry engaged in scaled-up mass production and research and development which enabled the US to enter the war prepared in April 1917. Further to this, this movement was indicator of the heightened understanding of the importance of scientific, industrial, and technological research and development in warfare including developments in the electro-acoustic sphere.

As the first truly industrial global conflict, combatants in the First World War had access to increasingly powerful, sophisticated and long-range technologies which required moving beyond the (limited) visual range to enhanced forms of listening. Thus, our four interlocking papers offer both international and interdisciplinary historical perspectives on a facet of telecommunications history not previously addressed in an international survey. Three of these were presented in various forms at a workshop organized as part of the project “Innovating in Combat: Telecommunications and intellectual property in the First World War” at the University of Leeds and held at the University of Oxford in January 2014, and thus have an organic unity arising from the shared

conversation and critique at that workshop.<sup>25</sup> What our contributors have to say on our key themes is a matter to which we shall return shortly.

## **2. Surveillance techniques beyond the Panopticon**

By looking at the First World War in terms of acoustic surveillance and its extension into non-visual forms of telecommunications, our contributors confront the limitations of a vision-centred approach to technological power and innovative new forms of telecommunication and interception. In examining how warfare stimulated the human-technological nexus to create new non-visual technique, we are explicitly moving away from a long-held Foucauldian pre-occupation with the visual. Three decades after his death, much history of technology (and indeed much other history) maintains Michel Foucault's emphasis on the ocular elements of technologically-mediated power, especially – although not exclusively – in institutions of medicine and incarceration. We can see this in his preoccupation with the disembodied “gaze” of power in *Discipline and Punish*; it is most explicit in the “The Eye of Power” where he discusses how the maintenance of institutional order via the Panopticon required rendering visible all covert “deviant” behaviour.<sup>26</sup>

Nevertheless, the general access of mass audio-visual media has (allegedly) replaced the Panopticon with the symmetrically operating Synopticon through which many can monitor at least some of what is happening around them.<sup>27</sup> Indeed few scholars now would overtly focus on vision in discussing the significance of Foucault's discussion of power-technology relations. For example, Michael Behrent's recent examination of Foucault's ambivalent concern with the structures of power in which technologies have been embedded does not mention the visual at all.<sup>28</sup> On the contrary it now seems more appropriate to focus on the (infrequent) mentions of the powerful *listener* in Foucault's work. As feminist theorist and literary critic Fran Bartkowski has suggested, Foucault seemingly alludes to the secret power of the silent ear in his *History of Sexuality*: “only those listening are heard”.<sup>29</sup> But a question remains: can this kind of observation on peacetime

social order be extended to more conflictual situations in which each side was relentlessly listening to the other while attempting counter-operations to prevent the same being done in return?

If we focus on the operation of the ear at least as much as the eye in technological engagements, what kind of fresh insights can be gained about technological manifestations of power and its operation? The broad implications of that enquiry go beyond the scope of this volume, so we will dedicate our discussions to the particular period of the First World War as a transformative ‘moment’ in understanding this transition.<sup>30</sup> We can now see that Foucault’s analysis was concerned primarily with the relatively static technological ordering of civic society during peacetime. He thus did not explore the role of warfare in transforming the technology-power nexus into different bodily epistemic mode, as we see in Axel Volmar’s outstanding paper on German auditory cultures in the First World War and their aftermath.<sup>31</sup> The orderliness of the Foucauldian *episteme* is only really sustainable in peacetime – if even then. So we follow Volmar investigating the chaos of warfare in which so many new technologies were created and subversively used to evade the scrutiny of the enemy gaze in an interactive cycle of escalating sophistication in counter-strategic methods.

Volmar’s approach highlights the way that it was not only the Second World War and Cold War that generated innovations in information technologies of computing and networking, that could be used across the entwined spectrum of military and civilian contexts. To this we would add new modes of electro-acoustic/telecommunications that transformed everyday life during and immediately after the First World War.<sup>32</sup> The novelty is that the history of wireless and telephony have not been analysed collectively from this point of view. With the exception of Helge Kragh’s work, histories of civilian developments in the use of telecoms rarely mention any military context and vice versa.<sup>33</sup> One thus might see that part of the pre-history of the Cold War-born internet has its roots in the intensive communications infrastructures borne out of the combat-intelligence

demands of the Great War.

While bringing a new integrated emphasis to the aural in the historiography of the dual-use paradigm as discussed above, we also follow another trend in the historiography of the First World War. Traditionally, scholarship on science and technology in the First World War has focussed on personal, technical, and operational narratives and was generally authored by or based upon accounts by active practitioners and participants. While those narratives provided an operational and historical context of the war of *materiel*, more recent scholarship has offered fresh insight into the development of military technologies as an enterprise not just of individualist endeavour but also of *industrial-scale* engineering during the First World War. Recent scholarship has argued that the First World War was won by a technocracy of industrial production, logistics and supplies managed by phalanxes of skilled engineers and bureaucrats – at least as much as it was won by traditional military tactics.<sup>34</sup> A similarly important innovation of scale was the mass production of radio sets during the First World War, especially to enable the mass mobility of advancing Allied troops in the last year of combat; this self-same development continued after the war to enable the mass development of radio broadcasting to domestic radio owners.<sup>35</sup>

This newer scholarship remains centred, however, upon the application of mass-production methods and the influence of industrialism and related scientific research upon these lethal weapons technologies and platforms. In this special thematic issue, we wish to broaden still further this broad historiographical frame of industrialised warfare to consider the domain of telecommunications, and particularly the innovative sensory aspects of telecommunication in the contingencies of combat. Without understanding how participants in combat shaped new telecommunications-based “listening” devices in response to an ever-escalating challenge from enemy, we cannot understand how such devices became the subjects of mass-production as outlined above. So our volume would emphasise instead how much new communications technology was

the result of innovation across and sometime between scientific, military, and industry attempting to meet these varying and evolving and sometimes competing needs.

This volume thus look particularly at extended modes of “listening” using electrical “wireless” technologies of that were still relatively young when the First World War began.<sup>36</sup> We consider experiences that went beyond the conventionally visual of how matters of life and death were planned, managed and mitigated during and after warfare, using telecommunications- related devices. Our contributors thus explore within a broad historiographical frame, what the stakes were in tactical/strategic knowledge of how sound, knowledge of sounds, and indeed the absence of sound (the latter sometimes indicating an imminent attack) could be used to plan for further cycles technological engagement with combatants. In focusing especially on how technologically-enhanced forms of listening and listening in – rather than of seeing – became critical during the First World War we suggest that in this war the aural/acoustic landscape technologically extended in unprecedented ways the physicality and meaning of human listening.

Further, we argue in the vein of Morat, Volmar *et al.* that this was not merely a fleeting phenomenon of war, but brought permanent changes of (to?) the auditory landscape after the First World War. The authors in this volume show that this new emphasis remained after the conflict had ceased: the world of both public radio and secret telephonic surveillance was firmly established during the interwar period. We thus offer a chance to re-engage with First World War command, operations, and technologies, to move away from popular fascination and engagement with trench warfare to a broader, more international consideration of the auditory core of this conflict and to show how the development of listening technologies were profoundly significant for the course, outcome, and aftermath of the war.

Naturally in all of this discussion we want to keep in view that the civilian and military

developments in communications were not independent – any more than visual and aural technologies operated in separate domains. Just as cinema came to embody sound in its visual operations by the 1930s, so did aural technologies from telecommunications broaden the sensory spectrum of military epistemology a decade earlier.<sup>37</sup> Overall our approach to analyzing extended modes of listening epitomizes the cumulative integration of the senses in modern technologies and thus in correlated developments in modern psychology too. As reviewers of this issue have helpfully pointed out to us, just as military and civilian activities are no longer fully separable (if they ever were before), so we can see that the sensorium of sound and sight were not siloed separate senses: they co-evolved and complemented each other.

### **3. Overview of the special issue**

All of the essays in this collection focus on Europe as a theatre of war, including the role of strategic neutrality. The first article by Phil Judkins considers how sound-based technologies were used in British air defense, particularly on the Home Front, during the First World War. Judkins' paper examines two key listening technologies, wireless interception and sound locators, with the operational outcome of these parallel, intersecting, and complementary technologies being an early warning system used to defend the British Home Front against German air attack, the world's first integrated air defense system. This practical system operated independently of alternative, more limited visual systems and provided a foundation for similar air defense systems used by the Fighter Command of the British Royal Air Force in World War Two.

Our second article by Bruton and Coleman moves into the naval sphere, considering how the rise of large-scale submarine warfare in the First World War prompted new technological counter-initiatives. Specifically the increased threat of German U-boats to Britain's Royal Navy led to a concentrated campaign of scientific and technical research and development on how to intercept and locate the German submarines. This led to a close alliance of British military, industrial, and

scientific communities to produce electro-acoustic technologies capable of combatting this immense threat. Bruton and Coleman offer a brief comparison with equivalent (or not) methodologies and systems developed by France and Germany in order to explore the varying degrees of success and necessity in developing maritime electro-acoustic systems by these combatants. Although mostly overlooked in favor of visual modes of maritime surveillance, in particular aircraft spotting, the wartime developments in electro-acoustic technologies led to a paradigm shift in the epistemology of naval warfare, with a permanent change from enhanced vision to enhanced hearing.

Continuing the theme of research being used to meet wartime technological needs but with a more international perspective, Schirmacher's paper examines the complex and evolving relationship between science and the military during the development of listening technologies by British, French and German combatants during the First World War with these technologies being used to combat increasingly powerful ballistics and artillery on the Western Front. Schirmacher considers how land-based combat changed from the visual to the audio with an increasing selection of audio-based surveillance technologies being made available, in part to combat the physical limitations of the human ear in the battlefield space.

Our final paper by Marklund examines the so-called "Danish loophole" which came to define neutral Denmark's telecommunications surveillance policy during the First World War. State-sponsored censorship first used to observe and monitor telegraphic traffic could be easily bypassed by using the telephone lines linking Denmark to Sweden and Norway. The solution, argues Marklund, was both political and technological: increased collaboration and communication between the Scandinavian countries in terms of telecommunications monitoring and censorship as well as mostly unsuccessful attempts to develop electro-acoustic systems and technologies capable of controlling and surveying the Scandinavian telephone network both during the Great War, and long after it ended.

Together, these papers offer a re-engagement with the traditional notion of war as a crucible for technological, cultural, social, and medical change, by focusing attention away from the visual towards technologically enhanced means of listening and increased audio surveillance which continues to the present day. An extrapolation of our treatment of sound and listening in World War I in British, German and Danish contexts points toward a scholarly agenda of understanding more fully the enormous deployment of listening devices – of acoustic and electromagnetic forms – in the interwar period, the Second World War, and its elaboration in the Cold War.

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<sup>1</sup> Biagioli, *Galileo's instruments of credit* and Crouch, *Lighter Than Air*. There is no modern scholarly study of the history of the periscope, but there is an informative historical study of the marine periscope in context from the First World War: Hoar, *The Submarine Torpedo Boat*.

<sup>2</sup> Haber, *The poisonous cloud* and Hartcup, *The war of invention*.

<sup>3</sup> For early military deployment of the telegraph see Beauchamp, *A History of Telegraphy*, 102-32

<sup>4</sup> Thompson, ‘Wiring the World’ especially 194-95.

<sup>5</sup> Hinrichs and Hinrichs, *Listening In*; Yardley, *The American Black Chamber*; Beesly, *Room 40*; and Sheffy, *British Military Intelligence*, 184-262.

<sup>6</sup> Kragh, ‘Telephone technology and its interactions with sciences and the military, c.1900-1930.’

<sup>7</sup> Edgerton, *Warfare state*.

<sup>8</sup> See Morat (ed.), *Sounds of Modern History*, especially the essays on the German context by Morat and Volmar.

<sup>9</sup> The Russo-Japanese war has sometimes been referred to as “World War Zero” due to its retrospectively construed role as a key precursor to World War One. See Wolff et al., *World War Zero* and Steinberg, “Was Russo-Japanese War World War Zero?”. For a discussion of wireless’s early usage in the South African Wars see Satia, “War, Wireless, and Empire.”

<sup>10</sup> This was the first war in which the journalists of the London *Times* published reports of battle outcomes received via wireless telegraphy. These were sent by war correspondent Lionel James for a month until charges of espionage by Russian combatants and Japanese forces forced James to return to more traditional methods of war reporting. For a contemporary account by a London *Times* special correspondent, see Fraser, *A modern campaign*; for a more recent account, see Slattery, *Reporting the Russo-Japanese War*.

<sup>11</sup> Poole, *The practical telephone handbook*, 497; Gooday, ‘Combative Patenting’; and Lord and Watson, *The Royal Corps of Signals*, 17–19.

<sup>12</sup> The traditional view that British military officers were hostile to the telephone before the Great War has been challenged in Hall, ‘The ‘Life-Blood’ of Command?’. The extent to which other nations followed suit is a matter needing further research

<sup>13</sup> See BT Archives POST 30/4304A Sir William Slingo’s report on work during the First World War (1919), in particular sections on Home Defence, Radio-Telegraphy, and Engineering Work: Telephones and Radio-Telegraphy.

<sup>14</sup> Nalder, *The Royal Corps of Signals* and Priestley, *The signal service in the European War*. This is discussed in detail in Subramanian and Gooday, “British telecommunications history in the First World War.”

<sup>15</sup> See Richards, *Centenary* for a history of the first 100 years of national amateur radio community in Britain beginning with the establishment of the Wireless Society of London (the precursor to the RSGB) in 1913.

<sup>16</sup> Gooday, ‘Combative Patenting’, 255-56; Crisell, *Understanding Radio*, 19-20. See also Hugill, *Global Communications Since 1844*.

<sup>17</sup> Devereux, *Messenger Gods of Battle*.

<sup>18</sup> Thompson, *Soundscape of Modernity: Architectural Acoustics and the Culture of Listening in America, 1900-1933* and Pinch and Bijsterveld (eds.), *Oxford Handbook to Sound Studies*

<sup>19</sup> See editorial introduction to Morat (ed.), *Sounds of Modern History*, 3-4.

<sup>20</sup> We cannot take up this comparative issue in depth, but this is an issue that can be pursued further in a broader elaboration of our thesis.

<sup>21</sup> Graves, *Goodbye to All That*.

<sup>22</sup> See discussion of Graves, *Goodbye to All That* in Hendy, *Human History of Sound*.

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<sup>23</sup> We embrace here both innovation involving epistemic shifts both from the battlefield and the laboratory. For a case of the former see Gooday's study of the Fullerphone's origins in Gooday, 'Combative Patenting'.

<sup>24</sup> For trench use of the periscope see, Hinrichs and Hinrichs (ed.), *Listening In*, 23-24

<sup>25</sup> The "Innovating in Combat" project (Principal Investigator, Graeme Gooday) was funded by the UK's Arts and Humanities Research Council, with project blog and website by project postdoctoral researcher Elizabeth Bruton at <http://blogs.mhs.ox.ac.uk/innovatingincombat/>

<sup>26</sup> Foucault, *Discipline and Punish* and Foucault, 'The Eye of Power.'

<sup>27</sup> Bogard, *The Simulation of Surveillance*; Mathiesen, 'The viewer society.'; and Boyne, 'Post-Panopticism.' Particularly influential for this collection is Zbikowski 'Listening ear.'

<sup>28</sup> Behrent, "Foucault and Technology."

<sup>29</sup> Bartkowski, "Power and Resistance."

<sup>30</sup> For a discussion of sound-ranging as a transformative battlefield technology of the First World War, see MacLeod, 'Sight and Sound.'

<sup>31</sup> Volmar, 'In Storms of Steel.' Volmar was one of the original participants in the Oxford 2014 workshop which inspired this special issue.

<sup>32</sup> Campbell-Kelly and Aspray, *Computer*; see also Evan and Hays, 'Dual-Use Technology.'

<sup>33</sup> Kragh, 'Telephone technology and its interactions with sciences and the military, c.1900-1930.'

<sup>34</sup> Thompson, 'Mud, Blood, and Wood'; Phillips, 'Early Experiments in Civil-Military Cooperation'; and Phillips, *Managing Armageddon*.

<sup>35</sup> Gooday and Arapostathis, 'Electrical technoscience and physics'; Gooday, 'Combative Patenting'; and Andrews, *Domesticating the Airwaves*.

<sup>36</sup> For the pre-World War One development of wireless telegraphy see chapter 6 of Arapostathis and Gooday, *Patently Contestable*, pp.141-74.

<sup>37</sup> Chanan, *The Dream That Kicks*.