

Sonic presence and spectral technology

Kevin Walker

Royal College of Art

Oliver Smith

London College of Communication

Francesco Tacchini

Ravensbourne College of Design and Communication

Abstract

We describe a series of artistic research experiments, each investigating and illustrating aspects of presence phenomena. In each, we utilise digital technologies to invert the prevailing academic approach to presence, with the intention not to teleport a person to another place but to draw attention to unseen phenomena in the here and now, specifically through sound. Our work is grounded in theories of experience, mediation and context, and we follow a methodology merging design practice with computational thinking.

Introduction

A mysterious black sphere hovers slowly past, emitting the sound of a conversation you may have just heard a block away. A small concrete cylinder with a black antenna discharges a steady stream of static. A golden circuit board comes to life with flashing lights and a high-pitched squeal that kills your mobile phone. At an altar adorned with mystical objects and symbols, you summon a rumbling sound from the ground.

These are products of artistic research investigating unseen forces, created by us in order to evoke the presence of remote others who may or may not be human, and may or may not have malicious intent. Our aim is to invert the prevailing academic approach to presence, with the intention not to teleport a person to another place but to draw attention to unseen phenomena in the here and now, specifically through mediation by sound and technology in particular contexts. Drawing from traditional definitions of presence, our work is situated not in virtual reality but in a physical reality which is made unknown through a mix of analog and digital, fact and fiction, with a particular emphasis on sound as an evocative medium. Our research questions are: What balance of objective (technological) and subjective (mystical) characteristics of technology-mediated experiences can evoke unseen presences? What specific mechanisms of sound as a stimulus can evoke unseen presences?

Through the four case study projects described in this paper, we detail a process for creating objects and experiences designed to evoke unseen presences by variously showing or hiding the mediating technology. By linking notions of presence with theories of context, mediation and experience, our aim is to further develop a conceptual model which underlies our work, informing design and analysis. We first discuss the theoretical grounding in relation to presence theory, then our methodology. The case studies then described are grounded in, and used in turn to inform, the theory we detail, and we conclude this paper with a discussion of the broader implications and future directions.

Theoretical grounding

The term *presence* in general usage denotes the state of simply being present, and in special cases, something which is present but is not seen (Oxford English Dictionary); the term is thus used as a verb (when something is present), or as a noun (when ‘a presence’ is perceived). *Telepresence* emerged as a research area

in the 1990s with the rise of virtual reality (VR) and related technologies, evaluating techniques and implications for transporting people virtually from one place to another, with particular emphasis on instances when the mediating technology is seen to disappear or become 'transparent' in favour of the virtual, embodied experience. Due to the glut of overlapping definitions of presence that have arisen since, Lombard and Jones (2006) introduced a framework for defining presence, emphasising the role and perception of technology, and the nature and specific aspects of the phenomena and stimuli under consideration. This framework helps to formulate specific research questions, in our case with regard to unseen presences which may be regarded as a balance between being objectively grounded in technological mediation, and subjectively perceived as mystical or otherwise inexplicable; specifically, we investigate human-created versus autonomous aspects of technology-mediated presences.

Presence v. omnipresence

In computer science, presence research has paralleled the emergence of embedded or ubiquitous computing (Weiser, 1991) and of mobile technologies. Thanks to ample research funding and commercial development, both areas have progressed such that we can say with certainty that particular types of presence have been achieved, at least in the urban, developed world. Computing and sensing systems, whether miniaturised or distributed at planetary scale, have become woven into nearly every aspect of commerce, governance, security and social interaction, via optical fibre underground and wireless signals overhead, such that these technologies have become omnipresent but invisible. Simultaneously at the human interface, mobile devices have become equally pervasive, and with multimedia communication software and social networking services, have indeed given their users a sense of presence, whether of transporting oneself somewhere else through video calling, experiencing some other place through media or game environments, or in terms of having an alternate presence on social media.

Back in the real world, however, both phenomena have had important political and social implications. The pervasiveness and invisibility of computing and sensing systems has enabled mass surveillance by governmental and commercial organisations. According to Ekbja and Nardi (2015) in an important article highlighting the political aspects of human-computer interaction (HCI), "The dispersal of small, ubiquitous moments of control is implemented through digital technologies, subtly affecting individuals through techniques of isolation" (*Ibid.*, p.49).

The ubiquity of mobile devices has meanwhile prompted equally widespread dissociation and split attention between one's online presence and embodied experience (Walker, Applin & Fisher, 2012). "The everyday spectacle of people ensconced in their own worlds, earbuds in place, making eye contact only with their smartphones is scarcely remarked on" according to Ekbia and Nardi (2015, p.49). Gergen (2002) terms the wilful ignorance of co-present others when on the phone as 'absent presence' (Gergen 2002, p. 227). If we extrapolate current trends toward increasing miniaturisation and disappearance of technology, these two trends are likely to merge as mobile phones give way to wearable and implanted technologies, linked to increasingly hidden distributed computing and sensing systems.

Amidst the omnipresence of embedded and mobile technologies, we therefore aim to shift focus away from telepresence and back to presence in its original definition, making device users aware of being present in objective reality, and making present the hidden systems underlying digital infrastructure.

Context

Our work is premised on the notion that people make meanings within particular contexts. Cole (1996) has made a distinction between context as "that which surrounds us" (physical context) and "that which weaves us together" (social context). Dourish (2004) has also argued for consideration of the social as well as physical context. Falk and Dierking (2008) add a third dimension of the personal context – the sum of an individual's prior knowledge, interests and beliefs as well as motivations and expectations, choice and control – and contend that meaning is made in the overlap of the personal, physical and socio-cultural contexts.

Nardi (1995) contends that activity theory is best suited for investigating context with regard to digital technologies, and has promoted its use within the HCI community (Kaptelinin and Nardi 2012, 2006). Pierroux (2006) has utilised activity theory to challenge Falk and Dierking's contextual model, arguing that separating context into personal, physical and social dimensions perpetuates a focus on the mere assimilation of information by an individual, treating context as an external, quantifiable variable. She proposes that meaning making does not happen *in* context; rather, context is an integral part of meaning making. Social interaction is generally regarded as significant in many contemporary approaches, she says, but how or why often goes unasked and is under-theorised.

Kaptelinin (2008) also believes that while Falk and Dierking's contextual model richly describes meaning making environments, it is not adequately suited to the design and analysis of digital technologies, due to its focus on large-scale contexts. He argues for the notion of 'activity contexts' which apply to human subjects and the objects of their attention. Walker (2010) synthesised these two approaches – the contextual model of Falk and Dierking, and the notion of activity contexts – into a coherent model for analysing, and designing for, meaning making in context(s), adding the dimension of mediation, which is discussed next. We use Walker's contextual model to ground the design work in our artistic research.

Mediation

Activity theory regards tools as mediating human actions and interactions in the world, differentiating physical from cognitive tools, and analysing an entire 'activity system' which includes people and the context of use (Vygotsky, 1978). Säljö (1996) regards meaning making as directly related to the appropriation and use of tools. Therefore, designing for appropriation requires that both the context and the motivation of tool use must be made relevant to device users. Kaptelinin and Nardi (2006) and others have applied activity theory to investigate a wide range of mediating technologies.

Being grounded in psychology, activity theory is focused on individual meaning making, albeit within a socio-cultural context. A broader conceptualisation of relations between tools and users is used in Actor-Network Theory (ANT), as developed by Latour (2005) and others. ANT views material and semiotic resources in a network of relationships in which both human actors and things are accorded agency. ANT contains a notion of 'mediators,' referring to things and concepts which mediate large-scale social processes, not specific tools which mediate intentional activities oriented toward goals and products, as in activity theory. ANT is thus oriented toward broader sociological study of widespread phenomena. While it has previously come under criticism for assigning agency to nonhuman objects, along with Object Oriented Ontology (Harman, 2010), ANT is seeing a resurgence of interest in de-centering the human, according to Anderson (2014), as artificial intelligence, robotics and the 'Internet of Things' experience rapid growth.

Verbeek (2015) uses ANT to ground his theory of mediation, which he applies to Human-Computer Interaction (HCI). He describes particular types of relations people have to technology. For example, technologies can be embodied, forming a unity with their human user which is directed outward toward the world (i.e. speaking through the phone to someone else); or conversely, technologies can be embedded in the

environment, actively detecting and interacting with humans. In ‘alterity relations,’ humans engage and interact directly and consciously with technologies, with perception of the world fading into the background; this can be said to be opposed to presence, as it brings the mediating technology to the fore. ‘Background relations’ are when technologies form an unconscious context to human relations – not directly mediating communication as in presence, but in the form of infrastructure, unnoticed visual and audio presences that we do not notice in our everyday experiences.

Verbeek then discusses four different points of contact between people and mediating technologies, drawing from Dorrestijn (2014) and related to human embodiment and cognition. ‘To the hand’ refers to direct physical engagement, and in fact equates to the etymology of the word ‘presence,’ from the Latin *praesentia*, ‘being at hand’. Mobile devices are the most obvious example – according to Lasen (2005), “Mobile phones are not only an extension of the owner’s presence, but they also allow the virtual presence of those linked to us by the phone” (Lasen 2005, p.X).

The contact point Verbeek terms ‘before the eye’ refers to how we engage with information conveyed by technology, and here we might include other senses including sound conveyed through, for example sonification of data, or vibration when used for notification. ‘Behind the back’ denotes how technologies in the material infrastructure, such as embedded sensing and computing technologies referred to above, influence our actions and experiences; for example when wireless connectivity affects our movements or behaviour. Finally, ‘above the head’ refers to “the role technology plays in our thinking (like having utopian or rather dystopian expectations of the social impact of technology” (Verbeek 2015, p.30).

Verbeek poses particular types of influence that technologies have on people when they relate to them through the above types of contact. These are visibility (hidden v. apparent) and force (strong v. weak), and various technologies can be characterised in a matrix of these two. For example, ‘coercive’ technologies are both apparent and strong, while ‘persuasive’ ones are apparent but weak in their influence. ‘Seductive’ technologies are hidden and weak, and ‘decisive’ technologies are hidden but strong in influence; both are the domain of what is called behavioural or ‘nudge’ design. Visibility is most directly related to presence, in terms of the degree to which a user is aware of the mediating effects and force of a particular technology. This applies to whether presence refers to telepresence, the perceived presence of someone else in the user’s proximity, or the presence (real or perceived) of a particular technology in the user’s proximate awareness.

Verbeek's dimensions of influence bring us back to political aspects of mediation and presence, which Verbeek is well aware of: "This makes the design of technologies a highly responsible activity. Designing technology is designing humanity, in a sense" (*Ibid.*).

Experience

Taking a critical perspective in the context of communication design, our interest is in engaging with the social and political implications of presence identified above. For us, presence, context and mediation all come together in the over-arching concept of experience, going beyond mere interaction. This implies shifting focus away from the screen, object or product and to the content being communicated, the context(s) in which the work is situated, and the key artistic or design concept through which communication takes place.

Dewey (1934) differentiates between *experience* as one's lived memories (what Falk and Dierking term the personal context), versus *an experience* which is a concentrated event bounded in time, involving an interaction between a creature and its environment. "Under conditions of resistance and conflict, aspects and elements of the self and the world that are implicated in this interaction qualify experience with emotions and ideas so that conscious intent emerges" (Dewey 1934, p.205). Such experiences, as "situations and episodes," have their own inherent rhythm and history which is separate from the overall flow of life experience.

This bears some resemblance to states of 'flow' identified by Csikszentmihalyi (2002), while Dewey states, "In an experience, flow is from something to something" (Dewey 1934, p.206). This also relates back to Falk and Dierking's (2008) notion of an individual's personal context, and thereby to the broader notion of lived experience, for as Dewey says, "experience becomes conscious, a matter of perception, only when the meanings enter it are derived from prior experiences" (Dewey 1934, p.218). Importantly for our purposes, he continues:

Imagination is the only gateway through which these meanings can find their way into a present interaction.... Interaction of a living being with an environment is found in vegetative and animal life. But the experience enacted is human and conscious only as that which is given here and now is extended by meanings and values drawn from what is absent in fact and present only imaginatively. (*Ibid.*).

Dewey therefore effectively links presence in a spatial sense with the temporal present – the here and now and linked to the real and the imagined.

In summary, our theoretical grounding links contemporary notions of presence to the pervasiveness of embedded and mobile technologies and their social and political implications, shifting our focus to traditional definitions of presence which apply both to human and nonhuman actors. Such presence(s) are situated in personal, physical and social contexts in which people construct meanings by linking past experience with presently experienced objects, environments and interactions. This meaning making process is mediated by a range of cognitive and physical tools (as termed in activity theory) or material or semiotic resources (as in actor network theory), including digital technologies. People relate to mediating technologies in different ways through a range of contact points, resulting in different types of influence which have ethical and political implications for design. Presence is contextualised within experiences which are spatially and temporally bounded and situated. Dewey is specifically concerned with aesthetic experiences, and we link technological design with the creation of experiences through artistic methods and strategies. This theoretical grounding prompts the following research questions in relation to our practice: What balance of objective (technological) and subjective (mystical) characteristics of technology-mediated experiences can evoke unseen presences? What specific mechanisms of sound as a stimulus can evoke unseen presences? Our methodology used in this practice-based artistic research process is detailed next.

Methodology

As artistic research, we utilise practice-led methods of making, reflecting upon and iterating work, alongside theoretical research to inform the work. This is characterised as theory construction according to Friedman (2003), and regards making as a complex, informed, physical, theoretical, intellectual activity where public and private meet, according to Sullivan (2005). We are less interested in evaluating audience reactions to our work than in evaluating process and product through reflection; we believe that artistic research can generate new knowledge as valid as scientific research.

Art, according to Dewey, represents an intensified form of experience, always with a material basis but with a singular quality that is more than the sum of its parts. He believes that art objects can become separated from both the conditions of their origin and viewers' experience of them, and aims in his

philosophy to restore a balance between intensified experiences and everyday experience. As above, intensified, time-bounded experiences – whether brought about through resistance and conflict in life events, or consciously manipulated through artistic works – are characterised by particular emotional qualities linked to ancient cognitive structures which developed early in human evolution. This in turn is linked to narrative and memory formation (Norman 2005; Bruner 2003).

Norman (2005) suggests that designed objects and experiences can elicit an emotional response at this visceral level, transcending rational thought through the ways things look, feel and sound. Mobile phones, for example, are considered an ‘affective technology’ according to Lasen (2005), as “objects which mediate the expression, display, experience and communication of feelings and emotions” (Lasen 2005, p.IX). Walker (2010), drawing on activity theory, provides evidence for the value of looking beyond the design of objects and technologies, to the design of activities and experiences which structure their use, with conscious attention to narrative and emotional qualities. Dewey (1934) provides a philosophical grounding for such a design process, grounded in aesthetics and direct experience.

The field of experience design has emerged by taking precisely this approach. While a sub-field of User Experience (UX) focuses on the design of services and customer experience around devices, software and products, some designers operate closer to Dewey’s artistic and aesthetic notion of experience. Jones (2009) describes the adoption by experience designers of artistic strategies of conceptual art to question the motives and implications of design and technology.

The parallel field of speculative design (Dunne and Raby, 2013) similarly uses design to question, imagine and raise awareness, particularly through the use of fictional future scenarios. For example, *Earwitness Objects* by de Weijer (2014) investigates the speculative phenomenon of ‘infinite sound’ originally posed by Marconi, through practice-led research, design and performance. Applied to telepresence, such an approach might imagine that humans have become mediators for technology, and fabricate scenarios in which devices experience feelings of presence.

We characterise our work as artistic research, with a methodology which adopts artistic strategies such as conceptualism, as well as surrealist blending of fact and fiction. Grounded in the theory around context, mediation and experience, we engage in practical design and making, focused particularly on creating engaging and immersive experiences situated in particular contexts and with attention to mediation by digital technologies.

De-computation

Specifically, we question the pervasiveness and implications of technologies by engaging directly with technologies themselves. We have termed this methodology ‘de-computation.’ It combines the steps of computational thinking with design making as a form of artistic research, aimed simultaneously at experience design and theory construction (Friedman, 2003). Computational thinking typically involves deconstruction of a problem or dataset into smaller parts, pattern recognition, abstraction, and design. As applied to a large dataset, for example, this involves breaking the data down into meaningful chunks or categories, looking for any consistent patterns visually or numerically, abstracting any findings into mathematical formulae, then generating an algorithm to automate or simulate effects across the same or another dataset.

For our purposes, we apply this methodology to non-digital areas such as natural and social systems such as food, finance, play and biology. These are explored by applying the steps of computational thinking; however, we adapt the steps in the following ways: De-construction involves selecting one or two aspects of the phenomenon to interrogate in depth, with initial research identifying meaningful patterns for further study. Abstraction is defined in the artistic sense of simplified representation, as well as in a computational sense – rendering the phenomenon under study using digital and electronic hardware, as well as in algorithmic terms; this sometimes involves the deliberate mis-use of technology. Abstracting phenomena into the realm of ideas, this aligns with our twin aim of theory construction (Friedman, 2003). The final step of design, then, may involve the creation of an algorithm, but for us typically involves representing a system physically and experientially in order to make visible the phenomena under study.

Thus, for us, computational thinking acts as a systematic methodology to incorporate notions of context as defined above, in order to directly engage with technological mediation, through the design of experiences. By rendering phenomena visible and experiential, this aligns our work with artistic research (the goal of art generally being to make visible that which we take for granted), and situates it in the experience of the real, not virtual, world.

As well as the theory described above, this work is inspired by Van de Velde (2004) who applies a computational metaphor to real-world phenomena, conceptualising the world as a kind of computer which computes its own future, with design practice harnessed to direct people’s attention and behaviour, and thereby ‘program’ the world. De-computation as a design methodology is described in further detail in

Walker and Fass (2015). It is implemented in our own work, as well as in an ongoing project of the same name run with our postgraduate students, in which they create work in response to a brief shaped around investigating particular phenomena. Most of the work described below has been created by students in this way, under our guidance.

Sound as subject matter and as material

We have applied the de-computation methodology to music, for example de-constructing composer Steve Reich's *Piano Phase*, and designing new work by abstracting the patterns detected; resulting work utilised heart rate data, patterns of coloured LED lights to simulate synaesthesia, physical objects whose proximity prompted various phased patterns of electronic sounds, a re-construction of Reich's composition as a colour-coded kinetic domino sculpture, and an umbrella which translated raindrops into a musical composition.

We then applied this methodology to sound as a mediator for social interactions, creating objects that responded to their social and physical contexts through designed experiences. This was primarily about conversations – between people and sounds, objects and technologies. We wanted to explore the relationship between how and where people experience sound, and how digital physical objects can enhance, augment, represent or disrupt that experience. The aim was to disentangle the observable relationships, abstract some working principles, derive a rigorous creative approach, and create physical outcomes. Some of the work described in this paper emerged directly from this project, which was called *Soundobject*.

We have also 'de-computed' the concept of resonance, interrogating this term in relation to physical phenomena – when an object's natural vibration frequency responds to an external stimulus of the same frequency; and in a social sense – how individuals and groups are attuned to societal rhythms, and how cultural ideas and experiences spread and are adopted. This resulted in, for example, a single-string instrument played by two human bodies in proximity, a room-sized resonating chamber played by groups of people, a kinetic model of the orbital resonance of three moons of Jupiter, and a VR investigation of social media designed to counter claims of the alienating effects of accelerated culture on contemporary consciousness.

As well as a topic for investigation, we increasingly use sound as both material and medium for de-computing other topic areas. For example, a machine drops a large metal sphere onto a metal plate whenever an explosion in Syria is registered by an associated Twitter feed, in a de-computation of the concept of

atmosphere; the sound of different types of food were used in a blackened room to de-construct a meal; a robotic protestor is designed to project a remote participant's voice at the authorities in a project de-computing surveillance; and a patch of earth instrumented with electronics sonifies rainfall in a de-computation of play. As a medium, sound is a fundamental and rich communicative force, as both material and de-materialised, with elements of spatiality and temporality. As a material, it can be generated or altered through synthesis or sampling, resonance or reverberation, whether in the form of music, ambient sounds, quantitative data, or the semantic or emotional qualities of human vocalisation.

De-computation of presence

We have not previously run a de-computation project specifically focused the concept of presence. However, the projects described in this paper raise relevant issues for presence research. Specifically, they isolate and illustrate particular aspects of the concept, in particular through inversion to look at the presence of inanimate and technological objects, and the evocation of unseen presence through mediation. Our focus remains within the scope of presence phenomena, defined as a state in which we overlook or misconstrue the role of technology, thereby feeling present in an environment or connected to people or things we experience via technological mediation. but we place particular emphasis on a design perspective which deliberately misconstrues, misuses or subverts mediating technologies to investigate presence phenomena.

Thus methodologically, through the critical lens of artistic research we show how such practice-led research can link the concept with personal, physical and social contexts. The locus of mediation shifts from technological objects to sound as a visceral and intangible material for communication. Our process of experience design following the methodology of de-computation illustrates one way in which presence can be experimentally investigated in real-world contexts.

Our intention in this paper is therefore to conduct an exploratory investigation into the concept of presence, through analysis of the case study projects described, discussing each in relation to the concept, and analysing each against our conceptual model in terms of context, mediation and experience. As our methodology traverses theory and practice, this serves to further develop our conceptual model, in preparation for further practical work specifically focused on presence.

Case studies

The following projects were created using the methodology just detailed, and are described in relation to our theoretical grounding, specifically addressing our research questions: What balance of objective (technological) and subjective (mystical) characteristics of technology-mediated experiences can evoke unseen presences? What specific mechanisms of sound as a stimulus can evoke unseen presences?.

Space Replay

This mysterious and performative object was created by students Julinka Eberhard, Francesco Tacchini and Will Yates-Johnson in the 2014 *Soundobject* project described above. It consists of a large, spherical, black latex balloon filled with small electronics and a measured mixture of helium and oxygen such that it hovers at a fixed height (Figure 1). The electronics, vacuum-formed into a cone-shaped enclosure before being fitted into the balloon, record ambient sounds then play them back after a predetermined amount of time – initially set to 20 minutes. Thus, whether remaining motionless or slowly moving horizontally through a space, it creates a sense of presence temporally and (when moving) spatially.

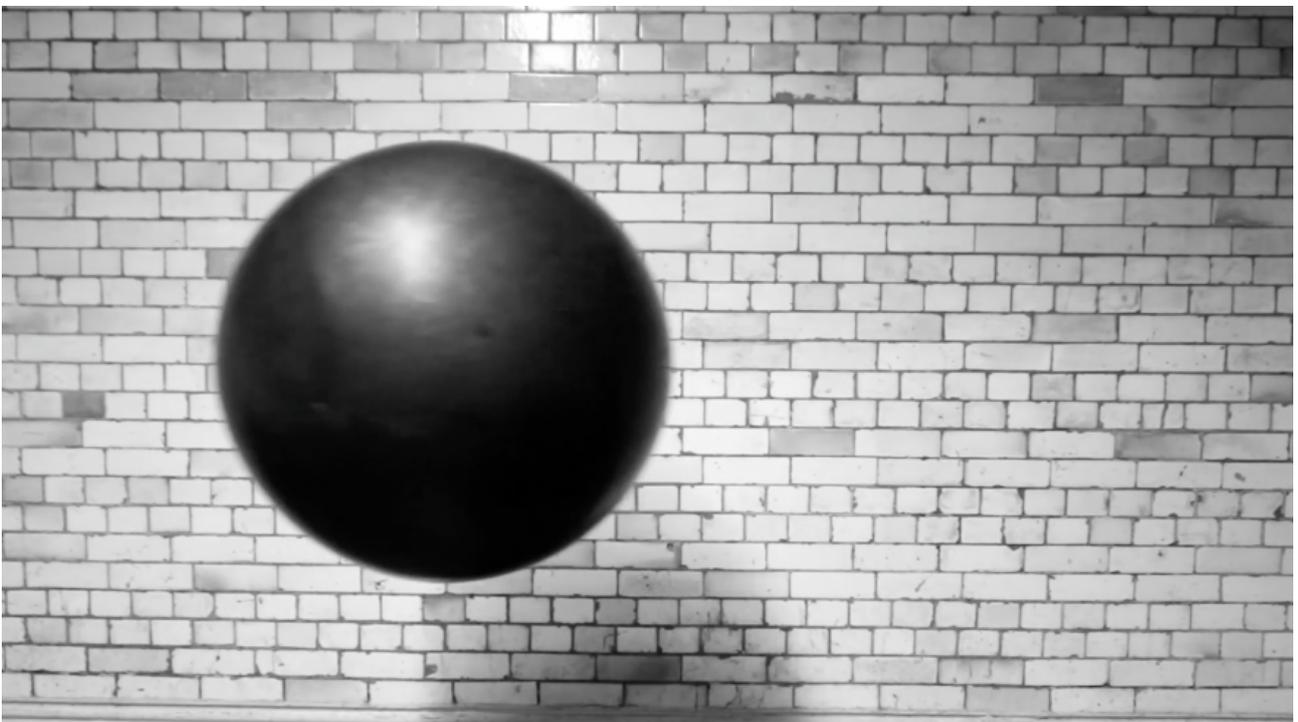


Figure 1. *Space Replay* by Julinka Eberhard, Francesco Tacchini and Will Yates-Johnson. Details and video:

<http://ied.rca.ac.uk/de-computation/space-replay>

The object was particularly designed to explore the acoustic properties of transitional spaces such as stairways, corridors and elevators. In their initial research, the designers identified two types of sound relevant to such spaces – ambient sounds that are either natural or byproducts of localised activity such as traffic; and sounds that are intentionally designed and implemented, such as a elevator arrival bell. According to the designers, “By constantly recording and replaying these ambient sounds, the levitating sphere produces a delayed echo of human activity.”

“To explore the relationship between how and where people experience these sounds, we needed a tool – a digital or physical object – that could augment or disrupt that experience,” according to Tacchini, “a tool to manipulate sounds by either time delay, echo, live transposition or transmission, amplification or pitch” (in Robarts, 2014). The object thus creates what Stinson (2014) calls a “delayed human echo.” She describes this as follows:

The orb is a sonic ghost of people past. The voices and sounds are a reminder of people who just passed through the very same space you are only mere minutes before. In that context, it’s actually sort of a lovely, ephemeral way to connect people who would otherwise just be ships passing in the night.

The fact that the object was a large, hovering, black sphere effectively hid the technology, but simultaneously embodied hidden network technologies with its clever and subtle use of sound. It was variously described as a “creepy floating orb” (Stinson, 2014) and an “obsidian nightmare from the future” (Sottek, 2014). The video documentation was described as “the creepiest and most mesmerizing video of the year” (Dunne, 2014). According to Bryant (2014), “Creating a device that records the noises we make raises sinister questions about the ever-present surveillance in our urban environment.”

Space Replay therefore highlighted for us the power of objects to evoke unseen presences, and most interestingly for us in this case, mass surveillance was equated with the occult. As Dunne (2014) described, “Some New Age believers in the paranormal claim to often see variously colored orbs of light floating around—supposedly, they’re ghosts and spirits. They say black orbs signify demonic energy and should be approached with caution.” In relation to our first research questions, regarding the balance of objective/ technological and subjective/mystical aspects of presence experiences, here technology was hidden but embodied in an evocative form which became a metaphor for surveillance by unseen others, whilst in

relation to our second question about the role of sound, it simultaneously prompted a sense of connection with more co-present others by bringing their voices closer. Thus a simple form and concept created fairly complex feelings of presence – particularly in public (physical and social) contexts, in relation to individuals' subjective (personal) contexts, relating for example to occult beliefs.

Spook-I

Armed with these findings, the lead author and a group of students, including Tacchini, planned an exhibition in late 2014 to explore this relation further. The exhibition was called *Possessed Objects* and took place at the Royal College of Art in December 2014. Tacchini continued investigating the theme of surveillance, specifically state-sponsored surveillance undertaken by the U.S. government. His research turned up 'ghost devices' with cryptic names which detect signals on various frequencies on the electromagnetic spectrum. Coincidentally, the paranormal research community monitors electromagnetic frequencies for the presence of ghosts and other spectral phenomena. More broadly, technology is often equated with magic (most famously by Arthur C. Clarke), and this artistic research became concerned with summoning technological ghosts and digital shadows, trying to uncover the codes of the technological environment. This turned up 'air-gapped' machines which intercept signals via LED lights flashing too rapidly for humans to detect, or via audio signals in the infrasonic or 'spooky' range, just out of human hearing.

Tacchini constructed a 'zombie computer' which communicated at high frequency (detectable by younger people and common consumer devices) using what he called a 'spectral sonic language'. The device was based on U.S. National Security Agency (NSA) plans leaked to the press by former government employee Edward Snowden, and created in order to investigate the technologies and procedures of State surveillance by directly experiencing them. A device detected any nearby mobile phone, collected its user's email address, and disabled its wireless service for one minute; when service was restored, the user received an email address ostensibly from the NSA. (Again coincidentally, similar devices are used by the paranormal research community to monitor specific electromagnetic frequencies.)

The jamming device was embedded in a larger device constructed from two circuit boards (actually a recycled video card from an old desktop computer), adorned with LEDs which were made to flash each time the device automatically activated every minute. It was displayed in a gallery, with an adjacent projection

showing detected devices and names, along with a linear spectrogram of the wireless network being targeted (Figure 2).

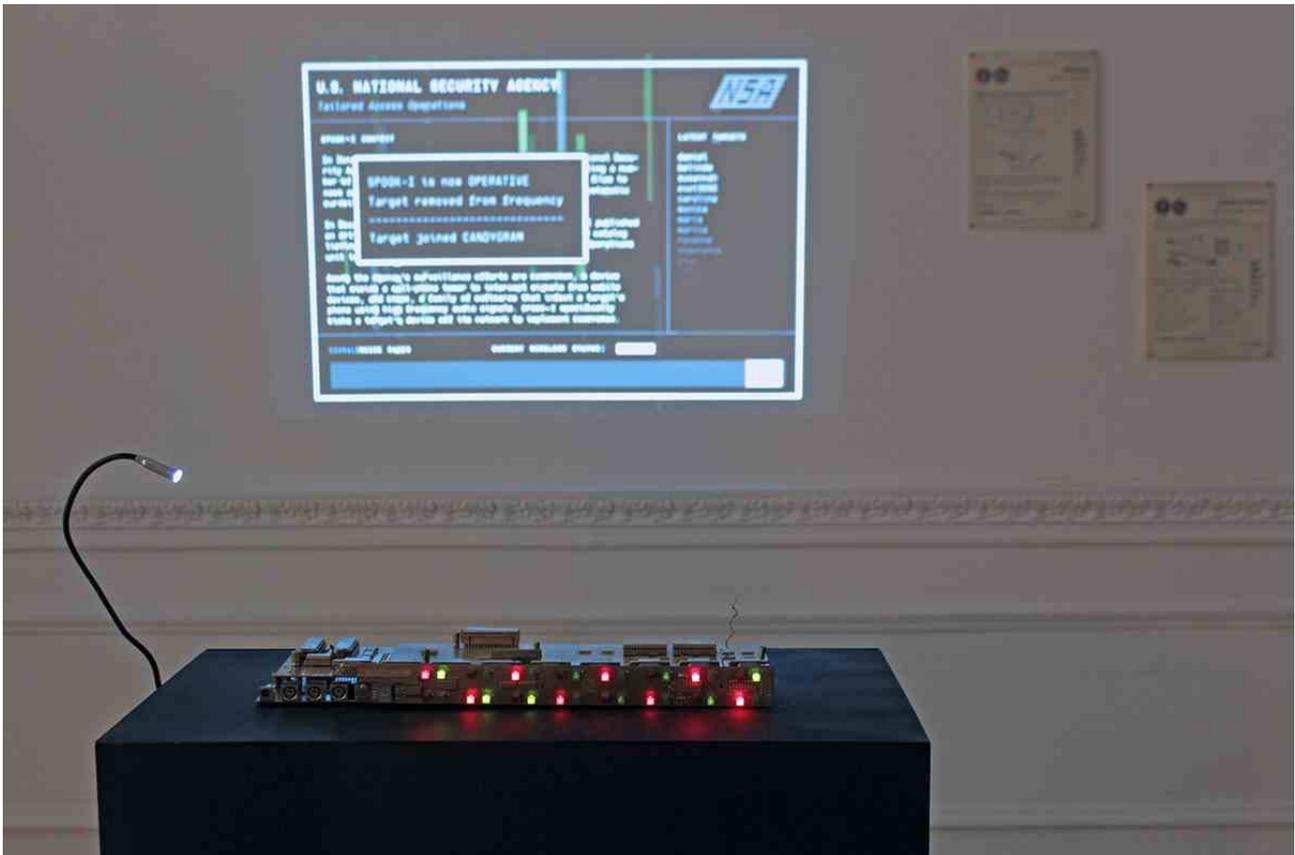


Figure 2. *Spook-I* by Francesco Tacchini, in the Possessed Objects exhibition at the RCA, Dec. 2014. Details and video: <http://tacchini.fr>

This project thereby investigated two notions of presence. It conjured an unseen and vaguely occult presence via ultrasonic and near-ultrasonic frequencies. (One of the NSA programs upon which it was based was called “SPOOK”.) The device itself was also intended to take on a life of its own as it automatically came to life for ten seconds every minute, with flashing lights and sounds barely audible (to some people). Sound was important for giving the object a distinct agency as it actively engaged with another device, disabled the latter, then communicated directly with its owner, hiding its own identity. The fact that only some people could detect the sonic presence (people over the age of 40 or so experience a gradual loss in hearing higher frequencies) connected to the belief that only individuals with special psychic powers are able to communicate with spirits, the term ‘spectral’ being alternately defined in relation to ghosts or to the electromagnetic spectrum.

Spook-I thus effectively produced a sensation of presence, as defined by Gumbrecht (2004) as well as revealing the presence of unseen agents – human and otherwise. Here, too, an additional definition of presence comes to light – that of an authority, as in ‘police presence’ (OED). The omnipresence of a pervasive security apparatus is linked to the production of a nonhuman presence through the use of spectral frequencies and objects with agency. In relation to our research questions, this device – in contrast to *Space Replay* – made technology visible, audible and deliberately disruptive, yet similarly as a mediator to unseen human observers. It specifically used high-frequency sound to then connect technology and observation to notions of the occult, referencing this through the title of the installation.

On/off/in[line]

Oliver Smith drew similar inspiration for his work in the *Possessed Objects* exhibition. Thanks to the documents leaked by Snowden, it is now clear that to be online is to be observed. What is not clear to most of us, however, is what it really means to be online or to have an ‘online presence’. In the early days of Internet adoption, ‘cyberspace’ was a separate place, analogous to where people feel telephone conversations occur – “the place between the phones” (Sterling, 1994). But 20 years later, the online and offline, digital and physical worlds are not as distinct as they once were, as mobile and other Internet-connected devices have contributed to a blurring of these boundaries.

The object created for the exhibition was intended to link intangible online space with distinct physical places through materials, mystical symbols, and sound. The installation consisted of a small concrete cylinder resembling a section of pipe, but with a black whip-style antenna emerging from one side. It was mounted on a wall, with a distinct orange cable leading up to it from the ground and a small light behind it; information was then projected onto and around it. It emitted sounds reminiscent of a modem from the last century, signifying and directly sonifying live online data packets being transferred. The device was linked to its current location, looking for any available wireless networks and making them present through sound and a projected radial spectrogram, the latter of which linked it visually with Tacchini’s work displayed on the opposite wall. (See Figure 3.)



Figure 3. *On/off/in[line]* by Oliver Smith, in the *Possessed Objects* exhibition, Dec. 2014 at RCA. Details and video: <http://oliversmith.cc/outcomes/on-off-in-line/>

The device was intended to be portable yet tied to location – it was small enough to be carried and used in various places, yet the weight and texture of the concrete linked it to hidden, fixed infrastructures. It pulls in signals at one end, and pushes audio out the other. It was taken to particular locations identified as ‘non-places’ as identified by Augé (1995). Sometimes identified with security, sometimes with seemingly benign infrastructure, such places acted as special trade zones with an almost sacred status. Their ownership was often ambiguous – an increasing trend in the developed world is the private ownership of public places, and such places were identified in which, for example, private security guards intentionally dressed like the police, and with implicit or explicit contractual relations with their inhabitants – a trespasser had to prove his or her identity or innocence to inhabit such spaces, and conform to an accepted group identity – ‘shoppers,’ ‘workers,’ etc. This mirrored the gatekeeping of online presence in which real-name and single sign-in policies enforce users’ identities and intentions, in accordance with terms of service set out by free-to-use, privately-owned network spaces.

Through abstraction, the device maps network activity in particular locations using seemingly mystical symbols and incomprehensible (to humans) sound. Its materiality followed from investigations we

undertook into natural materials with special properties, such as magnets used to levitate objects, aerogels and various ‘smart materials,’ plus subsequent experiments carried out by Smith and Tacchini making natural piezoelectric crystals which could detect and transmit sound.

On/off/in[line] thus transposes the notion of telepresence with physical and spatial presence, revealing the invisible ‘Hertzian space’ (Dunne, 1999) of the network, present in most urban locations in the developed world, and links this with material network infrastructure and identity. In relation to our research questions, this installation foregrounds technology and material infrastructure over mystical or subjective connotations, using sound as a link between physical materials and spaces, and ephemeral network data.

Ritual

For the *Possessed Objects* exhibition, Walker similarly linked notions of presence to objects and spaces. In contrast with the comparative technological focus of the two works described above, in this installation all contemporary technology was hidden and the focus was placed on natural materials, linked with perceived supernatural properties and processes. The idea of summoning the presence of a supernatural entity was carried to its (il)logical extreme, with hidden technology intended to create and mediate a multisensory experience.

The installation consisted of a tall table with walls on three sides, all draped in black fabric. A pentagram was hung on the centre wall, along with an animal skull (that of a hartebeest, on loan from a museum). The tabletop was arranged as an altar, with various natural objects – some bones, a forked stick, and some oddly-shaped stones, all placed atop a mound of dirt on the tabletop. A bespoke scent, derived from a book of local witchcraft (Gary, 2008) was created by a colleague and infused into the dirt, which was collected from a cemetery. A diagram was projected onto the floor directly in front of the altar, with symbols at the four compass points derived from Gary (2008). This was subtly animated with a number of shadows in motion, in a common illusion which induces viewers to lean into the motion of the animation, thus drawing them forward into the installation. A second animation of flames was projected on and around the skull and pentagram. Speakers were hidden in the fabric around the altar, so as to surround the visitor with sound once inside; specifically, a subwoofer emitted a low-frequency rumble which was intended to contrast with, and complement, the comparatively high-pitched sounds from the works described above. (See Figure 4.)

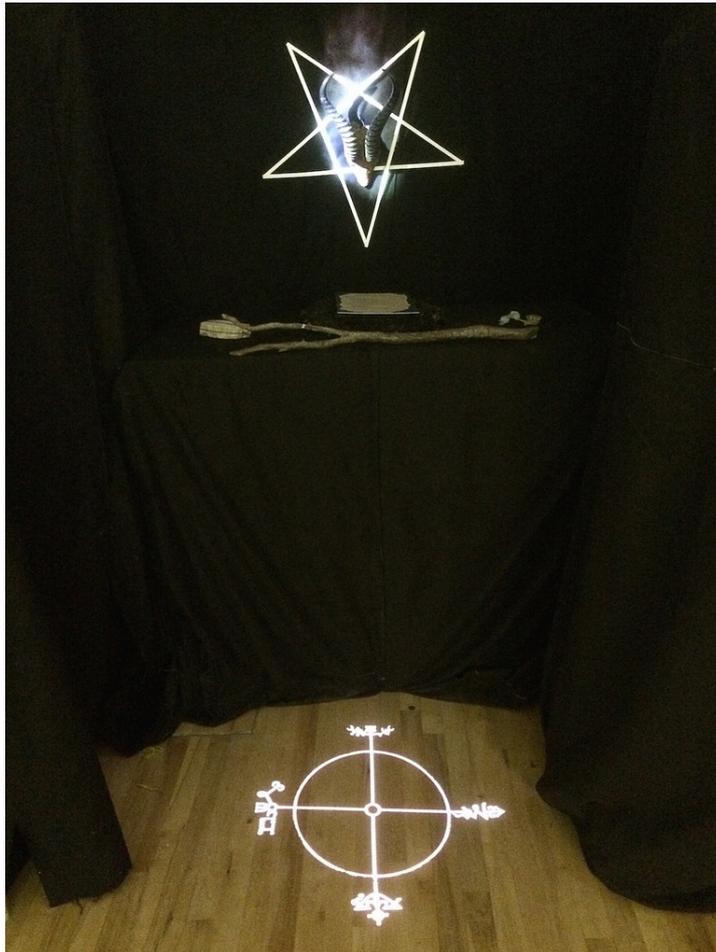


Figure 4. *Ritual* by Kevin Walker, in the Possessed Objects exhibition, Dec. 2014 at the RCA.

Once inside the installation, visitors were drawn to a parchment manuscript (illuminated via projection) on which were hand-lettered instructions to summon the Devil when recited. In these instructions, derived from an ‘authentic’ rite, the objects on the altar were described as having magical properties – the stick and rocks from a place imbued with magical meaning, and the dirt being from a fresh grave. No other technology or interactivity was present. The audio subtly varied in volume in a random fashion, similar to the sound of wind on a microphone, combined with a constant and suitably menacing rumble.

The intent of this installation was to create the feeling of summoning an unseen, quasi-human presence by arousing sensations in visitors through sensory means, abstract symbols, and cultural norms and expectations. The overall sensation evoked through the objects, smell and sound was to transport the visitor to the outdoors. As with many places, there is a strong and deep magical tradition in the U.K. Traditional lore and techniques from the West Country of England (Gary, 2008) were combined with practices from 1960s California (LaVey, 1969) to create a ‘non-place’ in which the visitor felt a sense of telepresence. Traditional

English magic has deep roots and continues to be practiced, with a strong emphasis on the magical properties of particular places, objects and materials. LaVey (1969), writing during (and largely prompting) a Satanic scare during the 1960s and 70s, describes a philosophy combining hedonism with theatricality; having worked as a side-show organist, he readily embraces the theatrical nature of religious ceremonies. The arrangement of the altar and the rite described in the manuscript were thus ‘authentic,’ though a combination of these magical traditions from two different times and places.

Special attention was paid to sound as a powerful medium for creating presence – particularly when contextualised with objects, set design and other sensory means. Exposure to frequencies just below the threshold of human hearing (~20Hz) is thought to be perceptible by the inner ear if the sound pressure is sufficient (Oud, 2012). In the environment, low-frequency sounds are often associated with either wind or industrial machines and processes, and sometimes manifest as vibrations. Such *infrasound* (low-frequency, as opposed to high-frequency ultrasound) energy is also associated with paranormal activity.

As with the other works described above, abstraction was used to link presence with meaning through the deliberate use of mystery. Here, planetary symbols adapted for use in West Country witchcraft were placed at the compass points, which were projected with accuracy, and the altar placed against a west-facing wall as specified by both Gary (2008) and LaVey (1969). In addition, the manuscript contained some foreign language words (Enochian, also associated with traditional English magical rites), for as LaVey describes, the use of foreign language in such ceremonies increases a sense of mystery. Linking back to the present, the use of ciphers and scripts relates to technological practice in the codes and coding used in programming and network protocols.

Finally, cultural norms and expectations were exploited to deepen feelings of presence. Specifically, a notice posted at the entrance to the exhibition contained a warning that complex electromagnetic forces were used inside which might cause unusual sensations or disrupt communications; it was also said to be potentially offensive to those with religious sensibilities. This was in part intended to generate expectations, based on evidence that people who expect to experience paranormal activity due to phenomena such as electromagnetic fields are more likely to perceive them (French et al, 2009). The installation was placed such that it was obscured when visitors entered the exhibition, thus could be heard before it was seen; the prominent placement of the pentagram and skull – with their strong cultural associations to black magic – were intended to elicit a state of arousal when first viewed.

In relation to our research questions, this installation was closer to *Space Replay* than *Spook-I* and *On/off/in[line]* in that it hid the technology and relied more on subjective cultural beliefs, while using sound in an even more subtle way intended to evoke emotional states rather than to convey content.

Discussion

Returning to the research questions, we first sought to investigate what balance of objective (technological) and subjective (mystical) characteristics of technology-mediated experiences could evoke unseen presences, as we defined them in our theoretical background, in relation to pervasive technologies and the social and political implications thereof. Such presences could be human or abstractly conceived as technological – though we recognise that human actors are behind all technologies, whether they fabricate the physical infrastructure, write the algorithms that affect our information consumption and behaviour, or formulate the institutions and policies which similarly become invisibly embedded into contemporary societies. We deliberately linked technology with mystical or occult connotations, as subjectively experienced by individuals based on cultural norms and beliefs, and this connection was explored in experiential objects and installations designed to evoke emotional states in relation to such beliefs. We secondarily and specifically investigated the use of sound to evoke such presence states, looking for specific mechanisms regarding sound which could trigger and sustain these states. Each case study was investigated in relation to context, mediation and experience.

Context

Context was further divided into personal, physical and social contexts, following Falk and Dierking (2008). They link the personal context most strongly to individual meaning making, and in our case studies, we relied on individuals' experience of, for example, surveillance (*Space Replay*), their use of mobile devices (*Spook-I*), use of wireless networks (*On/off/in[line]*), and cultural and religious experiences (*Ritual*). As discussed previously, our aim was not to evaluate the effectiveness of our interventions in an empirical way, but merely to investigate these phenomena through reflective practice. In terms of the personal context then, we presented our work to audiences (both on site and globally via online documentation) in urban, developed

places, who we assumed to have an interest in art and some knowledge and interest in the concepts embedded in the work.

Regarding the social context, all the works described were intended to be experienced by multiple individuals at once; *Space Replay* explicitly relied on a social context in order for audio information to be collected from one group of people and transmitted to another. *Spook-I* and *On/off/in[line]* relied on wireless network infrastructures in which human communication is represented by digital data. *Ritual* was presented in a gallery as a group exhibition, but in its physical configuration was best experienced by a single person at a time. Falk and Dierking regard the social context more broadly as the socio-cultural context, linking this to broader cultural issues similar to the way activity theory conceptualises meaning making as an inherently dialogic, social process rather than a solely individual, cognitive one. Thus all our case studies were situated within a particular cultural milieu, and particularly linked concepts of mysticism with those of technology.

The role of the physical context is perhaps most interesting with regard to our case studies, and to the notion of presence more broadly. Networked digital technologies effectively link people and locations separated by time and space. Specifically in our case, *Space Replay* linked places and people in relatively close proximity, in public places, whereas *Spook-I* evoked a U.S. intelligence-gathering agency located an ocean away, *On/off/in[line]* linked the gallery with ‘non-places’ of physical infrastructure and the more abstract network space, and *Ritual* deliberately linked the gallery with places widely separated in both space and time – locations in the West Country of England, ancient traditions, and conceptual places such as Hell.

Mediation

The case studies demonstrate varying levels of hiding the mediating technology in order to communicate concept and content in particular contexts. While we have used activity theory in the past to analyse mediation (Walker, 2010), Verbeek’s (2015) mediation theory provides a more nuanced model. For example, his notion of embodiment relations, for example taking a mobile phone user as directing his or her actions through the device and toward the world, could be seen not only in *Spook-I* which disrupted network coverage, but also in *Ritual*, in which use of a much more low-tech tool (a forked stick) was utilised to summon unseen others. Whereas Verbeek focuses on digital technologies, activity theory more broadly encompasses not only low-tech tools as mediating technologies, but also cognitive tools such as language (regarded by Vygotsky as the ‘tool of tools’) to mediate how we make sense of abstract concepts – in the case

of *Spook-I* through the high-tech language of surveillance, and in *Ritual* through an ancient language of summoning.

What Verbeek terms hermeneutic relations describes ways in which people read how technologies represent the world; this is most apparent in the case studies in which the mediating technology was made explicit – for example in how *On/off/in[line]* created a sonic and graphical representation of network landscapes, or in how the black *Space Replay* ball represented the abstract concept of governmental surveillance. Conversely, Verbeek's notion of alterity relations, in which technologies fade into the background, is perhaps most relevant for traditional telepresence research, but what we sought to invert. However, in all cases except for *Space Replay*, our subtle use of sound was intended to operate in the background. The physical and psychological effects of ultrasonic and infrasonic sounds on the body have been effectively disproven, but we sought to link them to explicitly emotional and cultural content. In *Spook-I* and *On/off/in[line]*, high-frequency sounds represented network activity, whereas in *Ritual*, low-frequency sound represented supernatural, ostensibly evil activity. In all cases the sound was hidden in some way, yet was the most important medium for communicating the content of each work.

People engaged with technologies in all four of the contact points Verbeek describes. 'To the hand,' for example, indicates physical interaction, as in how people handle mobile phones (for example in *Spook-I*). 'Before the eye' indicates how people engage with information presented by technologies (for example the projections in *Ritual*), and as mentioned, we can extend this notion to include content (informational or emotional) communicated sonically as well, for example in *Space Replay*. 'Behind the back' refers to material infrastructure that impacts our actions and experiences – most obvious in *On/off/in[line]* and *Spook-I*. 'Above the head' indicates how we think about technology, and this was explicitly used in all the case studies, including the comparatively low-tech *Ritual*, which in the context of the other works in the exhibition, aimed to relate technology to magic.

The ways technology influences us was thus the focus of all the installations. Verbeek characterises this influence in terms of visibility and force. In particular, we have detailed the various ways technology was made visible, from the explicitly disruptive *Spook-I* to the subtle *Ritual*. Both installations, however, used technology in a forceful way, seeking to coerce and provoke their audience. Comparatively, *Space Replay* and *On/off/in[line]* were passive experiences with regard to technological influence, but again took opposite approaches toward visibility, with *Space Replay* hiding the tech while *On/off/in[line]* exposed it.

Experience

Finally, we turn to the notion of experience and the design of experiences, reflecting on the case studies. As mentioned, the focus of our practice is on how people experience concepts and content in context(s) (i.e. experience as a verb), and on the design of experiences bounded in time and space (i.e. as a noun). In fact, meaning is made in the interaction between these two notions, when people bring to bear their personal contexts to particular situations in social and physical contexts. Whereas Renaissance thinkers such as Leonardo da Vinci regarded all information as derived from direct experience (observation and experiment), for us experience is counterposed against information for its inherently emotional quality – as Dewey (1934) explains, when we might say, “*That* was an experience.”

Ritual is one common cultural form of experience, which may or may not be social but takes place in particular times and places, characterised by sequential actions. The *Ritual* installation, in the context of the Possessed Objects exhibition, sought to tie ancient rituals with contemporary rituals – getting online, checking email, even going to an art exhibition. Bringing Falk and Dierking’s model of personal, physical and social contexts highlights particular aspects for consideration in the design of experiences, and the various aspects of Verbeek’s mediation theory detail further considerations when any sort of mediating tool is involved, from computers to sticks to language. It is often said that in our screen-mediated age, people increasingly seek direct, ‘unmediated’ experiences away from the screen, but activity theory exposes the mediating role of cognitive structures – there are no unmediated experiences, rather a range of mediation, and often multiple levels of mediation. *Ritual* and *On/off/in[line]* foreground the important role of materials to evoke feelings and memories, while all the case studies described herein aimed at a poetic approach to experience, not directly communicating information. The use of sound aims at pre-cognitive understanding, arguably even bypassing the mediation of language, getting closer to direct, unmediated experience.

Dewey characterises art as experience as a continuous line from the temporally- and spatially-bounded space of the gallery back to the artist’s intentions and production process; the art experience, he says, is completed by the viewer, not when the artist finishes the work. Thus the artist’s personal experience is as important as the viewer’s in the construction of meaning from an artwork. Thus a work should become more than the sum of its parts, through the flow in time from artist’s intentions to viewer’s experience. Such experience relies on the viewer’s presence, or rather, his or her being in the presence of the artwork. The

works we have described were designed to evoke remote, mysterious presences, and we hope the model we have described for their production and analysis is useful to other researchers and practitioners.

References

- Anderson, K. (2014) Object intermediaries: How new media artists translate the language of things. *Leonardo* 47(4): 352-359.
- Augé, M. (2009) *Non-Places: Introduction to an Anthropology of Supermodernity*. Verso.
- Bruner, J. (2003) *Making Stories: Law, Literature, Life*. Cambridge, US: Harvard University Press.
- Bryant, R. (2014) Space Replay floats hauntingly through spaces echoing its surroundings. *Dezeen* 13 Mar 2014. <http://www.dezeen.com/2014/03/13/space-replay-floats-hauntingly-through-spaces-echoing-its-surroundings/> (Accessed 30 May 2016)
- Cole, M. (1996) *Culture in Mind*. Cambridge, MA: Harvard University Press.
- Czikszentmihalyi, M. (2002) *Flow: The Psychology of Happiness*. Rider.
- Dewey, J. (1934) *Art as Experience*. New York: Putnam.
- Dorrestijn, S. et al. Future user-product arrangements: Combining product impact and scenarios in design for multi-age success. *Technology Forecasting and Social Change* 89 (2014), pp. 284–292.
- Dourish, P. (2004) What we talk about when we talk about context, *Personal and Ubiquitous Computing* 8: 19–30.
- Dunne, A. (1999) *Hertzian Tales*. Cambridge, MA: MIT Press.
- Dunne, A. and Raby, F. (2013) *Speculative Everything: Design, Fiction and Social Dreaming*. Cambridge, US: MIT Press.
- Dunne, C. (2014) This giant floating black ball is giving me nightmares. *Fast Company Design* 6 Mar 2014. <http://www.fastcodesign.com/3027321/this-giant-floating-black-ball-is-giving-me-nightmares> (Accessed 30 May 2016)

- Ekbia, H. and Nardi, B. (2015) The political economy of computing: The elephant in the HCI room. *Interactions* 22(6) (October 2015), 46-49. DOI=<http://dx.doi.org/10.1145/2832117>.
- Falk, J. and Dierking, L. (2008) How Visitors Learn through Media and Interaction. In Tallon, L. and Walker, K. (Eds.) (2008) *Digital Technologies and the Museum Experience*. Walnut Creek, CA: Alta Mira Press.
- French, C., Haque, U., Bunton-Stasyshyna, R. and Davisa, R. (2009) The “Haunt” project: An attempt to build a “haunted” room by manipulating complex electromagnetic fields and infrasound. *Cortex* 45(5): 619-629.
- Friedman, K. (2003) Theory Construction in design research. *Design Studies* 24 (6).
- Gary, G. (2008) *Traditional Witchcraft: A West Country Book of Ways*. Troy Books.
- Gergen, K. (2002) The challenge of absent presence. In Katz J. and Aakhus, M. (eds.) *Perpetual Contact: Mobile Communication, Private Talk, Public Performance*. Cambridge University Press, 227-241.
- Gumbrecht, H. (2004) *The Production of Presence*. Palo Alto, CA: Stanford University Press.
- Harman, G. (2010) *Towards Speculative Realism: Essays and Lectures*. Zero Books.
- Jones, R. (2009) Are you experienced? *Frieze* Jan-Feb 2009.
- Kaptelinin, V. (2008) Meaning making in museums as bridging activity contexts: Toward a theoretical framework for interaction design. Working Paper WP-08.01. Department of Informatics, Umeå University.
- Kaptelinin, V. and Nardi, B. (2012) *Activity Theory in HCI: Fundamentals and Reflections*. Morgan and Claypool.
- . (2006) *Acting with Technology: Activity Theory and Interaction Design*. Cambridge, MA: MIT Press.
- Lasen, A. (2005) Understanding mobile phone users and usage. In Gosset (Ed.), *Wireless Future Studies* 4. Vodafone Group R&D.

Latour, B. (2005) *Reassembling the Social: An Introduction to Actor-Network Theory*. Oxford: Oxford University Press.

LaVey, A. (1969) *The Satanic Bible*. Avon Books.

Lombard, M. and Jones, M.T.(2015). In M. Lombard, F. Biocca, W.A. Ijsselsteijn, J. Freeman, & R. Schaevitz (Eds.), *Immersed in Media: Telepresence Theory, Measurement and Technology*. London: Springer.

Nardi, B. (1995) Studying context: a comparison of activity theory, situated action models, and distributed cognition. In Nardi, B. (Ed.) *Context and Consciousness: Activity Theory and Human-Computer Interaction*, pp. 69-102. Cambridge, MA: MIT Press.

Norman, D.A. (2005) *Emotional Design*. New York: Basic Books.

Oud, M. (2012) Low-frequency noise: a biophysical phenomenon. *Geluid (Sound)*. Kluwer Media.

Pierroux, P. (2006) *Meaning, Learning and Art in Museums*. Oslo: Unipub.

Robarts, S. (2014) Floating sphere records and replays public space sounds. Gizmag 7 Mar 2014. <http://www.gizmag.com/space-replay-floating-sound-sphere/31128/> (Accessed 30 May 2016).

Säljö, R. (1996). Mental and physical artifacts in cognitive practices. In Reimann, R. and Spada, N. (Eds.), *Learning in Humans and Machines: Towards an Interdisciplinary Learning Science*, pp. 83-96. Oxford: Pergamon.

Sottek, T.C. (2014) Space Replay is an obsidian nightmare from the future. *Verge* 8 Mar 2014. <http://www.theverge.com/2014/3/8/5485178/space-replay-is-an-obsidian-nightmare-from-the-future> (Accessed 30 May 2016).

Sterling, B. (1993) *The Hacker Crackdown*. Bantam.

Stinson, L. (2014) A creepy floating orb that captures and replays ambient noise. *Wired* 4 Feb 2014. <http://www.wired.com/2014/04/nightmarish-black-orb-records-noise-public-spaces/> (Accessed 30 May 2016).

- Sullivan, G. (2005) *Art Practice as Research: Inquiry in the Visual Arts*. Sage.
- Van de Velde, W. (2003) The World as Computer. *Proceedings of the Smart Objects Conference*, Grenoble, FR, 15-17 May 2003.
- Vygotsky, L. S. (1978). *Mind in Society: The Development of Higher Psychological Processes*. Cambridge, MA: Harvard University Press.
- Walker, K. (2010) Designing for meaning making in museums: Visitor-constructed trails using mobile digital technologies. PhD Thesis, University of London.
- Walker, K., and Fass, J. (2015) De-computation: Programming the world through design. *Nordes 2015: Design Ecologies*, Stockholm, 7-10 June 2015.
- Walker, K., Applin, S. and Fischer, M.(2012) Visualising PolySocial Reality. *1st Intl Workshop on Just-in-Time Sociology*, Lausanne, CH Dec 2012.
- Verbeek, P-P. (2015) Beyond interaction: A short introduction to mediation theory. *Interactions* May-June 2015,
- Weiser, M. (1991) A Computer for the 21st Century. *Scientific American* 265(3), 66-75.