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There's something in your eye: ethical implications of augmented visual field devices

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Abstract

Purpose – This paper aims to explore the ethical and social impact of augmented visual field devices (AVFDs), identifying issues that AVFDs share with existing devices and suggesting new ethical and social issues that arise with the adoption of AVFDs.

Design/methodology/approach – This essay incorporates both a philosophical and an ethical analysis approach. It is based on Plato's Allegory of the Cave, philosophical notions of transparency and presence and human values including psychological well-being, physical well-being, privacy, deception, informed consent, ownership and property and trust.

Findings – The paper concludes that the interactions among developers, users and non-users via AVFDs have implications for autonomy. It also identifies issues of ownership that arise because of the blending of physical and virtual space and important ways that these devices impact, identity and trust.

Practical implications – Developers ought to take time to design and implement an easy-to-use informed consent system with these devices. There is a strong need for consent protocols among developers, users and non-users of AVFDs.

Social implications – There is a social benefit to users sharing what is visible on their devices with those who are in close physical proximity, but this introduces tension between notions of personal privacy and the establishment and maintenance of social norms.

Originality/value – There is new analysis of how AVFDs impact individual identity and the attendant ties to notions of ownership of the space between an object and someone's eyes and control over perception.

Keywords Augmented reality, Autonomy, Transparency, Human values, Augmented visual field devices, Informed consent

Paper type Research paper

1. Introduction

Visual augmented reality (AR) involves projecting light in such a way that both natural light and artificial light enter the eye simultaneously, so some objects seen in the visual field can be traced back to physical objects, and other objects seen are virtual objects, for which no physical object is the source of reflected light. As high-tech innovations go, AR

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is not a particularly recent invention. As early as 1968, Ivan Sutherland (1968) wrote about a "head-mounted three dimensional display". Nearly 30 years later, Mann (1997) wrote about a much smaller system with a similar function; his system included "eyeglasses, a handheld control, and a computer worn in back under the shirt". More recently, Google Glass generated a tremendous amount of publicity, despite its rather modest AR goals compared to those earlier devices. Houghton (2013) describes Google Glass as:

> […] a wearable Android-powered computer built into spectacle frames so that you can perch a display in your field of vision, film, take pictures, search and translate on the go as well as run specially-designed apps.

About that same time, Meta (2013) announced more ambitious goals for Space Glasses, a device they described as "augmented reality 3D glasses". Unlike Google Glass (which is designed to stay out of the way of most of the visual field), Space Glasses use two "see through TFT LCD displays" with the intent that the user will see "three-dimensional display output on top of the real world". In the demonstration movie on their homepage, they show people playing chess, designing a vase, using facial recognition and playing laser tag using virtual images projected as if in space. Space Glasses also include a high resolution, forward-looking camera. As of this writing, Space Glasses are not yet available for purchase and have not captured the public's imagination as much as Google Glass.

Recently, Microsoft (2015) announced the pending release of HoloLens, "the world's most advanced holographic computing platform". HoloLens seemingly will project holographic images into the physical space that are visible to, at least, the wearer of the HoloLens. Other advances in this arena include research to embed AR capabilities into smaller devices, including contact lenses (Stauth and Parviz, 2006; De Smet *et al.*, 2013), and Magic Leap's recently filed patent application for technology that, rather than having the user viewing artificial light emanating from a screen, will project light directly onto the wearer's retina (Abovitz *et al.*, 2015). The holy grail of all of these technologies is to create an environment where the user interacts with virtual and physical objects in a natural, seamless way. It appears that the goal of many of these technologies is to make the virtual objects as similar as possible to the physical objects in the immediate environment to the point that the user is unable to distinguish between the virtual and the real in his/her interactions. We will call devices that are attempting to achieve these goals as augmented visual field devices (AVFDs).

Some of the ethical concerns raised about AVFDs are not new; however, the nature of these concerns changes when these technologies are combined into a single device with proposed components of AVFDs. Promoters speak of the advantages for the individual user of the device; however, there seems to be little analysis of the potential disadvantages for the individual user and almost no analysis of the impact these devices might have in larger groups and on social structures. Brinkman (2014) warns against a simplistic view of AR as "a mixture of reality and virtuality, like a mixture of salt and pepper; it's a compound in which the combined elements have new and powerful properties". The AVFD's cameras are an obvious point of concern. Denning *et al.* (2014) conducted an experiment in which they documented the reactions of bystanders to cameras and recording devices. Their work revealed that the newness and unfamiliarity of these devices caused bystanders to view them differently from other recording

devices such as mobile phones. Although Denning *et al.* (2014) focused solely on recording components, AVFDs certainly will contain other familiar components such as global positioning system (GPS).

We are primarily interested in how AVFDs will literally change how we look at and engage with things and with each other. Implicit in the study of any interaction between humans and their socio-technical context is the idea of agency. Although it is beyond the scope of this paper to do a detailed analysis of this complex topic, it is helpful to briefly examine some important works in this area to inform our analysis. The example of AVFDs speaks to what sociologists in the mid 1990s-2000 referred to as the micro-macro issue: the interaction between individual agents and the social system in which they are embedded (Archer, 2004). In a push back against emerging post-modernism, Margaret Archer in *Being Human* examined human agency, our self-consciousness which she sees emerging from our practical activity in the world, a relationship that she feels can never be severed (Archer, 2004, p. 3). She states:

> The fundamental task of this book has been to give precision to what is meant by the causal powers proper to agency itself. These are the powers which ultimately enable people to reflect upon their social context, and to act reflexively toward it, either individually or collectively. Only by virtue of such powers can human beings be the active shapers of their socio-cultural context, rather than the passive recipients of it (Archer, 2004, p. 308).

Although the focus of Archer's analysis is the interaction between the agent and social systems through actions in the real world, our analysis will examine how the interactions might change if the world is now one that is a mix of virtual and real[1].

Pickering (1995) in *The Mangle of Practice: Time, Agency, and Science* also emphasizes the relationship between the individual and aspects of the world of science. In scientific culture, the machines that seem to exhibit superhuman capabilities do not exist in a vacuum, but are rather enveloped by human practices in a human realm (Archer, 2004, p. 17). He extends the idea of agency to the realm of the material. He writes that a constitutive intertwining exists between material and human agency (Archer, 2004, p. 16) and considers what we need to have to achieve a perfect symmetry with both (Archer, 2004, p. 18). Our consideration of the development of AVFDs and their uses is informed by Pickering's conception of the intentional structure of human agency. He sees the latter "as differing from nonhuman agency in its temporal structure, through its orientation to goals located in the future" (Archer, 2004, p. 20). His conclusions are interestingly appropriate to our complex questions of scientific practice involving new technologies. He suggests that we perhaps could move toward a less structured notion of human agency such as "drift" and:

> […] if we relax […] [the] […] determined focus on literal machines, we are left with a schema that might describe the evolution of any field of agency or agencies, nonhuman as well as human (Archer, 2004, p. 247).

He concludes that:

> One can imagine trying to conceptualize the evolution of the cosmos as a whole–of inorganic as well as organic matter–as evolving within fields of agency in dialectics of resistance and accommodation (Archer, 2004, p. 248).

Hayles (1999) work *How We Became Posthuman: Virtual Bodies in Cybernetics* examines the notion of virtuality: from virtual reality to posthumanism. She writes:

> Normally virtuality is associated with computer simulations that put the body into a feedback loop with a computer-generated image. […] Virtual reality technologies are fascinating because they make visually immediate the perception that a world of information exists parallel to the "real" world, the former intersecting the latter at many points and in many ways (Archer, 2004, p. 14).

Our analysis below of AVFDs extends her analysis of virtual reality gameplay using stereovision headsets and gloves, because in both cases, the user's sensory system can be placed into a feedback loop with a computer (Archer, 2004, pp. 26-27). Her study of post humanism "offers resources for thinking in more sophisticated ways about virtual technologies" (Archer, 2004, p. 290) and agency. She believes that for a human subject to be fully autonomous and to reach the full expression of human capability, that person must be seen as part of a distributed system and not one where artificial boundaries maintain a division between real life and "the illusion of virtual reality" (Archer, 2004, p. 290). It is this "splice" that allows us to envision the possibilities associated with the potential of new technologies that embrace the seamlessness of the virtual and the real.

In the analysis that follows, we will focus on four groups of stakeholders involved with AVFDs: developers, users (both individual and collective), non-users who are in sight of users and society as a whole. We use the term "developers" in a broad sense, including at least designers, software engineers and managers of the companies making these devices. We call non-users who can be physically (not virtually) seen by AVFD users "the watched". We are concerned about the ethical issues that arise as these devices (and their developers) mediate our view of the world and our place in it. Developers who change how we perceive the world visually have major responsibilities. Power relationships inherent in controlling information, content and context are important considerations for AVFD socio-technical systems. We take up these human perspectives in Section 3, after introducing some philosophical perspectives in Section 2. Section 4 concludes the paper.

2. Philosophical perspectives on augmenting reality

Philosophers have discussed perception for millennia. In Section 2.1, we use Plato's Allegory of the Cave to establish some perspectives, and in Section 2.2, we do the same with two notions of transparency.

2.1 Plato and augmented reality

In Plato's Allegory of the Cave (Plato, 1974), prisoners are chained in a cave so they see only shadows on a wall and never see anything else. Plato supposes that if some of the prisoners escaped and learned about the sunlight and objects in the world above, they would not be welcomed back by prisoners still in the cave. Plato speculates:

> […] they descend into their old habitations; – in that underground dwelling they will not see as well as their fellows, and will not be able to compete with them in the measurement of the shadows on the wall; there will be many jokes about the man who went on a visit to the sun and lost his eyes, and if they find anybody trying to set free and enlighten one of their number, they will put him to death, if they can catch him.

In trying to apply Plato's allegory to AVFDs, it is interesting to consider which group of prisoners should represent people with AVFDs and which group of prisoners should represent people without AVFDs. Advocates might argue that people with the new information available through AVFDs represent the freed prisoners, because they have

access to enriched informational horizons, and living without this augmentation is "just looking at shadows". But, critics of AR, in general, and of AVFDs, in particular, could argue that AR is a distorted reality, and those distortions are similar to the shadows in that they distract people who focus on the virtual (unreal) to the detriment of their view of the physical (real) world.

No matter which group the allegorical prisoners are assigned to, it seems likely that people who grow to rely on AVFDs will be (as Plato predicted) significantly incompatible with people who do not. Fundamentally, these two groups are seeing different worlds. The experience of living in an AR and the experience of living in an un-AR will diverge as AR increases in complexity and as some people spend increasing amounts of time in AR.

Other issues important both to Plato's cave and to modern AR are questions about who controls what people see and about the nature of that control. In Plato's cave, the most powerful players are conspicuous by their absence: the people who forcibly compel prisoners to constantly face the wall where shadows appear. In current implementations of AR, users voluntarily call up applications, so the horror of forcibly compelled AR seems at first blush unrealistic. Yet, the nature of those applications will limit the users' choices and, thereby, prescribe what augmentations are available to users.

Even though the developers of AR do not use chains, we should not underestimate their power. The users of AVFDs and their technological successors are voluntarily surrendering at least partial control of what they see. The control that users surrender to developers creates a significant responsibility for developers.

2.2 Transparency and augmented reality

"Transparency", "openness" and "opacity" are active areas of philosophical exploration. For example, Turilli and Floridi (2009) point out two irreconcilable meanings of "transparency":

(1) information visibility, which allows, for example, for outsiders to see details of a corporation's finances; and

(2) information invisibility, as when a computational process is said to be transparent to an end-user.

Both these senses of "transparent" are important to our analysis of AR.

The first sense of the word, visibility, is at the heart of the visual encounter with AVFDs. These devices do not block the user's view completely; the projected virtual images should be translucent so that physical reality is still visible (though partially obscured) by the virtual reality projections onto the visual field. The balance between transparent and opaque will be in the hands of developers when creating virtual images. If the virtual images are too transparent, the possible benefits of the AVFD might be diminished; if the virtual images are too opaque, the act of obscuring reality may lead to harm.

The other sense of transparency, the invisibility of technical details to users, has less to do with the visual experience and more to do with how people think about what goes on inside these devices. There could be a large gap between what the devices actually do and what users and others think the devices do. For example, users may not realize how much information about themselves and others is being collected and communicated by the devices.

Another important transparency issue is that those around an AVFD wearer will not usually know when the user is paying attention to the device. The user's attention will become less visible to others. One of the authors of this paper asked a group of teachers what they would think about their students wearing Google Glass in the classroom. The teachers said it would be impossible to teach effectively because students would be too distracted or because "I wouldn't know when they weren't paying attention". This change of the social dynamic will have ethical significance as AR devices proliferate. Importantly, future AVFDs may be invisible to others, with the user invisibly changing the social dynamic.

3. Human perspectives on augmenting reality

Friedman and Kahn (2000) applied value-sensitive design principles directly to AR and listed seven human values they predicted would be important: psychological well-being, physical well-being, privacy, deception, informed consent, ownership and property and trust. They advise that:

> […] future value-oriented analyses of AR needs to distinguish between the content that is being augmented, the technology performing the augmentation, and the social context of the augmented interaction (2000).

The content of AVFDs and the contexts in which they will be used are likely to be remarkably broad if they are successfully integrated into people's lives.

AVFDs will have a significant impact on what it means to be present. Here, we adopt a notion of presence that Floridi (2013, p. 43) calls successful observation. He introduces the notion of "space of observation" to refer to the whole of what might be observed by a collection of observers that access the environment. In particular, when telepresence is possible, there are notions of the local space of observation (LSO) and the remote space of observation (RSO). According to Floridi's model of telepresence, AVFDs bring remote observations into the wearer's LSO.

In the rest of this section, we briefly survey the range of questions and concerns that arise as Plato's allegory and transparency issues collide with Friedman and Kahn's human values and changing notions of presence via AVFDs.

3.1 Psychological well-being

If AVFDs become widely available, there could be both beneficial and harmful psychological effects. Simons and Chabris (2013) report that one advantage cited by Google's Sergey Brin is that the device "frees your eyes" in a way that consciously looking at a screen does not. However, in that same article, they warn that "Google Glass […] does not abolish the limits on the human ability to pay attention" (2013). This is a concern if there is virtual and real content to absorb. The tension between convenient access to information on the one hand and information overload on the other hand could have psychological significance. The distractions of virtual content combined with negotiating physical space could create anxiety and accidents.

Additional psychological concerns emerge from an analysis of human understanding of physical spaces. Traditionally, people in the same physical space shared similar, although not identical, LSOs. AVFDs challenge fundamental assumptions about physical spaces. When two people share the same physical space and only one is an AVFD wearer, neither can assume similar LSOs. This was always true to some extent, as we all bring different psychological perspectives to an encounter

and we have separate physical perspectives of the space; but, the addition of virtual overlays will intensify the differences. Contrary to natural tendencies, the wearer cannot assume to know the physical space as keenly as the non-wearer and has to resist tendencies to project the RSO onto the non-wearer's sense of the physical space. Of course, the non-wearer can make no reliable assumptions about the wearer's LSO either.

Another divide AVFDs create between users and non-users is a reduced sense of shared experience. In a report by A.J. Jacobs on his experiences with Google Glass (2013), his wife complained of some of his behaviors when he wore the device. But, Jacobs liked some of the same experiences that bothered those around him: "I'm in my own secret world, like the kid with the flashlight under the blanket, but without the flashlight or blanket". This aspect of AVFDs is both psychologically and ethically disconcerting to those who are not experiencing the same reality.

There are long-standing concerns about how earlier technologies separated people socially and psychologically. For example, the Alliance for Childhood (2012) has an extensive discussion of how what it calls "screen technologies" may have serious social and psychological harms for children, particularly if children use the screen technologies for long periods of time. Clearly, the design of AVFDs is moving toward increasing, rather than decreasing, the amount of time people spend at least partially paying attention to computing outputs. Gelernter has a "deep dislike for how [Google Glass][…] would impose itself between the user and his world including other people in it" (Economist, 2013, p. 28). AR could degrade human communication if people use it as a "teleprompter"; spontaneity and frankness might be diminished.

3.1.1 Who is in control? There are fundamental questions about who is controlling an AVFD's psychologically important augmentations. If the user has tight control over the augmentations and if the augmentations benefit the user and the watched, then we foresee positive results. For example, Jacobs (2013) suggested that he could use Google Glass to remind him to be kind to others. However, if the control of the device does not reside with the user, there are potentially serious ethical problems, especially when the user is not fully aware of who or what is controlling the psychologically (and, we would argue, ethically) significant effects of messages and images being projected. Such external control might be inherent in the design, or it might require user permission. Users might surrender control of their devices for many reasons, including ignorance, financial incentives or status incentives. For example, one might allow advertisements to appear when looking at businesses in exchange for discounts. Governments might request or mandate the ability to send messages and images to citizens in certain geographic areas or situations (such as announcing weather warnings or traffic snarls). Additionally, external forces (individuals or organizations) might surreptitiously take control. Many writers have voiced concerns over the possibility of hacking Google Glass (Schwartz, 2013).

However, there may be social benefits to preventing a certain level of user control. Many social norms are established and persist because people in close physical proximity have similar LSOs. AVFD designers may choose to integrate into a user's LSO all of the RSOs of nearby users, thus retaining a feature of the physical spaces we occupy. Yet, AVFDs allow us to raise the question of whether people present in the same physical space ought to have similar LSOs. On one hand, doing so by design would be helpful to teachers whose students would be sharing the same information. On the other, this capability suggests the need for the ability for someone to opt out, as the

implications of this situation remain unclear. Of course, such a shared experience raises privacy concerns, discussed below.

As a final consideration, it is possible that doctors or courts may mandate that certain people wear AVFDs to manage behaviors that are deemed to be anti-social. This kind of mind control through mediated reality could have serious ethical problems, but it also could have potentially useful outcomes both for the patients/perpetrators and for society as a whole.

3.1.2 Identity. AVFDs may help individuals establish their own identities. There is the potential for a deep blending of the physical and virtual self. In the physical world, people use jewelry, body piercings, tattoos and other procedures to distinguish themselves and establish at least part of their identity. People use posts on Pinterest, Facebook, Twitter and Instagram to create a virtual part of themselves. With an AVFD, a person could conceivably make identity-establishing virtual items, a type of virtual jewelry, so that others with a compatible device will see the pinned objects when they look at the person. Those viewing someone who is virtually decorated through an AVFD will see that person as part physical and part holographic and perhaps be unable to distinguish between the two. Liberati (2014) notes an important distinction between additions to the visual field that are essentially annotations (e.g. having someone's name appear when the computer recognizes a face) and additions that are visually integrated with the image of the physical object (e.g. having pseudo-colors indicating skin temperature projected onto the image of a person). Annotations are separate from the person in a way that skin coloration is not.

Ideally, a person ought to have autonomy over her/his identity, yet the AVFD through which the person is being viewed may be owned by someone else. At the very least, there is the opportunity for the owner of the AVFD to use different virtual accoutrements on a person than those selected by the watched. The possibility of decorating others, especially without their consent, seems fraught with difficulties. The problem becomes even more pronounced in a group setting. This technology opens up new avenues for cyber-bullying when tormentors maliciously decorate hapless victims using AVFDs.

3.2 Physical well-being: risks and benefits

Concerns have been raised about threats to physical safety caused by Google Glass. For example, the UK's Department of Transport announced that it plans to ban driving while wearing Google Glass. Some dispute that Google Glass would be dangerous, and others insist that it could improve safety (Van Camp, 2013) by delivering helpful notifications and reminders in a way that allows drivers to keep their eyes focused on traffic. But, if users invoke distracting content on their AVFD, negative consequences seem inevitable. Prohibiting the use of an AVFD while driving reduces potential negative consequences but also may reduce potential positive ones.

AVFDs are starting to be used in medicine and in medical education. Physicians have experimented with Google Glass during surgeries and consultations. Participants reported promising results but are aware of potential problems (Ostrom, 2013). The area of physical well-being and AVFDs demonstrate the importance of context and content to a full ethical analysis. These concerns tend to be application- and user-specific.

3.3 Privacy

Context and content play a strong role in discussions of privacy. Helen Nissenbaum's Theory of Contextual Integrity, which focuses on norms of distribution and norms of appropriateness, is helpful here in assessing when privacy has been violated (Nissenbaum, 2010). As suggested in Denning *et al.*'s (2014) study, privacy concerns around the use of AVFDs involve both overt and covert use of the camera. The watched and the information gathered about them is potentially problematic. Google describes their amassing of information in a positive light by emphasizing not only its non-intrusiveness but also the usefulness of information gathering to users. But, Google does not directly address the potential harms to the individual whose privacy might be violated according to Nissenbaum's definition. Although creep shots are not new, wearable cameras make them easier to obtain, and AVFDs can link the image with other information.

Up until now, there has been no expectation of individual privacy in public spaces. Usually, the lack of privacy has been constrained by what is visible to the observer. How will that change when the observer is wearing an AVFD and what is visible is no longer constrained by physicality? There is a reasonable argument that the AVFD user has a right to control his/her own visual experience in public spaces; however, there is tension with the watched who may be unaware of how much information is "visible" to the observer. As in so many questions about technology and people, power relationships are clearly important. When AVFDs empower individuals to thrive and make choices that do not harm others, there can be a positive effect; when AVFDs enhance the power of those already powerful, diminishing the autonomy of the less powerful, there is a negative effect.

Another significant privacy concern is personal use regulation. Until now, regulation protecting individual privacy has been directed primarily at governments and companies:

> What about a world in which, simply by living their lives, people create vast searchable records of all they have seen – a world not of Big Brother, but of a billion Little Brothers? (Economist, 2013, p. 29)

Balboni thinks that users will lose out if AVFDs are simply viewed as professional tools and analysis of personal use of privately amassed data is not subjected to careful scrutiny (Economist, 2013, p. 29).

The use of AVFDs that are designed to maintain consistent LSOs among people in close physical proximity by including others' remote observations in the LSO of everyone nearby raises additional privacy issues. First, a user may not be interested in sharing his/her RSO with those nearby. Present-day social media may provide some guidance here. Sites such as Facebook encourage honest sharing of information. If, by design AVFDs have this same sort of "honesty" feature built-in, people will be selective about which things they choose to use to augment their realities, knowing that those augmentations will be shared with those in close physical proximity.

The second concern is something that Floridi refers to as "abduction into an informational space". One example of this is when a person is forced to listen to one side of mobile phone conversation (2013, p. 51). In a similar way, a person could be abducted into the informational spaces of those around them should AVFDs be designed to establish similar LSOs for people in close physical proximity. In the early days of

telephony, party lines had this sort of abduction built-in because of economics, but it went away as technology improved. It has re-emerged with mobile phones and social networking sites but in a slightly different way. Rather than the technology causing the abduction, it is how some users choose to use the technology that causes the abduction. Cultures that are more individually focused may find such abduction more troubling, yet those accustomed to more communitarian ways of thinking may find sharing the LSOs of those in close physical proximity comforting.

3.4 Deception

Deception is similar to the tango – it takes at least two, a deceiver and a deceived. Grodzinsky *et al.* (2015) considered deception to be "an intentional, successful attempt by developers to deceive users, and a misapprehension by people other than the developers". Wrathall (2009) offers insight into deception as a perceptual experience:

> In the genuine perceptual experience, the phenomenal character of things corresponds to the way things actually are. One then accounts for deceptions by treating them as the presentation of a certain phenomenal character in the absence of the objects necessary to make that presentation true.

He goes on to explain that "when we are deceived, it's because the thing really looks like what we take it as". So, deceptions, in this sense, have to do with misperceptions. It is how we view the world and how the world is presented to us (Grodzinsky *et al.*, 2015). This raises an interesting question when AVFDs combine physical and virtual perceptions. Everyone's perception of the same object may be different because of augmentations. We would not call this a misperception but rather several different augmented perceptions. So, how can we determine if an augmented perception is a deception? In a certain sense, AR is all about fooling the user's eyes and brain. So, where do we draw the line between legitimate augmentation and illegitimate deception? Great care should be taken to help users be discerning consumers of this new information. Next, we describe three possible deception relationships that are both likely and ethically significant with AVFDs.

3.4.1 Developers may deceive users. AVFD developers have several kinds of power over users. First, the developers know many technical details about the devices, details that are not obvious to most users. Developers could deceive users about the capabilities and sophistication of the AVFD and its algorithms. This kind of deception is common to many high-tech devices. However, the nature of AVFDs and the intimacy of changing what people see might increase the ethical significance of this particular technology deception.

The ancient slogan "seeing is believing" (Ammer, 1997) illustrates another way that AVFD developers might deceive users. Should developers succeed in engineering an AVFD experience in such a way that AR is indistinguishable (or nearly so) from physical reality, users might be deceived into believing in a physical existence that is not actually present. In the case of devices that display light directly on the user's retina, the intention to deceive cannot be eliminated from the nature of the AVFD. The user cannot distinguish between the two different sources of light. It will take other cues for the user to determine the virtual from the physical.

Regardless of whether a virtual object is a holographic image or is being displayed directly onto the user's retina, the developer takes on additional responsibility for the veracity of information attached to the object. Either purposefully or carelessly,

developers could deliver misinformation to users. It may be that users who see that information called up instantly and effortlessly into their visual space will be inclined to give that information's accuracy the benefit of any doubts. One way to mitigate this concern would be to make it obvious to the user the nature of control that he/she has over information. Yet, one of the developmental difficulties is determining a convenient way for a user to provide input into an AVFD. Shortcomings in this feature lead to more control for the developer and less for the user. Therefore, great care should be taken to help users be discerning consumers of the information they see.

3.4.2 Users may deceive the watched. In considering how AVFD users may deceive the watched, we focus on AR visual inputs, real-time video taken from the user's viewpoint. The potential for privacy invasion was one of the reasons Google Glass users were not universally welcomed into public spaces (Denning *et al.*, 2014, Kelly, 2013). Users, recording members of the watched, might explicitly or implicitly lie about their actions or intentions. In addition, users might misrepresent what they are seeing via their AVFD, as a user might have information that non-users do not. The user might misrepresent the presence or absence of the requested information or misrepresent the information. "Yes, I can see that […] " could be used as a method of establishing authority and seeking the power of information (whether the information is true or false). Rather than creating an atmosphere of trust, these potentials for deception could create distrust and uneasiness.

3.4.3 Users may deceive (other) users. One of the interesting aspects of AVFD systems is the potential for multiple users (who will probably have to be using similar, if not identical, systems) to interact in the virtual space overlaid on their individual physical views, such as when people play virtual chess or laser tag. But, it does not take a great deal of imagination to anticipate that some AVFD users who share virtual space with other users could rig the common virtual experience to their individual advantage. For example, one laser tag participant may find a way to have the game unfairly slanted to her advantage. A single user of an AVFD may choose to deceive himself or herself by adorning himself or herself with opulent jewels or keeping a long dead pet virtually close at hand. As virtual worlds and the physical world become increasingly blended, questions about what is real will begin to change. All of us can create our own blends of physical and virtual to create our own realities. Underlying assumptions about the extent to which people share the same reality will change.

3.5 Informed consent and autonomy

Medical informed consent (Dictionary.com, 2015) implies knowledge of the intended intervention, awareness of possible risks and benefits and an explicit declaration of agreement that a procedure can go forward. Consistent with the sensibilities of the subjects of Denning *et al.*'s (2014) experiment, there is a case that both AVFD inputs and outputs should be considered for informed consent. First, a user who uses an AVFD to record images or audio should do so only with the consent of people included in the recording, particularly if the recording is going to be shared. This is further complicated when the recording includes holographic images that appear to be a real part of the physical space. A simple, uniform method for describing the nature of the recording, what is allowed and what is not allowed and the actual obtaining of consent from the watched, especially in large crowds, is no simple feat.

Furthermore, if a developer or user is responsible for changing another user's virtual space, it should be clear to the affected user that this change is taking place. Surely, some such changes would be well known by the users involved; if a user bought a virtual chess program and the developer delivered an appropriate set of virtual objects for the players, no formal informed consent would be necessary. But, if a developer or a user X controlled the virtual space in such a way that all watched individuals were scanned and otherwise private information appeared in X's virtual view, then the watched individuals should be asked for their consent.

There are situations where people might waive AVFD informed consent. For example, some AVFD enthusiasts might want to gather and experience each other's virtual manipulations, or patients in an emergency room might give consent to medical staff with AVFDs. When fellow users were trusted or enthusiasts do not care about the consequences of giving up their control of virtual space, they might mutually agree to a wide-open shared experience, relieving any ethical concerns.

There might be, however, scenarios in which someone is coerced into using an AVFD. The coercion could be economic; for example, it might be required for job training. The coercion could be legal; for example, probation could be granted only if a convict was willing to undergo AVFD therapy. In these types of cases, authorities (commercial or governmental) may reason that the greater good (of a corporation or a policy) trumps the need for voluntary informed consent. Yet, forcing AVFD experiences on to individuals seems to interfere with individual autonomy.

There might be certain contexts where AVFDs may be used to create rich, immersive learning environments that allow students to interact with both virtual and physical objects. A student in such a class seems to have little choice but to don an AVFD. Using such a device as a classroom tool is not necessarily ethically problematic if all students have access. However, "having access" may be more complicated than simply having a device to use; some students may not benefit from an AR device. Blind students are an obvious example, but some sighted students might have adverse reactions to an AR device; how will such students be treated if an AR experience is a required part of a curriculum? The teacher and the school will also exhibit some level of control over the experience, with one or the other potentially having complete control over each student's use of the device. As a collaborative and learning tool, it may be useful for students to see the interactions and the results of interactions that other students initiate, but issues of autonomy should be considered.

3.6 Ownership

There are several ownership issues surrounding AVFDs. First, will AVFDs be owned (like most computer hardware) or leased (like much proprietary software)? We assume that the AVFD hardware will be owned, but that much of the software will be leased. Proprietary software is likely not to be readily accessible for users or for the watched; therefore, there may be interest in having at least some AVFD software as free or open source software (FOSS). We will not reprise the arguments about proprietary and FOSS solutions here, but this is a venue where those arguments will again play out, affecting the balance of power between developers and users and to a lesser extent between users and the watched.

Recorded images and sounds from the watched and from other users can be viewed as an ownership issue: who owns my recorded image and voice? Legally, particular

instances of this argument may turn up where an AVFD is deployed. If the recording takes place in a public space, then the watched might not have a presumption of privacy; if the recording takes place in a space that is not legally designated as public, then there may be a presumption of privacy.

The issues of ownership of devices and recorded images for AVFDs are interesting but not unique. Graham *et al.* (2013) demonstrate the power that comes with one AR technology, Google Maps, by demonstrating how Google shows and describes places differently depending on the language one uses to view a particular place. A more distinctive ownership issue for AVFDs is: who has legitimate claims to the virtual space that users see? A user can make some minimal claim to that space, as it is his/her device and as his/her eyes and visual cortex are most immediately impacted by the virtual image. However, the developers of the device work to design and deliver that virtual environment, and they might also make a claim of ownership; the developers clearly do have control, especially initially, on that virtual space. If some AVFD applications require real-time internet sharing (similar to what gaming systems use for multi-player games), again, that virtual space is claimed by both developers and users.

This sort of sharing also suggests a need for open standards. Proactive work on how virtual objects and experiences are to be represented and shared will allow users with different brands of devices to be unencumbered by those differences. There is a need in the AVFD arena for the same sort of frictionless interaction that people experience while texting, making phone calls and sharing photos. The establishment of these standards will involve issues of power and control.

In cases where both developers and users may have possibly legitimate claims to ownership, it is vital for participants to have explicit agreements about ownership of the virtual space. It may be that in particular applications (such as shared AVFD games), users will be content to relinquish control to enter into a group experience. In other applications (e.g. a surgeon using AVFD during an operation), users may demand a much higher degree of control, especially when they are responsible for critical decisions based partly on information delivered by an AVFD. In both these cases, the stakeholders can act ethically, but only when the agreements are explicit, appropriately detailed and understood by all parties.

Perhaps, the most important aspect of AVFD ownership is an individual's ownership of his/her own perception. Donning an AVFD allows someone to radically alter what a user perceives. This surrender of control has analogs in other technology. When seeing a film at a theatre, watching television and listening to an iPod, people give control over one or more of their senses to a machine that is part of a socio-technical system. But, the distinctive mixture of physical and virtual that is delivered by AVFDs may be seen as a qualitatively greater surrender. If it becomes commonplace to make that surrender on a daily, or even continuous basis, then part of who we are, and much of what we see, will be "owned" outside of ourselves. That is a major ethical issue with power at its core.

3.7 Trust

AVFDs are artifacts that mediate our perception of reality. Within the object-oriented model of trust (Grodzinsky *et al.*, 2015), the analysis of AVFDs falls into the category of human to human trust mediated by electronic means:

> The people who design, develop, or deploy a computing artifact are morally responsible for that artifact, and for the foreseeable effects of that artifact. This responsibility is shared with other people who design, develop, deploy or knowingly use the artifact as part of a sociotechnical system.

Both the developers and users should accept moral responsibility for the artifact. What is the impact on trust? Developers of AVFDs should have as an accepted goal, the examination of the effects of that artifact on society and the performance of its functions with the appropriate standard of care. A sub-goal here would be transparency: developers being honest with others about the capabilities of the device. Users who trust developers will buy their products and use them with confidence. However, if the user performs certain actions based on the trust he/she has in the artifact and if that trust is misplaced (i.e. the developer is manipulating the end-user and does not have the user's best interests at heart), then there is a violation of trust (Lynch, 2009).

Another issue is that of epistemic trust. How do we know what we know from our perceptions through AVFDs? Can we trust what we perceive to be true? Simon (2010) says that:

> […] trust and knowledge are fundamentally entangled in our epistemic practices. Yet despite this fundamental entanglement, we do not trust blindly. Instead we make use of knowledge to rationally place or withdraw trust […]

In the case of AVFDs, it is more difficult to trust what we see as true when the virtual and real are entangled and our world is mediated through this device. How does what we know impact what we perceive and conversely how does what we perceive impact what we know? Careful attention to our experiences with AVFDs will be required to develop answers to these important questions.

4. Conclusions

The development and availability of AVFDs will create a socio-technical system that includes multiple users interacting over a shared physical and virtual space mediated through AVFDs. Although our focus in this paper has been on the ethical concerns associated with this device, we found that the underlying concept of devices that merge virtual and real brought out philosophical, sociological and political questions about agency and appearance. It would be interesting, for example, to bring Hannah Arendt's (1998) concept of the "space of appearance" as described in *The Human Condition* to the world mediated by AVFDs; how would the idea of a space actualized by human interaction for the purpose of discussing public matters change when discussions are augmented by ongoing access to information and affected by the ability to identify and peruse information associated with speakers? Could productive political discussion occur if participants are not directly face-to-face but separated by devices? How would AVFDs affect the power of the collective to persuade and affect change? These very interesting questions, although beyond the scope of this paper, merit further research.

Our analysis in this paper demonstrates that there are conflicting ethical concerns that arise over the wide range of potential uses of AVFDs. The value of preserving shared experiences comes into conflict with privacy considerations, and identity and autonomy concerns come into conflict with ownership ideals. Ultimately, many of these conflicts center on the issues of control and power on the part of the developers.

The developer has at least two kinds of controls in these situations: first, the developer controls the initial configuration of the system, including what the users will see (virtually) and how much control each user and the developers have over those virtual images. The second kind of control is real-time, after the AVFDs are deployed. In particular, one question for developers is which virtual images ought to be shared when two or more users are in close proximity? In a move toward simplicity, the developer might decide that no one's virtual images take precedence and, thus, block everyone's. At the other extreme, the developer could allow everyone's virtual images to be seen. This also seems to detract from the value of AVFDs, as such an experience would be visually cluttered and noisy. To establish a fair means, developers will have to decide whose preferences should take priority. This ethical question might be context-specific, but it should be tackled early during development.

Traditionally, the question of ownership of the space between an object and someone's eyes has not been called into question. AVFDs have the potential to force us to consider that question. It opens up new opportunities for individual freedom for AVFD users, such as The Artvertiser (2015), a device that displays art while obscuring advertisements in public spaces. On one hand, an advertiser might argue to the AVFD developer that such ability ought to be blocked on the AVFD. On the other hand, there is no clear argument that one ought to be subjected to advertising in public spaces. Yet, the intriguing question remains, should someone be allowed to own the visual experience in a public place? Developers, and the systems that they produce as part of AVFDs, will have an important role to play in the environment that surrounds these devices.

The phrase "I can't believe my eyes" is meant to say that something is extraordinary, surprising and unexpected. But, if it becomes commonplace not to believe our eyes because of AVFDs and policies that allow others to control what we see, society will be engaging in a risky socio-technical experiment. AVFDs will have important effects on users, on those who interact with users and on society at large. Developers, users and the watched should think carefully about these effects now, when most AVFDs are at an early stage of development.

Note

1. Although we are not social theorists, we recognize the importance of the interactional element and how it applies to a socio-tech world. We turn the reader to Archer's body of work (2004) for a more in-depth analysis.

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