University of Glasgow

Centre for the Study of Perceptual Experience

The Royal Society of Edinburgh
KNOWLEDGE MADE USEFUL

POLICY AND PRACTICE RECOMMENDATIONS FOR AUGMENTED AND MIXED REALITY

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WORLD CHANGING GLASGOW

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SUMMARY

This policy report arises from the research project *Augmented Reality: Ethics, Perception, Metaphysics*, conducted at the University of Glasgow's Centre for the Study of Perceptual Experience between November 2021 and November 2023. It was funded by a grant from the Royal Society of Edinburgh. The project brought together experts in various academic fields, with partners from industry and regulatory bodies, to explore the nature of augmented and mixed reality technology, the theories underpinning them, and the ethical and legal questions prompted by new technology in this domain.

Augmented and mixed reality is a fast-moving domain. The use of these technologies is likely to be increasingly widespread in coming years. The project has identified core opportunities and central areas of risk for ethical deployment of these technologies, including **privacy, information, identity, accessibility, autonomy, and well-being**. We have also concluded that the nature, pace and drivers of technological development mean that we can't rely on either market forces or a process of 'natural evolution' to maximise opportunities and minimise risks. So, active intervention is needed to shape the technological trajectory and its effect in these domains.

Our summary recommendations are as follows, with more details below.

1. **Developers** should focus on ways of marking out virtual objects and features, which can reliably distinguish the virtual from the real, rather than aiming for imperceptible or seamless integration, and should adopt design standards which guard against the covert influence of virtual content.
2. **Industry and policy-makers** should ensure people have information about what data is collected by AR and MR devices, straightforward access to personal data, and control over their digital identity (including profiles that influence what virtual content they receive).
3. **Policy-makers** should integrate education about AR/MR and their benefits and risks into critical thinking curricula in schools and, more urgently, into a campaign of digital literacy for adults, focusing on the novel privacy risks involved in ostensibly familiar activities.
4. **Public- and industry-funded research** should prioritise these research questions:
    a. To what extent is an individual opt-in regime for AR/MR data capture consistent with what we hope to achieve with such data?
    b. How can AR/MR devices best be adapted to offer novel forms of support for users with visual impairments and other sensory disabilities, e.g. through sensory substitution technologies?
    c. What are the expected costs and benefits of transitioning from screen-based to AR/MR technologies, and how can development maximise sustainability gains?
    d. What are the effects of AR/MR use on mental well-being, including on the behaviour and cognition of users? How can we develop test practices that allow us to predict the psychological effects of AR/MR?
    e. When and how might designers best indicate that an object is virtual in AR/MR, consistently with the other purposes of the technology?
    f. How can we capture AR/MR experiences so that they are preserved for posterity?

We also recommend a periodic process of review for recommendations 1-3, to evaluate the implementation of these recommendations and their continuing aptness.

1. TECHNICAL INTRODUCTION TO AUGMENTED AND MIXED REALITY

Augmented Reality (AR) is a related technology to the better-known Virtual Reality (VR). Both technologies use computer vision to understand the position and movement of a user, and games engines take those into account to render computer generated (virtual) objects or environments. VR typically takes over 100% of the user's visual or auditory field. AR selectively intervenes to create the sense of virtual elements integrated with the world. If a virtual object in AR is to be convincing enough to be mistaken for a real one, it needs to match the lighting conditions, the shadows, the reflectance and the pin-point accurate position of a real object in that place. AR technology must therefore understand the user's position and perspective to an extremely high degree of accuracy, capturing and processing the world and people around the user in extraordinary detail. This demanding technical challenge is further compounded by the desire to have small, lightweight, attractive devices that otherwise let users perceive the real world naturally and without significant mediation.

The term 'true' AR is used to designate technology that, apart from the virtual objects and features, otherwise allows direct, unmediated perception of the world. But many current headsets adopt a hybrid approach called 'Mixed Reality' (MR). This mimics the performance of 'true' AR by relaying a video of the world to you via a camera feed and inserting virtual objects into it. MR technology operates differently to 'true' AR: it effectively uses VR technology to achieve its ends. Some people think of MR as a form of AR, others think of it as distinct. Whichever, the ethical and legal opportunities and risks associated with AR and MR overlap substantially. So, in this report we tend to use the term 'AR', but everything we say applies equally to MR as well.

XR is the umbrella term that covers each of VR, AR, and MR. We don't aim to deal with VR here, so don't use the terminology of XR, albeit that some of the recommendations made in this report might be applicable in that wider domain.

AR is a key target on the roadmap of the biggest technology companies in the world: Meta, Apple, Microsoft, Google, and Sony. Enabling services and technologies are the focus of Amazon, NVIDIA, Qualcomm, Snap, and Bytedance. AR is very likely to replace screens quite generally in coming decades,becoming as ubiquitous as today's smartphones, computers and televisions *combined*. It will be a new technological epoch.

We have recent precedents for this kind of technological revolution, for example the advent of the internet and smartphones. These have transformed how we live, work, learn, and communicate, with undoubted benefits, but also problems. How might we have prepared ourselves better before these technologies took hold? What policies or practices might we have adopted to protect ourselves better? What could we have done to get benefits sooner, and more safely?

In this project we aim to ask those questions about the anticipated advent of AR. On the positive side, AR will be an extraordinary new way to access information and experience the world. You will be able to test out furniture in your house, or clothes on your body. You could change your living room wallpaper to suit your mood, or have a seaside view from your urban kitchen. You could have an expert guide you in 3D as you repair your boiler, or go on a class field trip to the bottom of the sea. You could have a personal IMAX in your bedroom, or be virtually present in 3D with distant relatives. You could have errors in your work, or dangers in your environment, highlighted in your visual field. You could build your own museum from 3D copies of ancient artefacts, or artistic masterpieces. On the negative side, AR poses ethical risks in a number of domains. In what follows we consider six: privacy, information, identity, accessibility, autonomy, and well-being.

2. PRIVACY

AR devices can capture data on an unparalleled scale. An AR user will generate data about their location, what they see and hear, what and who they look at (using highly accurate eye-tracking), and what grabs or holds their attention. How the user reacts can be captured by monitoring actions and behaviour, but also in more subtle ways, such as how their physiology changes (e.g. pupil size, skin blush). It is likely that all this will allow reliable inferences about biometric data and personal characteristics.

Besides user data, AR can capture data about other people too, including their location and behaviour. This can happen today via cameras and filming, and with AR this capture has the potential to be both ubiquitous and covert if, as is likely, the constant wearing of AR devices becomes the norm. This will allow others, including non-users, to be tracked (using face or gait recognition technology across multiple data streams from multiple users), and their own biometric and personal data captured (through analysis of facial expressions, behaviour, and movement).

This data capture and processing has potential positives for AR users and others, by providing tailored information to the former about where they are and what they're seeing, and by providing real time information to the latter about events in their environment (e.g. traffic to avoid).[1]

Nonetheless, the scale of this data-gathering introduces significant privacy concerns which outstrip the capacity of existing mechanisms to manage. The amount of data collected, and the ability to analyse it, will increase exponentially, allowing unprecedented access to personal information for users and non-users alike. As AR devices become widespread, there is a likely possibility that people will constantly record the people and the world around them. The density of recording devices will go far beyond that of even current smartphones and CCTV. Recording will be both ubiquitous and non-transparent. One can often spot when a camera is in use, but many proposed AR devices - like AR-enabled glasses which look like normal spectacles - will be undetectable to third parties. Indeed, AR users themselves might forget that they are constantly recording (and that their own data is being captured).

Existing laws (e.g. about data processing, or about filming/photographing others in public places) cover some relevant territory here, and could be extended to address some privacy concerns. However, the distinctive features of AR technology require new protections for privacy that go beyond just extending current rules or practices.

For example, some potential privacy dangers are currently addressed by requiring users to give explicit consent to specific data capture and usage before they are able to access the technology in question. The scale, ubiquity and non-transparency of AR data capture, including for third parties, will outrun an approach reliant on this kind of case-by-case explicit consent. As AR suffuses the public realm, there is a danger that neither users nor non-users will have a realistic ability to opt out.

To protect individual privacy in the face of this threat, we recommend a two-pronged approach. One is the 'gatekeeper' solution: we extend current practices by seeking explicit consent. That would require ensuring that people are well-informed, and offering a realistic alternative to participation, including for non-users. Continuing to require explicit consent will protect people's ability to make their own decisions about risk, and also serve a wider educative function by keeping risks salient in people's minds.

The other is to investigate alternative models for securing legitimacy without relying on a model of explicit consent. Consider, for example, social practices around the use of sat-nav technology for motorists. While motorists without sat-nav have not consented to their location being recorded, it often is, so that information about the density and speed of traffic can be relayed to people who have sat-nav. Yet, few worries about the use of people's data in this way have emerged.

[1] AR could in principle also be used to enhance privacy by disguising people's identity from users. See Section 4 ('Identity') for further discussion.

Cases like this suggest that people might be prepared to abandon the model of case-by-case opt-in, in at least some privacy-sensitive contexts, if the payoff in terms of individual convenience and empowerment is clear enough. In such cases, so long as individuals are well-informed about them, an alternative model of tacit consent might suffice, in which people's participating in the activity which involves data gathering is taken to imply that they agree to their data being collected.

We suggest that the key thing when considering privacy in AR is not to avoid risk entirely, but to take an integrated attitude to it. That means taking a stance that is consistent with the attitudes we take in other domains, where people have to make choices about taking on some measure of personal risk to enjoy the benefits of new technologies. That might mean pulling back on the requirement for case-by-case explicit consent in some contexts where there isn't a realistic option for people to opt out at reasonable context. In those cases we should seek to uphold individual agency by other means, e.g. through governance mechanisms like referenda or legislation.

This reasoning is reflected in our recommendations.

Our Recommendations

Industry and policy makers should agree on a standard for ensuring clear information about what data is captured about both AR users and third parties. They should prioritise mechanisms to ensure a meaningful option of non-participation, including new technological solutions to be developed in parallel to AR, e.g. wearable tags that signal whether or not the wearer has opted in to data capture by others' AR devices. The practice of iterative value-sensitive design offers a model for such development.

Public- and industry-funded research should evaluate whether an individual opt-in regime of this kind would be consistent with what we hope to achieve with AR-harvested data.

Policy makers should ensure that everyone is educated about AR data gathering and processing, including what is gathered, for what purposes, and by whom. This should be part of childhood critical thinking education. It is also important as part of a campaign to increase digital literacy amongst adults, because the new domains of data-gathering created by AR are associated with familiar activities which adults will not have previously regarded as raising privacy concerns.

3. INFORMATION

The internet and social media have made information more widely available than ever. They have also created informational silos that resist different perspectives and make the accuracy of information increasingly hard to discern.

AR will augment these two impacts on information in critical ways. Virtual enhancements to what one sees can come in the form of textual information (for example descriptions of what is inside a store) or more purely sensory information (for example adjustments to the colours of nearby objects). In theory, these enhancements may be wholly innocuous, simply making the user aware of relevant and important information, or nudging them in a positive direction. But the effect might also be negative, e.g. by drawing attention to irrelevant information or objects that advertisers want users to attend to. And to the extent that the virtual enhancements in individual experiences are manipulated in ways similar to those found in current social media, the risks of informational silos and fake news are just as robust for AR as for current social media. Virtual enhancements embedded in AR might be algorithmically shaped to align with (and thereby reinforce) the user's political views, e.g. by hiding displeasing experiences, or highlighting ones that provoke a positive reaction. These manipulations can be overt, where textual information conveys locales and people that are 'favourable' to the user's own biases. They can also be covert, where, in seamless AR, the sensory effects that reinforce political bias, or promote an advertiser's interests, aren't noticeable to the user.

Users cannot be expected to navigate and protect themselves from these risks themselves, and our recommendations reflect this.

Our Recommendations

Developers should ensure that AR devices allow users to be aware of their operation at any given time. Careful design of user interface to highlight augmented content and to avoid covert insertion will be key to this, although we also recommend (for reasons given below in Section 6) that there should be permissible exceptions where users (but not developers) can opt out of these protections.

In addition, users should be able to be aware of who has curated the current virtual augmentations they experience, and have access to the kinds of profiles used to determine the AR content they experience. These constraints will permit virtual augmentations to be a useful informational tool and create a backstop against augmentations being used to mislead and misinform.

Policy-makers should ensure that users should be educated to be aware of the informational benefits and risks of AR. This should be a component of critical thinking curricula in childhood education, and also part of a campaign of digital literacy for adult users.

4. IDENTITY

The identities of things – including objects, places, other people and oneself – are a pillar of our ethical and political lives. Our beliefs, actions, emotions, commitments, and so on are based on what things we take ourselves to be perceiving and interacting with in our environment. We decide who to talk to, and how to talk to them, based on who we identify them as. We decide how to navigate a space based on what things we identify as being in that space. How we feel toward something derives from what we take that thing to be.

There are also numerous ways by which our own identities are presented to others, presentations that greatly impact how others respond to us. We are generally able to discern the identities of things around us through basic perceptions and interactions: we can see what kinds of objects are on the side of the street and what people are nearby. It is rare in our current daily lives that we aren't sure of the identity of the space we are entering or the person we are engaging with. When these identities are not known, we typically engage with caution.

Our project identified areas in which AR technology might help secure, but also undermine, our ability to identify things in our environment, and our ability to manage how we present ourselves to others in our environment. Virtual augmentations can help identify where your friend is in the park and which store has the shoes you're after. However, they can also make someone unfamiliar look familiar or contain misleading information about what a store offers. Regarding self-expression, I can select how I wish to present myself to others by transmitting my preferred virtual augmentations to devices of those looking at me. However, someone could also choose to impose virtual augmentations on me that I find objectionable. That would contradict our commitment to people having control over their own identity and how that identity is presented to others.

A further aspect of identity concerns the future role of AR experiences in developing our identity, both individual and collective, over time. There is a risk, familiar from other areas in which digital technologies have overtaken older analogue and physical record-keeping, that we fail to record these important parts of our digital heritage for posterity. It will be important to develop protocols for identifying and archiving important AR experiences so that they are preserved for posterity, perhaps by integrating practices being developed for video games and other digital content.

Our recommendations focus on protecting individuals' control over their digital identities.

Our Recommendations

Developers should ensure that AR devices allow users to be aware of their operation at any given time. Careful design of user interface to highlight augmented content and to avoid covert insertion will be key to this, although we also recommend (for reasons given below in Section 6) that there should be permissible exceptions where users (but not developers) can opt out of these protections. In addition, users should be able to block unwanted augmentations being imposed on them via other users' headsets. These constraints will augment users' ability to use AR technology to explore and express their identities, while also protecting them - and third parties - from such augmentation being used to frame identities in undesirable ways.

Policy-makers should review existing laws around defamation and whether they can be adapted or extended to offer individuals protection from AR misrepresentation, strengthening legal protections and ensuring that emerging norms in this arena are consistent with accepted legal and social practices elsewhere.

Policy-makers should also prioritise education about the possibility of identity manipulation through misrepresentation, misdirection, and selective presentation. This should be a component of critical thinking curricula in childhood education, and also part of a campaign of digital literacy for adult users.

Public- and industry-funded research should develop ways to capture AR experiences so that they are preserved for posterity as part of our digital heritage.

5. ACCESSIBILITY

The development of AR technology raises questions of accessibility in three key dimensions: ability, sustainability, and equality.

Concerning ability: AR is a primarily visual medium, typified by the augmenting of the visual field. Spatial audio and haptic technology might enhance this, but the main augmentation that AR devices aim for is visual. This risks excluding people with visual impairments from the new experiences and benefits that AR can bring, in a way that, at best, can be partially compensated by engaging other sensory modalities using present technology. This makes accessibility for visually impaired users a most pressing question for accessibility.

These challenges are balanced by opportunities for greater inclusion. Successful AR technology will require computer vision that can read the lighting of the context, the size, shapes, and distances of objects in the scene, their movements, and their material qualities. This will pave the way for a range of currently impossible aids and tools for the visually impaired user. The world could be 'seen' by the device, and relayed to the user via other modalities. Moreover, those with atypical hearing, mobility, or dexterity may find new avenues to assistance too. By adopting the approach of Universal Design - design aimed at as broad a range of users as possible - we may make considerable accessibility gains across the board through AR.

Concerning sustainability: there is an environmental risk to widespread production of AR devices. That encompasses not just the manufacture of millions of devices made of plastic, silicone, and rare metals, but also the energy and computing power needed for such sophisticated computer vision, high-definition display, and 3D graphics. These all represent clear costs to the widespread use of AR.

These costs should be balanced against the compensatory gains from AR devices replacing other screen-based technologies, if we assume that there will be a corresponding drop in demand for smartphones, televisions and other monitors. There is also the possibility that AR devices might allow other changes with positive environmental impacts, e.g. virtual laboratories, prototypes, training services and artworks: all of these will likely consume fewer resources than their non-virtual counterparts, as well as a reduction in the carbon required to move physical objects and people around the world. A key question for research is to perform a cost-benefit analysis of this technological change, and to direct product development to maximise efficient use of resources.

Concerning equality: the promised gains of AR (in life, work, learning, and social connection) are of societal importance. Access to them will depend on the ability to acquire and use AR devices. This raises problems if the cost of those devices is a significant impediment for people who are already economically, socially or educationally disadvantaged. For one thing, the development of AR technology would then exclude such people from the positive opportunities involved. For another, AR may become an essential vehicle for important civic, social or economic activities in future, just as the internet has in recent decades. If it does, then inability to afford or make use of AR devices will make engagement with those activities either impossible or more costly, thereby compounding existing disadvantages.

We do not know the cost of AR devices yet, but XR technologies are generally considered prohibitively costly. There is some truth in that perception since the high-end VR experiences require a powerful gaming computer, and Apple's MR device - the Vision Pro - will cost around $3,500 at launch in 2024. On the other hand, the experiences possible on a Meta Quest 3, both VR and MR, are extraordinary at around £500. That is still a clear barrier to many, but it represents a cost that is on a par with laptops and tablets which are considered basic tools in education and work contexts in wealthy countries. If AR devices eventually reach that cost level, but replace a significant proportion of the functions of the other devices then the cost barrier will not make them the preserve of the very few.

Our recommendations aim to maximise the positive opportunities AR presents for accessibility, while mitigating its risks.

Our Recommendations

Developers should attend to the needs of people with visual and other impairments when designing AR devices, and also prioritise the development of adequate low-cost technology so as to mitigate inequalities of access to AR for civic, social and economic activity.

Public- and industry-funded research should research the potential (through e.g. sensory substitution) for AR devices to offer novel forms of support for users with visual impairment and other sensory disabilities.

Public- and industry-funded research should also conduct comprehensive cost-benefit analyses to give policy-makers detailed and reliable modelling about the anticipated effects of transitioning from screen-based to AR technology, and to help nudge development in directions which maximise environmental gains from resource use, energy use, and reduced need for transportation.

6. AUTONOMY

Individual autonomy is a central ideal in our ethical and political practice. The autonomous individual is someone who decides for themselves what is valuable, and lives their life in accordance with that decision. Considerations of autonomy are related to the themes we have already considered. Privacy matters for autonomy because it allows someone control over what people know about them and their lives, and gives someone the space to pursue their own values. Information is important because it is a key tool for autonomy understood as 'self-authorship', and because informed voluntary consent is necessary for upholding autonomy, especially in situations of risk and uncertainty.

AR technology might support individual autonomy in some areas. It can enrich people's information about their environment and options to help them decide what to endorse, uphold the independence of their decisions, and help them effectively to exercise responsibility to live the lives they value.

AR can also pose an especial danger for individual autonomy through *manipulation,* which threatens autonomy in multiple dimensions. AR content which misinforms, or uses information selectively, or diverts attention in a way that the user isn't aware of, can undermine their independence because it is *covert*. (That might happen whether or not this is the intention of AR designers; covert influence can emerge unwittingly.) The individual ends up with values or preferences which they wouldn't have if they hadn't been subjected unwittingly to this influence. Manipulation also undermines responsibility, diminishing the extent to which the individual's own decisions and values explain the course of their life.

Both these dangers turn on the way that the effects of AR can bypass a user's conscious awareness. It matters that individuals can be aware of what is happening to them. This suggests the development of design norms – enforced by regulation, if necessary – which highlight virtual content and avoid it being covertly inserted into users' experience. There is, of course, a difficult balancing act here: seamless immersion might be very attractive to some users, e.g. for leisure or artistic reasons, or in educational and training settings where it is important for a virtual object to look indistinguishable from the real thing. Regulation which precluded such AR experiences would itself undermine autonomy by precluding users choosing to have such experiences. So, there is an equilibrium to be struck here.

The most important thing is to ensure that it is only users, and not developers, who can explicitly choose to opt out of the general rule that virtual content in AR should be highlighted. That points to building this in as a feature of AR firmware, rather than software, to minimise developers' capacity for circumventing these protections.

Our recommendations therefore focus on this aspect of the technology.

Our Recommendations

Developers should ensure that AR devices allow users to be aware of their operation at any given time. Careful design of user interface to highlight augmented content and to avoid covert insertion will be key to this. We recommend that this be implemented through firmware, so that users may choose to opt out of these protections in individual cases, e.g. for leisure or artistic reasons, but that developers cannot.

Policy-makers should prioritise education about the possibility of manipulation through misrepresentation, misdirection, and selective presentation. This should be a component of critical thinking curricula in childhood education, and also part of a campaign of digital literacy for adult users, especially in light of the risk - highlighted in Section 2 above - that adults might be especially vulnerable to manipulation because of the apparent similarity of AR devices to (non-AR) tools they have used with impunity in the past.

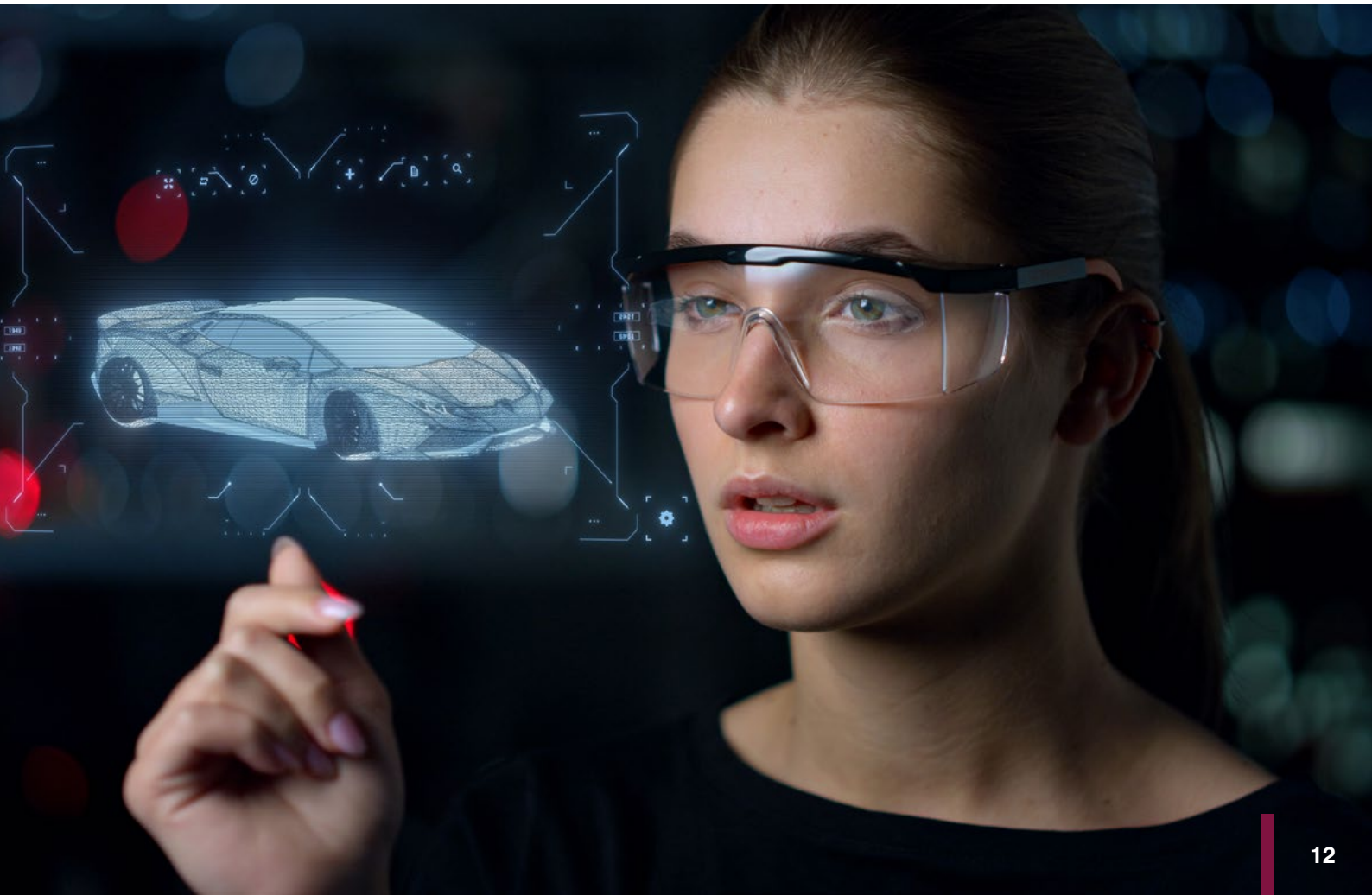
7. WELL-BEING

AR has potential to affect users' well-being in a number of dimensions.

First, consider physical well-being. AR may improve people's physical safety, by guiding them away from danger, such as hazards, which may be well-known or ones detected via other user's headsets, such as riots, chemical spills, and unstable buildings or land. It might guide people to their destination via well-lit, busy areas and away from dark, quiet routes. It can track people and could deliver that information to loved ones, in the way mobile phones can do today. It might be able to detect and record who is approaching you and could send that information to the police, thus serving as a deterrent to crime in the way that CCTV does. It might nudge you to buy healthy products in a supermarket and steer you away from other items, in a way that is sensitive to each user's diverse needs and circumstances (e.g. dietary needs or allergies). It might be used to motivate physical activity, through feedback on progress in a more detailed way possible now, and gamification of activity, such as Pokemon Go.

AR may also lead to physical harm. If virtual objects are inserted into the visual field, and the user does not realise that they are virtual, then they may try to use them for physical support and come to harm. For example, a virtual handrail might lead people to fall if they reach out to try to use it for support. A virtual barrier might lead people to feel safe on a high ledge, when they are in fact in danger, or may seem to provide a shield to protect people from wild animals or falling debris, when it does not. And even if people do know that certain objects are merely virtual, they may reflexively try to rely on them to their detriment. Similarly, AR might guide people towards unhealthy options via advertisements or making certain options salient that would not otherwise be so.

Maximising benefits to physical well-being, while averting the dangers of harm, involves a real tension. On the one hand there is a drive for AR content to be seamless, visually integrated with the real environment and imperceptible as virtual. On the other, it is important that users can remain aware of what is virtual and what is real. Resolving this tension is a key priority for the development of user interface and graphic design in AR software.



Second, consider mental well-being. AR has wide potential to support this. Social anxiety might be alleviated by providing users with information about their interlocutor, such as their name, personal details, interests, and details of previous interactions, to help keep the conversation flowing. AR could guide people around unfamiliar environments. Loneliness could be alleviated by providing contact with real or virtual interlocutors, making them appear to be in the user's company. Environments could be made to appear pleasing to users, tailored to their individual preferences. People may be able to encounter virtual versions of objects that enhance their cultural lives. Your garden could host a daily exhibition of virtual sculptures that are copies of art works from around the world.

These potential benefits come with concurrent dangers with making the world look as it is not. We have already discussed some dangers arising from the ability of AR to occlude or alter people's apparent identities, but there might be mental costs to the user of the people around them, or their environment more generally, being misrepresented in this way.

AR may also be detrimental to people's mental health in other ways. If everyone seems to perceive a different reality then we may begin to become isolated from one another. Just as people sometimes don't socially interact with each other because they would rather interact with the world through their mobile phone, so people might interact less with each other if they don't seem to be living in the same perceptual worlds. There is a cost to us spending less time together in a common environment.

As explored in Section 5 ('Accessibility') above, there is a danger that, as AR becomes ubiquitous, individuals may face pressure to spend resources on ever-more expensive technology to avoid marginalisation or exclusion.

Finally, there is at present scant research about the impacts of AR technology on behaviour and cognition. There is some reason to think that these impacts may be negative, especially for young users.

These considerations about well-being inform our recommendations.

Our Recommendations

Developers should prioritise convergence on a design standard which balances the considerations of visual seamlessness and integration on the one hand with the importance to users of being able to distinguish virtual from real content when it matters.

Public- and industry-funded research should urgently prioritise research into the effects of AR use on mental well-being, including on the behaviour and cognition of users.

CONCLUSION

The imminent technological revolution promised by AR offers us unprecedented opportunities. Early intervention will allow us to guide development in a way that maximises the individual and social benefits of AR technology, while averting or mitigating some of the risks mentioned above.

Central to our approach has been to ask three key questions for each intervention: Why, what, and who? 'Why', because there are diverse ethical, social and political considerations at play, and debates about the benefits we want to secure, and the dangers we want to avert. 'What', because different kinds of interventions will be legitimate and effective in different domains. Some consist in extending existing mechanisms (legal, social, technological) to the AR domain. Others require recognising that AR will take us beyond existing boundaries, and that we need to develop new solutions. 'Who', because this is a complex situation with multiple different stakeholders with different priorities. Our recommendations reveal that all stakeholders have vital roles to play: developers, industry, policy-makers, and research bodies alike.

FURTHER RESOURCES

This section lists underpinning research presentations from the project, including links to recordings where available. (Where presentations touched on multiple topics, they have been listed under the most relevant.) The section also includes some selected further resources which would be a useful starting point for someone wanting to explore the rich literature on these topics.

All recordings for the workshop series are archived at the project website, along with other useful information about resources and project participants: https://www.gla.ac.uk/cspe/projects/augmentedrealityethicsperceptionmetaphysics/.

1. Theory and technology of AR, MR and VR

D. Chalmers 'The Virtual and the Real', *Disputatio* 9 (2017): 309-352.

D. Chalmers 'Perception, Illusion, and Hallucination in Virtual and Augmented Reality', Workshop 2, 31 March 2022.

A. Declos 'Virtual Properties and their Troubles', Workshop 5, 29 September 2022.

A. Fisher 'Imagination in AR and VR', Workshop 4, 28 July 2022.

S. Holmes 'Meta and AR', Workshop 1, 27 January 2022.

F. Macpherson 'Is Virtual Reality Experience Veridical, Illusory or Hallucinatory? A Complex Answer Based on a New Theory of Illusion and Hallucination and the Nature of the Technology Used to Create Virtual Reality'. Working Paper. University of Glasgow Enlighten research repository, https://eprints.gla.ac.uk/226457/.

M. McDonnell 'Making a success of Academic <> Enterprise partnerships', Workshop 6, 27 October 2022.

N. McDonnell 'VR and AR and Technology', Workshop 1, 27 January 2022.

N. McDonnell & N. Wildman 'Virtual reality: Digital or fictional?', *Disputatio* 11 (2019): 371-397.

M. Terras, Interview with N. McDonnell, In-person Conference, 9-10 November 2023.

N. Wildman 'Augmented Reality Fictionalism', Workshop 4, 28 July 2022.

N. Wildman 'Problems with Passthrough', In-person Conference, 9-10 November 2023.

J.R.J. Williams 'How Many Skeletons?', Workshop 5, 29 September 2022.

2. Privacy

L.P. Francis & J.G. Francis *Privacy: What Everyone Needs to Know* (New York: Oxford University Press, 2017).

C. Hills 'Immersive Technologies & Data Protection Implications', Workshop 6, 27 October 2022.

S. Lehman 'Hidden in Plain Sight – Exploring Privacy Risks of Mobile Augmented Reality Applications', Workshop 7, 26 January 2023.

A. Marmor 'What is the Right to Privacy?', *Philosophy & Public Affairs* 43 (2015): 3-26.

M. McGill 'Bystanders and Privacy', Workshop 1, 27 January 2022.

C. Mills 'Ethical Reasoning about Augmented Reality', Workshop 7, 26 January 2023.

H. Nissenbaum *Privacy in Context: Technology, Policy, and the Integrity of Social Life* (Stanford: Stanford Law Books, 2010).

B. Roessler *The Value of Privacy* (Cambridge: Polity, 2005).

C. Yiu 'Next steps toward AR glasses and the metaverse', In-person Conference, 9-10 November 2023.

3. Information

D. Brown 'AR, Indirect Perception, and Illusion', Workshop 2, 31 March 2022.

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